ON-LINE CONFERENCE 2021

East-Asian Association for Science Education

ASIAN COLLABORATION TOWARDS THE DEVELOPMENT OF NEW SCIENCE EDUCATION FOR THE FUTURE; WISE PREPARATION WITH SDGS/STEM

Photo by Dr. Yoshisuke KUMANO

JUNE 18 (FRI)- 20 (SUN), 2021

Main Host Server: Shizuoka University, Shizuoka, JAPAN

EASE E·A·S·E East-Asian Association for Science Education

East-Asian Association for Science Education EASE 2021 ON-LINE CONFERENCE

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Narika Corportaion

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2021 International Conference of East-Asian Association for Science Education

Greetings!! It is my great honor to announce the 2021 International Zoom Conference East-Asian Association for Science Education, Shizuoka, Japan. As all of you have known that 2020 ICEASE at Korea was canceled because of COVID 19. We are all straggling with the unbelievable difficulties in all of the activities as human beings. We are all living in the middle of historical epoch within the time of great changes of Global community.

Our theme this time is settled down as "Asian Collaboration Towards the Development of New Science Education for the Future; the Wise Preparation with SDGs/STEM" This theme has strong connection not only with the COVID 19, but also with rapid changes of Science, Technology, Engineering, Liberal Arts, and Mathematics toward SDGs. We will be able to find good solutions towards many issues that coming up globally. Those issues and problems cannot find proper solutions without good collaborations among all of the countries in the world.

I would express my great thanks to all of the participants for 2021 International Zoom Conference EASE. Your presentations, your ideas, your questions and our discussions will be able to elaborate super solutions for the future!!

We will have six keynote speakers including myself, who will be able to provide stimulated ideas and research results for our researches in science education. I strongly wish that all of the participants should listen to their keynote speakers carefully.

Let us enjoy by joining EASE. New members and old members should attend the all-member meeting and please vote for the new president and new executive members from each region. Also, we will welcome new country members for EASE. They are the researcher from Thailand and Indonesia! Welcome to EASE!! In a near future, I would like to propose that we should upgrade the name from EASE to Asian Association of Science Education (AASE). This is one of the tasks for the New President!

Best Wishes

President of EASE, 2018-2021

Y. Kumano

Yoshisuke Kumano,Ph.D.
E・A・S・E President

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＊Alphabetical order

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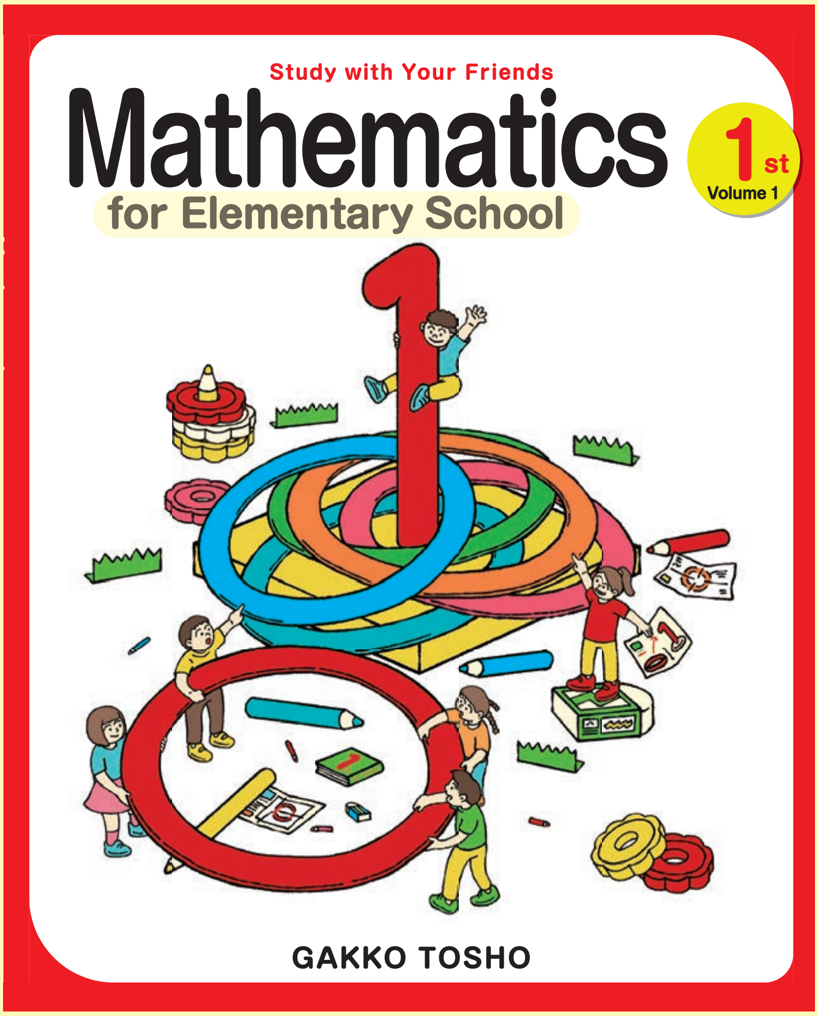

Mathematical Thinking:
How to develop it in classrooms

Published in 2020
English Edition Chief Editors:
Masami Isoda, Aki Murata

1st Grade Vol.1, Vol.2

2nd Grade Vol.1, Vol.2

3rd Grade Vol.1, Vol.2

4th Grade Vol.1, Vol.2

5th Grade Vol.1, Vol.2

6th Grade

6th Grade
Bridge to the Junior High School

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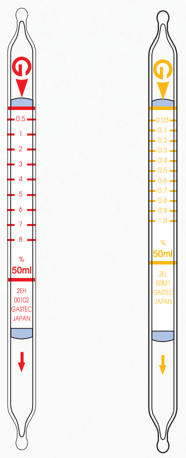
CO_2



Align the “50▲▲” guide mark for the Carbon dioxide detector tube with the red line.

O_2

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We have been contributing in terms of educational promotion at Shizuoka Prefecture according to the scholarship enterprise (student-loan and student-loan grant), educational research promotion services (educational activity encouragement / training assistance / educational practice research papers reports, etc.), and education cultural projects (parents-and-teachers-association activities support, area training culture support, etc.).

Moreover, we strive for the substantial welfare works (gifts of happiness as the family, gifts for the memorial events, etc., discount coupon for the hotels, complete physical examination assistance, etc.) to you, the educational persons who are the members, and we provide grace to the life.

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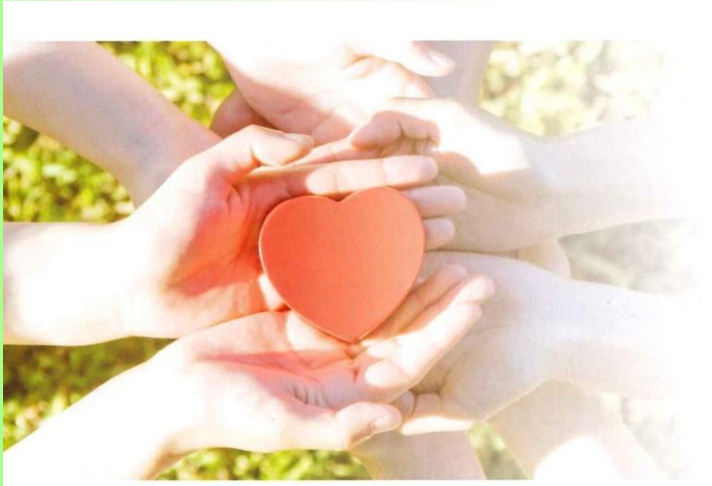

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Shizuoka Prefecture Education Hall 4F, 1-12, Aoiku, Sunnpu-machi, Shizuoka-shi, Shizuoka Pref., Japan TEL 054-205-5130

2021 International Conference of East-Asian Association for Science Education

Japanese Standard Time (JST) is GMT +9

GMT	JST	KST	CST	HKT	ICT	WIT	WITA	WIB
+0	+9	+9	+8	+8	+7	+9	+8	+7

=DAY1: June 18th (Fri.) =

Time (JST)	Contents				
09:30～10:20	Opening Ceremony				
10:30～11:30	Key note：Dr. Jeff Weld				
12:00～13:00	Tutorial Session				
13:00～14:30	Lunch time		EM Meeting		
			Chair Meeting		
14:30～16:00	Oral Session1				
	Room1 C3-1	Room2 C3-2	Room3 C3-3	Room4 C4-1	Room5 C5-1
16:30～18:00	Oral Session2				
	Room1 C3-4	Room2 C3-5	Room3 C3-6	Room4 C4-2	Room5 C5-2
18:30～19:30	Key note：Dr. Myeong kyeong SHIN				

=DAY2: June 19th (Sat.) =

Time (JST)	Contents							
10:30～11:30	Key note：Dr. Pradeep Maxwell Dass							
11:30～14:00	All-member's Meeting							
14:00～14:30	Break				Chair Meeting			
14:30～16:00	Oral Session3							
	Room1 C1-1	Room2 C2-1	Room3 C3-7	Room4 C3-8	Room5 C4-3	Room6 C4-4	Room7 C5-3	Room8 C6-1
16:30～18:00	Oral Session4							
	Room1 C1-2	Room2 C2-2	Room3 C3-9	Room4 C3-10	Room5 C4-5	Room6 C7-1		
18:30～19:30	Key note：Dr. John Stiles							

Japanese Standard Time (JST) is GMT +9

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=DAY3: June 20th (Sun.) =

<table>
<tr><td>Time (JST)</td><td colspan="7">Contents</td></tr>
<tr><td>09:30～10:20</td><td colspan="7">Junior Session</td></tr>
<tr><td>10:30～11:30</td><td colspan="7">Key note：Dr. Gillian Roehrig</td></tr>
<tr><td rowspan="2">11:30～12:30</td><td rowspan="2" colspan="3">Sponsor Session</td><td colspan="4">EM Meeting (New member)</td></tr>
<tr><td colspan="4">Editors Meeting (New member)</td></tr>
<tr><td>12:30～13:00</td><td colspan="3">Break</td><td colspan="4">Chair Meeting</td></tr>
<tr><td rowspan="2">13:00～14:30</td><td colspan="7">Oral Session5</td></tr>
<tr><td>Room1
C1-3</td><td>Room2
C2-3</td><td>Room3
C3-11</td><td>Room4
C4-6</td><td>Room5
C5-4</td><td>Room6
C6-2</td><td>Room7
C7-2</td></tr>
<tr><td rowspan="2">15:00～16:00</td><td colspan="7">Member Group Session</td></tr>
<tr><td colspan="7">Room1
EXPLORING SCIENCE TEACHER EDUCATION FOR CLIMATE CHANGE EDUCATION: CHALLENGES IN ASIAN COUNTRIES</td></tr>
<tr><td>16:30～17:30</td><td colspan="7">Key note：Dr. Yoshisuke KUMANO</td></tr>
<tr><td>17:30～18:30</td><td colspan="7">Closing Ceremony</td></tr>
</table>

Keynote Speech

Day1 (June18th)	10：30～11：30	Dr. Jeff Weld
	18：30～19：30	Dr. Myeong kyeong SHIN
Day2 (June19th)	10：30～11：30	Dr. Pradeep Maxwell Dass
	18：30～19：30	Dr. John Stiles
Day3 (June20th)	10：30～11：30	Dr. Gillian Roehrig
	16：30～17：30	Dr. Yoshisuke KUMANO

DAY1 (June 18th) 10:30～11:30

How America's Strategy for STEM Education supports the United Nations Sustainable Development Goals

Dr. Jeff Weld

Executive Director for the Iowa Governor's STEM Advisory Council
Professor at the University of Northern Iowa in Cedar Falls, Iowa
Former senior advisor for STEM Education, White House Office of Science and Technology Policy

Jeff Weld PhD directs Iowa’s widely acclaimed statewide STEM education program on behalf of the governor. A decorated college professor, scholar, and former high school teacher, Jeff frequently writes for, speaks to, and strategizes with groups aspiring to unleash the transformative power of STEM education at the national, state, and local levels. In late 2017, he accepted a White House invitation to join the Executive Office of the President as senior policy advisor for STEM education in the Office of Science and Technology Policy to lead the production of America’s Strategy for STEM Education, a nonpartisan five-year plan to guide federal agencies and to rally the nation around STEM education. Returning to the helm at Iowa’s STEM program in 2019, Jeff continued to serve the Office of Science and Technology Policy part-time for nine more months, helping to develop federal strategies that translate lofty STEM policies into practical, measurable and impactful federal agency programs. In his recently published memoir, Charting a Course for American Education (Torchflame Books, 2021), Jeff takes the reader along behind the scenes and between the lines on a twenty-one-month adventure imbued with personal and policy intrigue, illuminating the shadows of American education policy-setting at the heights of American government. Dr. Weld is on extended leave from a faculty position in the Department of Biology at the University of Northern Iowa, where he prepared future science teachers and naturalists, generating $7 million in external grants and publishing over 70 peer-reviewed research articles, essays, and book chapters on science education. He also published the landmark STEM book Creating a STEM Culture for Teaching and Learning (NSTA Press, 2017), and the textbook The Game of Science Education (Allyn & Bacon, 2004). In 2014, the Triangle Coalition bestowed upon Jeff the STEM Champion award, and in 2013 the University of Iowa recognized Weld with the College of Education's

Alumni Accomplishment Honor. In 2007 Jeff was named National Collegiate Biology Teacher of The Year for four-year institutions by the National Association of Biology Teachers. A decorated secondary science teacher through the 1990's, Jeff was the Ciba-Geigy Life Science Teacher of the Year in Iowa, Pella Corporation's Focus on Teaching Excellence award recipient, and a National Access Excellence Fellow of the Genentech Corporation. Dr. Weld earned his doctorate in Science Education, as well as Masters and Bachelors degrees at the University of Iowa. In his free time Jeff is an avid skier, writer, and restorer of vintage Honda motorcycles. Married thirty-five years to wife Mary, they have two grown sons David of Austin, TX., and Andrew of St. Paul, MN.

Abstract

Shortly after member states of the United Nations adopted Sustainable Development Goals in 2015, the Executive Office of the President of the United States set about developing a five-year STEM Education Strategic Plan, in 2018, through the Office of Science and Technology Policy. The most broad coalition of stakeholders ranging from business and industry, K-12 and higher education, nonprofit and out-of-school services, and policy organizations contributed to a consensus national plan, called Charting a Course for Success: America's Strategy for STEM Education. Spanning the years 2019 to 2023, the document weaves nine priorities for systemic impact, closely aligned with and supportive of the U.N. Sustainable Development Goals. Details will be shared.

DAY1(June 18th) 18:30~19:30

Learning for tomorrow: the role of school science

Dr. Myeong-Kyeong Shin

Professor
Science Education Department, Gyeongin National University of Education, Incheon, South Korea

=Education=

Ph.D. Science Education, 2000 The University of Iowa

MED. Science Education, 1993 Seoul National University, Korea

B.S. Science (Earth Science), 1991 Seoul National University, Korea

=Occupational Experience=

2006-present: Assistant and Associate Professor at Gyeongin National University of Education

2015-2017: Director of International Affairs Center of Gyeongin National University of Education

2013-2014: Visiting professor at Virginia Polytechnic Institute and State University

2005-2006: Research professor at the Kongju National University

2004-2005: Researcher at the Gifted Education Center of Cheongju National University of Education

2003-2004: Research staff for the research project of 'the Informal learning in Natural Science Museum'

1998-2003: Co-Director of Korean Science Teachers Workshop The University of Iowa Coordinator of Korean Science Teachers Workshop

1996-1997: Web-Design for Science Education Center, The University of Iowa

1999-2000: Administration Associate, Science Education Center, The University of Iowa

=Research Funds involved as a PI=

2017-2020: Proposing New Topology of School Science for 2040: Developing Convergent Science Activities Embodied with Computational Thinking Sponsored by National Research Foundation

2014-2016: Practical Work in School Science: from Epistemological Practice to Hermeneutical Understanding Sponsored by National Research Foundation

2013-2014: Exploring School Science Inquiry Norms as Disciplinary Inquiry through Comparative Analyses of Characteristics of Communicative Interactions Found in Science Classes of Korea and U.S.Sponsored by National Research

Dec-Jan, 2013: 'Designing future science classroom' Sponsored by Korea Foundation for the Advancement of Science and Creativity

2011-2013: 'Rebuilding the Scientific Inquiry Norm for Science Education on the Bases of Hermeneutical Study of 'Practical Work' Found in Science Classes' Sponsored by National Research Foundation

2012: 'A Study for the Development and Application of Global Curriculum towards Reinforced Science Education' Sponsored by Korean Ministry of Education

2011-2009: 'Building the Understanding Epistemological Practice of Practical Work in the Science Classes : Focusing on Multi-dimensional Analyses and Synthesis of Constructing Knowledge, Inquiry, and Interaction' Sponsored by National Research Foundation

2010: 'Developing a Cycling Model of Exhibit Materials for Science Museum' Sponsored by National Science Museum of Ministry of Education

2009: Analysis of Communicative Pattern in Best Earth Science Classes for Characterizing Earth Science Inquiry Sponsored by National Research Foundation

2008: Defining Discourse Patterns and Participant Structures Corroborated with Developing and Practicing Science Writing Heuristic Modules in Science Classrooms Sponsored by National Research Foundation

2007: 'Defining Socioscientific Norm Found in Science Class Discourse Analysis in the Context of Teacher Oriented Action Research' Sponsored by National Research Foundation

Abstract

Early 1974, Alvin Toffler edited a book titled 'Learning for tomorrow: the role of the future in education (Alvin Toffler, 1974)'. He started with the statement of 'Today's learners are being divorced from their own future selves'. He presumed that the 1960s was a decade of a high-change environment and criticized that the education of school had not responded to it properly.

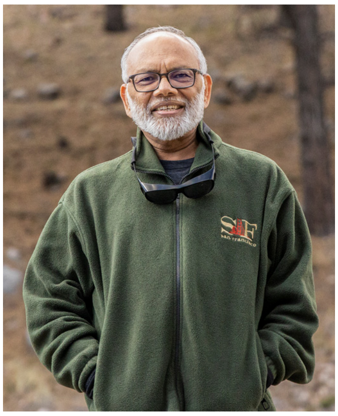
Almost fifty years after, we confront the similar situation than ever. Now all of us might face the much bigger and more complicated waves than that. More over, COVID 19 pandemic had made school environment shifted without discussion and reaching any consensus of what such changes mean to human development. It was vital that teachers become active in the integration of technology in teaching and learning. The study of 'Proposing New Topology of School Science for 2040: Developing Convergent Science Activities Embodied with Computational Thinking' had started with consideration of such context. During this three year research project, I analyzed STEM education and developed several convergent science activities focusing on computational thinking skills. The research started with developing highly technology-equipped lesson designs including works on defining what computational thinking means to future citizens.

At the end of three-year study, however, the research focus were moved to infusion of value education in school science by adopting problem solving approach and decision- making process for students.

I also propose the vision of the East-Asian Association for Science Education as a next president. New member countries of Indonesia and Thailand joined the constituent regions in 2021 and the association will jump to representative of the East-Asian Science Education covering seven regions. More members mean more collaboration, which the association would be ready for a big step forward. The association shall create real opportunities of discussing 'learning for future citizens' with looking beyond technology and moving toward inclusive, human-centered future. We could find ways to facilitate all the members' ability to positively impact their science classroom, school and communities.

DAY2(June 19th)
10:30～11:30

STEM and STEM Education: Collaboratively addressing global challenges of the 21st century



Dr. Pradeep Maxwell Dass

Walkup Distinguished Professor of Science Education
Director, Center for Science Teaching and Learning
Northern Arizona University, Flagstaff, Arizona, USA

Dr. Dass is the Walkup Distinguished Professor of science education at Northern Arizona University (NAU) in Flagstaff, Arizona, USA, where he also serves as the Director of the Center for Science Teaching and Learning. Dr. Dass spent the first 14 years of his career as a high school biology teacher in India, including 10 years at Woodstock (international) School. Since receiving his Ph.D. degree in science education from the University of Iowa in Iowa City, USA, in 1997, he has worked as a science education faculty member in three universities: Northeastern Illinois University, Chicago, Illinois; Appalachian State University, Boone, North Carolina; and Northern Arizona University, Flagstaff, Arizona. During his 24-year career as a university faculty, he has taught a variety of science education and biology courses, as well as worked extensively with in-service teachers in various professional development projects.

His research and scholarly interests span the full continuum of teacher professional learning including pre-service teacher preparation and in-service teacher professional development. He has investigated and written about approaches to teaching and learning that promote science education in the context of real-life situations, issues, problems and questions, such as the Science-Technology-Society approach (STS), and pedagogies, such as the Learning Cycle approach, that enable students to engage in and experience authentic scientific practices within K-16 educational contexts. He has conducted numerous workshops for both school teachers and college faculty to promote these pedagogies and help teachers and professors implement more active, student-centered, forms of instruction.

On the disciplinary side, he has investigated the impact of learning about the history and philosophy of science or of a specific science discipline (such as biology) on student understanding of the nature of the scientific enterprise. More recently, he has become involved in improving engineering education at the college level and is collaborating with engineering faculty at NAU in this effort.

He has provided leadership in STEM Education at the national level as the president of the UTeach STEM Education Association (USEA), at the state level as the president of the North Carolina Science Leadership Association (NCSLA), and regionally as the Regional Director of the Far West Region of the Association for Science Teacher Education (ASTE). He has over 60 publications including peer-reviewed articles, book chapters, commentaries, book reviews, and laboratory manuals (for college Introductory Biology courses), and has served on editorial review boards of several science education journals, both in the USA and internationally. Funded by both national and state level funding agencies, his research and scholarly activities continue to impact science teaching and learning in school classrooms across the USA and abroad. He has shared his work through 140 conference presentations, workshops, and institutes across the USA, India, and Japan.

Outside of his professional life, Dr. Dass is a musician. He plays the bass guitar in his church worship team. He has been married thirty years to his wife, Priya, who is a Clinical Exercise Physiologist and Certified Personal Trainer. They have two grown sons, Amaal and Nikhil, who are both avid musicians collaborating together on their own band and music production.

Abstract

"Quality Education for ALL" is the Sustainable Development Goal #4 of United Nations Department of Economic and Social Affairs. This goal calls for inclusive and equitable quality education and lifelong learning opportunities for all. A question that arises out of this goal is, what does quality education mean for the 21st century? The famous educationist and philosopher, John Dewey, said:

Education is not preparation for life; education is life itself. Education, therefore, is a process of living and not a preparation for future living.

If education is a process of living, then we must consider what that process means for the 21st century in terms of quality. Life, and therefore the process of living in the 21st century, faces many challenges and situations of a global nature. Hence, quality education for ALL becomes an imperative if we, as the world citizenry, are to live successfully in the 21st century. Effectively meeting the global challenges we face depends heavily on our understanding of and capability in the disciplines collectively referred to as STEM. Indeed, STEM has become a prerequisite for full and effective participation in the 21st century global society and economy. Thus, we cannot have quality education without including quality STEM Education.

Since many of the 21st century challenges require collaborative action in order to address and cope with them, and since many of them are heavily STEM-laden (such as global climate change, COVID19 pandemic, to name just a couple), this presentation will focus on the collaborative nature of and an imperative to collaborate in STEM and STEM Education. Specific examples of collaboration in STEM and in STEM Teacher Education will be shared, with the hope that some of these may be emulated between and among the professionals and institutions participating in East-Asian Association for Science Education.

DAY2(June 19th) 18:30～19:30	Current integrated STEM education initiatives in Southeast Asia

Dr. John Stiles

Senior STEM Specialist, Southeast Asia Ministers of Education Organization (SEAMEO) Regional STEM Education Centre, Bangkok

Dr. Stiles has experience as a secondary school science teacher in Thailand, Kuwait, Belgium, the U.S., and England and as a University faculty member in Teacher Education in the U.S. He has won teaching awards in conservation education and for excellence as a graduate teaching assistant and cited by the Beryl Buck Institute for exemplary use of technology in university teaching. He was previously a Science Education Specialist at the Institute for the Promotion of Teaching Science and Technology (IPST) in Bangkok and a regional science education consultant in the U.S. Author of 30 peer-reviewed articles and book chapters, he has 25 years of experience developing science education curricula and programs and presenting workshops and STEM and science education courses to teachers around the world. He has been editor of three scholastic journals and is the current editor of the *Southeast Asian Journal of STEM Education*, an International peer-reviewed online journal. He received his BA in Liberal Arts from Drake University and his MS and PhD in Science Education from the University of Iowa.

Abstract

STEM education continues to find its way into school curricula and inform policymakers everywhere in the world. While some countries have been implementing STEM education in their educational standards and policies for many years, several other countries lag far behind and are just now awakening to realize its power for learners and for the future of sustainable economic and environmental well-being. For example, after many years of steady progress and embrace by states and schools, in 2018 the United States released its first ever comprehensive strategic plan for STEM education. Conversely, some countries are still struggling with understanding what STEM education actually is and have no concrete plan for its inclusion, even though the evidence for implementing STEM education is overwhelming. This address will highlight the current initiatives in STEM education in Southeast Asia, most notably by the newly formed Regional STEM Education Centre in Bangkok, one of 26 centers overseen by the international governing board of the Southeast Asia Ministers of Education Organization (SEAMEO) with offices in all ten ASEAN (Association of Southeast Asian Nations) countries and Timor-Leste (East Timor).

DAY3(June 20th)
10:30～11:30

Toward a Common Understanding of STEM

Dr. Gillian Roehrig

Professor at the University of Minnesota
Former president of Association for Science Teacher Education
Next president of the National Association for Research in Science Education (NARST)

Dr. Roehrig is a professor of STEM Education at the University of Minnesota. Her research explores issues of professional development for K-12 science teachers, with a focus on implementation of integrated STEM learning environments and induction and mentoring of beginning secondary science teachers. Her work in integrated STEM explores teachers' conceptions and implementation of STEM, curriculum development, and student learning in small groups during STEM lessons. She has received over $30 million in federal and state grants and published over 100 peer-reviewed journal articles and book chapters. Through this work she has provided professional development opportunities for numerous teachers in Minnesota and across the world, including Djibouti, Egypt, Indonesia, Japan, Korea, and the United Arab Emirates. She has mentored 46 PhD students in STEM Education, who promote and support equitable STEM education across the world. She is a former board member and president-elect of NARST: A worldwide organization for improving science teaching and learning through research and former president of the Association for Science Teacher Education.

Abstract

Advocates of K-12 science, technology, engineering, and mathematics (STEM) education argue that teaching practices which integrate disciplinary STEM content can greatly improve student learning. Integrated STEM instruction can also better prepare students to address 21st century problems, such as climate change, health, and the environment, which are inherently interdisciplinary in nature. However, no one accepted definition of integrated STEM instruction exists, nor do researchers or educational practitioners agree on what integrated STEM looks like in practice, which greatly complicates the development of STEM education. This presentation shares conceptual and empirical research that addresses the need to develop a common vision for integrated STEM. There is agreement in the literature on some characteristics of integrated STEM instruction: (a) the inclusion of an authentic, real-world context, (b) explicit connections between science, technology, engineering, and mathematics, (c) an understanding of different STEM career pathways, (d) intentional development of 21st century competencies, and (e) an emphasis on student-centered pedagogies. However, these consensus characteristics are not defined in enough details to result in agreement on how to observe and evaluate integrated STEM teaching. To address this gap, we propose a new STEM Observation Protocol developed through the conceptual development of instrument items which were tested using over 2000 integrated STEM classroom videos.

DAY3(June 20th) 16:30～17:30	**What Kinds of STEM/STEAM Model does Work for the Real Situations in Japan and Asian Countries Comparing to the Western Countries within the Society 5.0**

Dr. Yoshisuke KUMANO

President, East-Asian Association for Science Education,
Professor Emeritus, Vice Director STEAM Education Institute, Shizuoka University, Japan
Director of NPO Shizuoka STEAM Education Development Center

＝Position＝

Professor Emeritus and Specially Appointed Professor, Shizuoka University (2021- present)
Vice Director of STEAM Education Institute, Shizuoka University (2021-present)
Director of STEAM Education Institute, Shizuoka University (2020-2021)
Professor of Science Education, Graduate School of Science & Technology (Ph.D. Program), Informatic Section, Graduate School of Education, Faculty of Education, Shizuoka University (from 2005-to 2021)
Visiting Scholar at the University of Iowa
(2012, September–2012 December, Fulbright Scholar)
Associate Professor of Science Education, Shizuoka University (1995-2005)
Lecturer of Science Education, Shizuoka University (1993-1995)
Meikei Hight School, Chair of Science Education (from1981 to 1989, from 1991 to 1993)

＝Education＝

1989-1993　The University of Iowa (Fulbright Program), Ph.D. (Science Education.)
1978-1980　The University of Tsukuba, MD. Science Education
1976-1977　Macalester College (Governmental Exchange Program) Geology
1974-1978　Miyagi University of Education, BS.（Geology)

＝Awards＝

The Best Paper of Japan Society for Science Education in 29th, July1996, from Japan Society for Science Education; Implementation of STS Instruction in Meikei High School - Problems and Realities of Pilot Japanese STS Approach -, The Journal of Science Education in Japan, 1993, Vol. 17, No. 3, 115-124.

The Prize for the Educational Research, The Researches on the Innovation of the Science Education and Earth Science for the Life-Long Learning and High Science and Technology Intensive Society, August 27th, 2008, Japan Association of Education Organization.

The Prize of the Minister of MEXT, the Section of Dissemination of Science and Technology, Dissemination and Promotion of Science & Technology and Conservation of Environment in the Local Setting and National Setting, April 13th, 2010.

Leading Researcher of Shizuoka University, From April 14th, 2011 to March 31th, 2013, selected only 22 researchers from all faculty members by the Selection Committee, Shizuoka University, and April 14, 2011.

The Best Paper of Japan Association of Energy & Environmental Education, The Energy and Environmental Learning using iPad software – Decision making program for high level radioactive waste storage -, Journal of Energy and Environmental Education, Vol.6, No.2, 3-10, August 17th, 2013.

Leading Researcher of Shizuoka University, Second Phase, From January 1st and 2nd, 2014 to March 31th, 2016, selected only 22 researchers from all faculty members by the Selection Committee, Shizuoka University, and December 25th, 2013- March 31st, 2016.

Research Fellow of Shizuoka University, Third Phase from April 1st, 2016 to 2019 March 31st extended up to 2021, March 31.

＝Professional Activities＝

◆President (2018-2021), Vice President (2013-2017), East-Asian Association for Science Education.

◆Vice President (2018-2020), Executive member of the Society of Japan Science Teaching (2013-2017)

◆Vice President (2010-2013), Auditor of the Japan Society for Science Education (2013-2016).

◆Vice Chair (2007-2010), Executive Committee Member for Science Education, National Curriculum Standards Development Committee in Japan (Middle School Science).

◆Associate Editor (2019-present), International reviewer, International Committee Member, Association for Science Teacher Education, (USA) (2006-2021)

◆International Judge for International Earth Science Olympiad (2002-present)

◆Executive board member and auditor (2012-present), Japan Earth Science Olympiad Committee

◆JICA Specialist and Expert; Development of Science and Mathematics Teaching for Primary and. Secondary Education in Indonesia (IMSTEP) (1998-2008).

◆ Adviser (2017-present), President (2011-2017), Japan Association of Energy and Environmental Education

◆President of the Association of the Shizuoka Earth Science Education (2017- present)

◆Associate Editor, "K-12 STEM Education", The Institute for the Promotion of Teaching Science and Technology (IPST), Thailand (2014-presnet)

◆Author of science textbooks for elementary & secondary schools, Dainippon-Tosho from 2000-Present that one-third of children has been using our science textbooks in Japan.

◆Director for Science Festival in Ru/Ku/Ru, No.1-24 Shizuoka Youth Science Festival (1997-2020)

○Recent Publications (Major Papers from 28 edited book chapters and 74 edited papers)

○Invited Presentation and Presentation (out of 257 presentations)

Abstract

At first part of my speech is the greeting and appreciation of one great researcher whose name is Professor Emeritus, Dr. Robert Yager (1930 - 2019) who has just passed away on August 6th, 2019. The main reasons why I want to talk about him are (1) he was one of the founder in researches in science education in the US, (2) he took care international Ph.D. candidates from all over the world especially from the Asian countries. From Japan, we have only two people who got Ph.D. from him and many visiting scholars from Japan. There are many researchers in Korea, Taiwan, Thailand, Indonesia, Malaysia, and so on. Kumano, myself and new president, Prof. Myeong-kyeong SHIN are among the two of them. Is this coincident? Dr. Yager took care of us exactly same way whatever any culture, any religion, any country. All of the graduates like him and trust him so well. We would like to be the researcher just like him. I would like to express my greatest sincere to him and his education to us.

Two decades have already been passing in the 21st century. Second part of my talk focuses on the contexts of STEM/STEAM learning in Japan. Japan is currently the third largest economy in the world, and it has been found that major dynamic "learning" changes have been developing in Japan. The fundamental contexts are briefly explained in terms of the STEM/STEAM area in relation to the National Defense Education Act of 1960 in the United States. For more than 50 years, our focus had been controlled by the national examination. Many changes and developments have occurred in STEM/STEAM learning, especially between 2016 and 2021. These changes are described with reference to several contexts, including the drive to promote 21st-century skills or competencies. The governmental level, such as the Ministry of Economy, Trade and Industry (METI) and the Ministry of Education, Culture, Sports, Science and Technology (MEXT) in Japan developed unique education policies. Then, the Japanese prefectural government and independent city government have engaged in the local actions connected to STEM/STEAM learning. As one of the exemplary trial, "Shizuoka STEM Academy" is described as an action research. The author predicts that there will be country-wide development of systemic reform in Japan. However, communication of leaders and team members at each school, institution, university, and company, as well as local and national policymakers, will be an essential and fundamental component in this development. Especially, systemic reform funding is needed to move toward a 'Society 5.0'.

Oral Session 1

Day1 (June18th) 14：30～16：00

Room1	C3-1	Science Education for Middle or Secondary School and Related Areas
Room2	C3-2	Science Education for Middle or Secondary School and Related Areas
Room3	C3-3	Science Education for Middle or Secondary School and Related Areas
Room4	C4-1	Science Education for High School and Related Areas
Room5	C5-1	Science Education for Undergraduate or Graduate School Students

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Oral Session 1	Day1 (June18th) 14：30～16：00
Room1	C3-1
【Category】	3: Science Education for Middle or Secondary School and Related Areas

=Chairperson=

Prof. Indarini	Universitas Pakuan

=Presentation Program=

1	1-3-1-18-1（FY1M-GYS3-UW021） James Green（Chosun University） Young-Shin Park *EXPLORING THE DEVELOPMENT OF COMPUTATIONAL THINKING PRACTICE GUIDELINES AND THEIR IMPLICATION AND APPLICABILITY IN STEAM LESSONS*
2	2-3-1-18-2（FY2V-F49U-EQ021） Indarini Dwi Pursitasari（Universitas Pakuan） Annisa Nurramadhani *Science Context-Based Inquiry Learning Model: Feasibility Study to Develop Students' Critical Thinking Skills and Science Literacy*
3	3-3-1-18-3（FXIH-KU7F-FO021） Wai Wai Kyi（Hiroshima University） Tetsuo Isozaki *Comparison of Science Education in Myanmar and Japan: Objectives and Contents Covered in Secondary School Science Curricula*
4	4-3-1-18-4（FY3F-FOFJ-VR021） Nanda Syah Putra（Universitas Pendidikan Indonesia） Anna Permanasari *School Community Perspective On Environmental Literacy*

EXPLORING THE DEVELOPMENT OF COMPUTATIONAL THINKING PRACTICE GUIDELINES AND THEIR IMPLICATION AND APPLICABILITY IN STEAM LESSONS

James Green[1] and Young-Shin Park[2]

1. *Chosun University, Gwangju, South Korea*
2. *Chosun University, Gwangju, South Korea*

Abstract

Computational thinking is not a new term, but it is a moderately new concept for science education. This research was a journey of self-study for the researcher from having little working knowledge of computational thinking (CT) to being an expert and able to design and develop courses designed around CT. The aim of the research is that teachers could use it as a guide on their own journey to increase their knowledge of CT and how to apply it is their classroom. The first step was to see what kinds of CT practices can be found in STEAM programs and what description of CT in STEAM can be illustrated and whether a difference can illustrated between science focused and engineering focused STEAM programs. The STEAM programs were analyzed with the researcher's CT_AT tool. For the second step the researcher took the analyzed STEAM programs and recommended additional or adapted activities so that students would be exposed to a wider range of CT practices. The third step involved the researcher devising their own STEAM module, created from the ground up, with the aim of exposing the students to CT practices. After completion of the design phase the program was analyzed under the same process the ten STEAM programs were analyzed for the first step. For the fourth step the researcher asked two student teachers to use the CT_AT to analyze two STEAM modules.

Keywords: *computational thinking, STEAM, science education, self-study*

A SELF-STUDY JOURNEY OF COMPUTATIONAL THINKING DISCOVERY

This research was a journey of self-study for the researcher from having little working knowledge of computational thinking (CT) to being an expert and able to design and develop courses designed around CT. The aim of the research is that teachers could use it as a guide on their own journey to increase their knowledge of CT and how to apply it is their classroom. The self-study journey went through the literature review and putting ideas into practice by analyzing STEAM programs, suggesting enhancements to revitalize CT practice in those STEAM programs, and developing a module with an emphasis on CT, the researcher changed and their knowledge grew. It is hoped that teachers can use this dissertation as part of their professional development and follow the researcher's journey from CT novice to CT expert.

The research was done to answer four research questions. First, what kinds of computational thinking (CT) practices can be found in STEAM programs and what description of CT in STEAM can be illustrated and whether a difference can illustrated between science focused and engineering focused STEAM programs. The second research question was what additional or extended CT practices can be suggested to revitalize STEAM? The third research question was what difficulties were encountered when developing a new STEAM module from the viewpoint of exposing the students to CT practices? Finally, the fourth research question was from the experience gathered during the self-study how can the researcher develop a professional development program to aid pre-service and in-service teachers' in their own journey to study computational thinking?

For the first research question STEAM programs were analyzed with the researcher's CT_AT tool. The results of the analysis revealed that the found practices are distributed evenly between the three major categories of Data Practice (DP), Modeling and Simulation Practice (MS), and Computational Problem Solving Practice (PS). The research shows that the STEAM discipline does not determine what CT practices the students will be exposed to, but rather the activities created for the program.

To answer the second research question the researcher took the STEAM programs analyzed for research question 1 and recommended additional or adapted activities so that the students would be exposed to a wider range of CT practices. The researcher was able to propose an additional or modified activity for each module. These additional or modified activities introduced weakly exposed or missing practices. The ability to do this for each module without fail shows that it is possible for teachers and course creators to take existing programs and adapt them to include any CT practices that they require.

To answer the third research question the researcher devised their own STEAM module, created from the ground up, with the aim of exposing the students to CT practices. After completion of the design phase the program was analyzed under the same process the ten STEAM programs were analyzed for research question 1. The designed program was successful in demonstrating the feasibility for teachers and course content creators to produce STEAM programs from a CT viewpoint.

To answer the fourth research question the researcher asked two students to use the CT_AT to analyze two STEAM modules. The first stage was the students analyzing the modules with minimal input from the researcher. After each analysis the researcher and students met and discussions were had to reach a consensus of opinion on the CT practices. These discussions were very useful for both the researcher and the students to further their knowledge of CT and some good suggestions were made about how the CT_AT could be improved. It is hoped that the CT_AT could in the future be used as part of a professional development program.

SCIENCE CONTEXT-BASED INQUIRY LEARNING MODEL: FEASIBILITY STUDY TO DEVELOP STUDENTS' CRITICAL THINKING SKILLS AND SCIENCE LITERACY

Indarini Dwi Pursitasari[1], Annisa Nurramadhani[2]

[1]*Unversitas Pakuan,Bogor,Indonesia*

ABSTRACT
Science Context-Based Inquiry Learning (SCOIL) is a learning model that involves students through investigation and problem-solving. The purpose of this research is to develop SCOIL learning model and make a feasibility study to develop students' critical thinking, and science literacy. The method that is used in this research is descriptive by collecting teacher's opinion in FGD forum to make a judgment and advises based on that learning model design after it is tested in one of middle school in Bogor. Data collecting which is used in this research is questionnaire from 18 middle schools' teacher in Bogor. The judgment results are made quantitative, so that they were categorized to gain feasibility criteria of the learning model. The research result of this study is a draft SCOIL model that has been developed has five stages, namely Observation, Investigation, Representation, Conclusion, and Communication. Based on its stages, it is figuring out that the learning model can facilitate the students to improve their science literacy and critical thinking skills. A feasibility study expels the results 3,51. It can be concluded that SCOIL learning model is able to implemented in science learning.

***Keywords**: Science Context, Inquiry Learning Model, Critical Thinking Skills, Science Literacy*

INTRODUCTION

Science education in 21st century era has high demanding to develop students' critical thinking and problem-solving skills, creative thinking skills and innovation, communication, and also collaboration as it called Higher Order Thinking Skills (HOTs) in order to students are able to compete in this global society era (Erdogan, 2019; Zohar and Dori, 2003). Science education are implemented with integrated, holistic and contextual ways especially in middle school (Rubini., et.al, 2016), so that students are able to improve their experience in their daily life through the concept that they have already had in classroom. Science teaching learning process can trigger a critical thinking skill which provide students a chance to seek any information, asking a question, and leads to curiosity. Besides that, science literacy of students is also important to develop. It is to know their knowledge about science, how the use of science in different context, and relation with scientific ways of thinking or rational thinking. Students are not only making their decision based on their only experiences or personal interest, neither information of others belief (Osborne & Dillon, 2008; Harlen, 2010; ICSU, 2011;), but based on the data and fact. Both of them are the major component of science education, especially in middle school to make students think and responsible in their action at the society (Vieira and Tenreiro-Vieira, 2014).

The preliminary results based on Pursitasari, et.al. (2020) said that students' critical thinking skills in Bogor were still low which are 46,3 for average. Those are caused teacher cantered learning, then students cannot explore the content by themselves and less experiment that implemented in daily life. So that, this research is conducted to develop students' critical thinking skills and science literacy by developing Science Context-Based Inquiry Learning (SCOIL) learning model.

METHOD

The method that is used in this research is descriptive by collecting teacher's opinion in FGD forum to make a judgment and advises based on that learning model design after it is tested in one of middle school in Bogor. Data collecting which is used in this research is questionnaire from 18 middle schools' teacher in Bogor. There are 10 judgment categories by likert scale (1-5), for instance: Model rational, Purposes, Benefits, Model description, The relationship between model and science literacy aspect, The relationship between model and critical thinking skills, evaluation, and follow-up. The judgment results are made quantitative, so that they were categorized to gain feasibility criteria of the learning model.

RESULT AND DISCUSSION

Science Context-Based Inquiry Learning (SCOIL) learning model has already tested in one of middle school in Bogor with the steps: Observation, Investigation, Representation, Conclusion, and Communication. Eighteen science teachers gave the appraisal and discuss in FGD forum. The results of FGD forum can be shown on Figure 1.

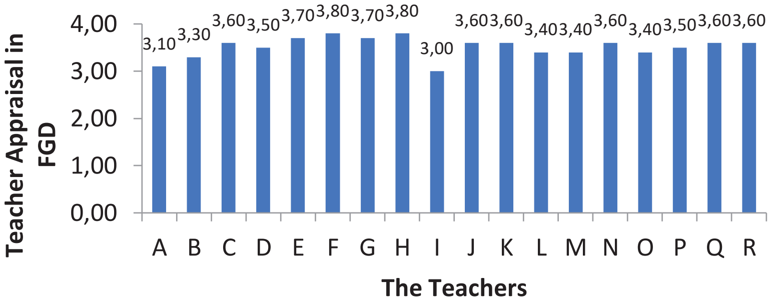

Figure 1. Teacher Appraisal in FGD Forum

The average results of teacher's appraisal in FGD forum are 3,51 means that this learning model in very appropriate category with some advises it is necessary to emphasize the stages in science literacy, it is needed time management when implement this learning model, need teacher training for Higher Order Thinking Skills (HOTs) before implementing this learning model, and this learning model which is initiated by contextual problem make students easy to comprehend the topic. The tested results of students' critical thinking skills by using SCOIL learning model are in middle category. That is the reason that before it is disseminated, it should be judged by the teachers in FGD forum.

CONCLUSION

It can be concluded that Science Context-Based Inquiry Learning (SCOIL) learning model is appropriate with the component and the aspect learning model judgement and able to develop students critical thinking and science literacy, and also it is able to implemented in science learning.

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COMPARISON OF SCIENCE EDUCATION IN MYANMAR AND JAPAN: OBJECTIVES AND CONTENTS COVERED IN SECONDARY SCHOOL SCIENCE CURRICULA

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2. Graduate School of Humanities and Social Sciences, Hiroshima University, Japan

ABSTRACT

This study aims to compare the lower secondary science curricula in Myanmar and Japan regarding similarities and differences in the following aspects: science curricula's objectives, and textbooks' contents and organization. Japan is among the top performing countries in educational achievement in international comparisons such as Trends in International Mathematics and Science Study (TIMSS) and the Programme for International Student Assessment (PISA). Thus, in Japan, the education system can evidently be defined as the best practice. Conversely, Myanmar is a developing country whose education system is in its infancy state. Myanmar has been reforming its education system for the improvement of educational standards. This study examines two science curricula and textbooks in Myanmar and Japan. We found that the science objectives are to help students learn and think independently, and to explore the scientific knowledge on their own. Contents in the textbooks are purposefully and carefully selected to best implement the curriculum standards.

Keywords: *Science Curricula, Objectives, Contents.*

RESEARCH QUESTIONS

- How can lower secondary science curricula's objectives, science textbooks' contents and organizations in Myanmar and Japan be compared?

RESEARCH METHOD

This study mainly employs document analysis to systematically review and evaluate documents. To uncover the science curricula of Myanmar and Japan, policy and curriculum documents, teaching materials, and textbooks are carefully examined and analyzed. Finally, the results are compared.

RESULTS

Comparing Objectives

In Myanmar, science curriculum's objectives are to: understand the basic concepts of science and learn and think scientifically; develop scientific skills and apply them in everyday life; know the successful works of scientists and increase the motivation; conduct scientific experiments; understand and value the environment and human body and scientific and technological inventions and findings; and increase the interest and inquiry into science. In Japan, the objectives are to: deepen the understanding of natural things and phenomena and explore scientifically; acquire basic skills related to knowledge and experiments; develop the ability to explore scientifically by observing and experimenting; and to foster an attitude of being willing to engage in natural things and phenomena and exploring them scientifically.

Comparing Science Curricula: Contents and Organization

In both countries, we found that science is taught as general science and also includes: physical science, chemical science, biological science, and earth science. In both systems, the science curriculum is highly coherent and arranged logically—it is spiral in nature with each topic developed carefully and in great detail and presented clearly and straightforwardly. In both contexts, science is the compulsory subject at all levels—from elementary to junior high school, G1 to G9 in Myanmar and G3 to G9 in Japan. Mother tongue (Myanmar language and Japanese) is used as the language of instruction in teaching science; this enables students to express their ideas and opinions easily and ask questions conveniently. In Myanmar, the same topic in each field is taught in every grade, while in Japan, different topics in each field are taught in each grade. In the physical science field, force and forms of energy are taught in Grades 6 and 7, and similar organization of topic of other fields was also found. In Japan's science curriculum, the subject is organized by introducing different topics in each field in each grade: for instance, in physical science, light and sound, electric currents, and motion and energy are taught in Grades 7, 8, and 9, respectively.

Comparing Science Textbooks

In Japan, textbooks are based on the course of study, as prescribed by the Ministry of Education, Culture, Sports, Science, and Technology (MEXT), and published by private companies after being authorized by MEXT; this is done to maintain the minimum level of requirement equally throughout the country. In Myanmar, the Ministry of Education (MOE) selects the contents and activities, which are based on the national curriculum standards, and prescribed in the national textbook. The difference in Myanmar's and Japan's textbooks was found in the use of some technical terms (eg. phenomena of light, convex mirror) in English along with Myanmar language in Myanmar's science textbooks while in Japan's science textbooks only Japanese is used. This is because, in Myanmar, after junior high school, from senior high school till university, students have to learn science subjects (physics, chemistry, and biology) in English. In both countries, science practical works are considered to be important parts of learning process. The textbooks contain comprehensive and step-by-step explanations and review and reflection activities; the latter are arranged in a way that allows students to explore them effectively and efficiently.

Conclusion

We concluded that the two science curricula are designed to train students and help them cultivate scientific knowledge, attitudes, and skills they need in the 21st century, so that students can apply their learning in their everyday life. Our findings reveal that the education systems of Myanmar and Japan are unique, given the contextual variations in economy, social status, culture, and human resources.

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SCHOOL COMMUNITY PERSPECTIVE ON ENVIRONMENTAL LITERACY

Nanda Syah Putra[1], Anna Permanasari[2]

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2. Universitas Pendidikan Indonesia, Bandung, Indonesia

ABSTRACT
The research aims to reveal the school community perspective on environmental literacy skills. The research samples were taken from a combination of students, teachers and employees working at the school called the school community. The number of samples in this study was 53 people. This research was conducted by disseminating a likert scale questionnaire consisting of 6 question parts with the total number of question items is 23. The analysis was conducted based on 6 main parts of questions about environmental literacy perspectives, namely people's perspectives on environmental literacy knowledge, perspectives on the importance of environmental literacy, perspectives on the benefits of environmental literacy, perspective on environmental literacy practice, perspectives on environmental literacy information, and perspectives on environmental expectations. Calculation of general tendency of respondents' scores based on average calculation (Weight Means Score). The results found that the school community perspective scores in the 6 main parts of the questions were 3.16, 3.36, 3.48, 3.28, 3.26 and 3.31 respectively. It is generally said that the school community shows a positive response in the perspective of environmental literacy.

Keywords: *School Community*, *School Community Perspective, Environmental Literacy*

INTRODUCTION AND METHODOLOGY

Seeing the complex environmental problems, public understanding of the environment and related issues must be instilled immediately (Disinger & Roth, 2000). Sukarto (2017) stated that by knowing the importance of character to care about the environment, it is very important to include this environmental education into formal education. The importance of environmental education is that to make people understand and be able to find solutions of environmental problems (Bonnett, 2010). The achievement of environmental education programs is to create a school community that has environmental literacy skills. Environmental literacy demonstrates people's knowledge of human interaction with the environment, knowledge of environmental issues (Burchett, 2015) and human role in safeguarding nature. The change of character owned by people who have environmental literacy skills is to have awareness to improve environmental problems (Wong & Chan, 2018). Therefore, Desfandi et al. (2017) stated that there needs to be a serious effort between all components including school residents to form students who have ecological/environmental literacy.

Then, people's perspective on environmental literacy will certainly affect the environmental literacy skills possessed by the person. The research aims to reveal the school community perspective on environmental literacy skills. Interpretation criteria of perspective scores can be seen in table 1.

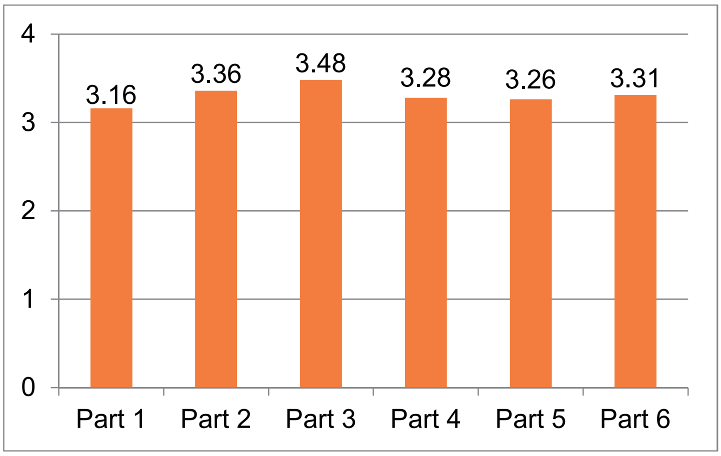
Table 1. Score Interpretation

Criteria	Interval
Strongly Agree	3.25 - 4
Agree	2.5 - 3.24
Disagree	1,75 - 2.49
Strongly Disagree	1 – 1.74

RESULT AND DISCUSSION

The analysis was conducted based on 6 main parts of the question about environmental literacy perspective namely the community's perspective on environmental literacy knowledge (part 1), perspective on the importance of environmental literacy (part 2), perspective on the benefits of environmental literacy (part 3), perspective on environmental literacy practice (part 4), perspective on environmental literacy information (part 5), and perspective on environmental expectations (part 6). The school community perspective scores in the 6 parts of the question were 3.16 (part 1), 3.36 (part 2), 3.48 (part 3), 3.28 (part 4), 3.26 (part 5) and 3.31 (part 6). For more detail information can be seen in figure 1.

Figure 1. Perspectives Scores on Environmental Literacy



The interpretation of perspective scores obtained by students are Agree (Part 1), Strongly Agree (Part 2), Strongly Agree (Part 3), Strongly Agree (Part 4), Strongly Agree (Part 5), Strongly Agree (Part 6). It is concluded that the school community shows a positive response in the perspective of environmental literacy. This positive response means that the school community supports the implementation of activities in improving environmental literacy skills. Then at least can be confirmed in this study that the school community has a good understanding of the concept of environmental literacy, aware of the benefits and importance of environmental literacy and practicing environmental literacy behavior in daily life.

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Oral Session 1	Day1 (June18th) 14：30～16：00
Room2	C3-2
【Category】	3: Science Education for Middle or Secondary School and Related Areas

=Chairperson=

Mr. Ari Syahidul Shidiq	Universitas Pendidikan Indonesia

=Presentation Program=

1	5-3-2-18-1（FXBN-Z4ZI-K4021） Nobuyuki KAWAI（Kobe Municipal Junior High School） *A NEW EXPERIMENT TO CHANGE NAÏVE CONCEPTIONS AS “ MOTION IMPLIES A FORCE ” INTO SCIENTIFIC CONCEPTIONS*
2	6-3-2-18-2（FXE1-AE2C-SV021） Rogelio Bañares Lacorte, Jr.（PHINMA University of Iloilo） Ryugo Oshima, Haruno Iwasaki *Japan’s Lower Secondary School Science Practices: A Filipino Science Teacher’s Viewpoints*
3	7-3-2-18-3（FY1J-G200-QB021） Shang Lingling（Northwest Normal University） Hu Shengli *Constructing scientific explanations through DPIE: an exploratory study that supports students in constructing causal explanations*
4	8-3-2-18-4（FXIH-5U39-XQ021） Kousuke SHIMADA（Hiroshima University） Tetsuo ISOZAKI *The newly revised Course of Study for secondary schools and the Nature of Science in Japan*

A NEW EXPERIMENT TO CHANGE NAÏVE CONCEPTIONS AS " MOTION IMPLIES A FORCE " INTO SCIENTIFIC CONCEPTIONS

Author Nobuyuki KAWAI

Kobe Municipal Ibukidai Lower Secondary School , JAPAN

ABSTRACT

The purpose of this study is to evaluate that the new experimental device based on "The Principles of a force" is effective in understanding both "the conception of an inertia" and "the conception of a force and a motion". It is known that most students have naïve conceptions after studying about a force and a motion at school. One is that the object moving at equal velocity implies a force to the same direction, and another is that the object doesn't increase its speed even if it is continued to add the force. For these subjects, I predicted that they were solved using "The principles of a force" developed from "The principles of the statics" written by Simon Stevin. The principles of a force are "The motion doesn't change" equals "Resultant Force=0" and vice versa. This "change" means the change of the speed and the direction. I thought that the principles of a force make all students can understand "the principles of an inertia" and "the principles of a force and a motion". For its purpose, I developed the new experiment device. After I demonstrated the experiments to them, they were asked two questions about "the conceptions of an inertia" and "the conceptions of a force and a motion". They answered them more correctly than the other students without having the experiment. The number of correct answers was significantly different between the experimental group and the control group by Fisher's exact test. These results indicated that the experiment would be effective in changing naïve conceptions as "Motion Implies a Force" into scientific conceptions.

Keywords: *New Experiment, Principles of a force, Naïve Conceptions, Inertia, Force and Motion.*

INTRODUCTION

It is known that most students have naïve conceptions after studying about a force and a motion at school. One problem is that the car moving at equal velocity, implies a force to the same direction, and another is that the cart does not increase its speed even if it is continued to add the force.

In my preceding research, I asked the students for the Question 1 and 2 (Fig.1&2). To Q.1, 70% students chose "③" that the forward force was bigger than reverse one though the car ran at a constant velocity. Also to Q.2, 83% students chose "①" or "②" that the cart ran at a constant velocity (Table 1). And 65% students chose the wrong to both.

For these problems, I predicted that they were solved using "the principles of a force" developed from "the principles of the statics" written by Simon Stevin(Table 2). The principles of a force are "The motion does not change" equals "Resultant Force ＝ 0 " and vice versa. This "change" means the change of

Question 1: Which force was bigger, forward or reverse, when the car ran at a constant velocity?

A : Forward force / B : Reverse force

① A＜B
② A＝B
③ A＞B

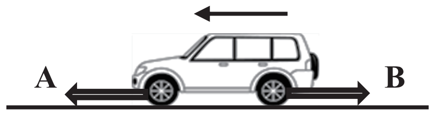

Figure 1: Question 1 about an Inertia

Question 2: What happens to the speed of the cart when you continue pulling the cart by same power without the friction with the floor?

① It runs with the constant speed all the time.
② It runs fast in the beginning, It runs in the constant speed immediately.
③ It becomes faster.

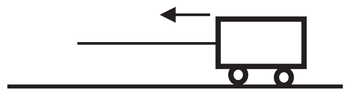

Figure 2: Question 2 about a Force and an Acceleration

Table 1: The answer to Q.1 and Q.2(Kawai2021)

Question 1	②	②	●	●
Question 2	③	●	③	●
% student	12	18	5	65

○: correct, ●: wrong, n=57

the speed and the moving direction. As Table 2 indicates, I thought that the four conditions solve "Q.1 and Q.2", and that all students could understand "the principles of an inertia" and "the principles of a force and a motion". For this purpose, I developed the new experiment device using which we can try four conditions.

Table 2: The principles of force (Kawakatsu 1992)

	Initial Velocity = 0	Initial Velocity ≠ 0
Resultant Force＝0	Statics Resultant Force＝ 0 ⇔ Do not begin to move Inertial Law in the initial velocity 0	Dynamics Resultant Force＝0 ⇔ Do not accelerate / Decelerate Inertial Law
Resultant Force≠0	Dynamics Resultant Force≠0 ⇔ Begin to move Law of Motion in the initial velocity 0	Dynamics Resultant Force≠0 ⇔ Accelerate / Decelerate Law of Motion
Conception to form	Conception of the Force is formed by the principles of a Force in the initial velocity 0.	Law of Force and Motion develops based on the conception of the Force.

OBJECTIVES

The purpose of this study is to evaluate whether the new experimental device based on "The principles of a force" is effective in understanding both "the conceptions of an inertia" and "the conceptions of a force and a motion".

THE DEVELOPMENT OF THE EXPERIMENTAL DEVICE

My experiment was made using the balance of the force by both side weights. One thread tied to the weight going over the pulley, attached to the right side of the object, and another attached to the left side. Three speedometers over the thread, indicated the speed and acceleration/deceleration of the object. This apparatus was used to control the motion and acceleration of the object by both weights.

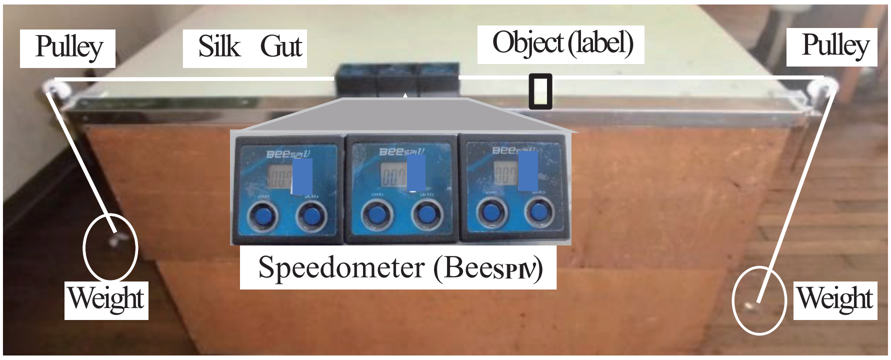

Figure 3 The Experimental Device

RESULTS

Before the experiment, the 22 Lower Secondary school students predicted the motion of the object in four conditions (Table 2). And after I demonstrated the experiments to them, they were asked Question 1 and Question 2. As I showed the results in the Table 3, they answered it more correctly than the other students without having the experiment. The number of correct answers was significantly different between the experimental group and the control group by Fisher's exact test.

CONCLUSION

These results indicated that the experiment would be effective in understanding both "the conceptions of an inertia" and "the conceptions of a force and a motion".

Table 3: The answer to Q. 1 and Q. 2

	% correct Control Group n=32	% correct Experimental Group n=22	
Question 1	28.1	72.7	**
Question 2	25.0	86.4	**

**p＜.01

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JAPAN'S LOWER SECONDARY SCHOOL SCIENCE PRACTICES: A FILIPINO SCIENCE TEACHER'S VIEWPOINTS

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ABSTRACT
This paper explores the different facets of science education in a public lower secondary school in Japan to provide insights into the current practices in schools in Japan and to other countries that aim to improve the quality of science education. Particularly, this paper explains a foreign science teacher's perceptions based on the observations during the immersion and the data gathered from the students' perspectives (N=205) regarding their science classes using a questionnaire. Emphasis on knowledge content and procedural skills through inquiry-based activities are core to the science classes in Japan. Adaptive learning through the provisions of academic support from the teachers, as well as from afterschool learning platforms, enhances science education making students more motivated and interested in their science classes. Evidences of high levels of self-regulation among students were also observed. While students enjoy freedom in some stages of inquiry, they believe that they do not have perfect autonomy in finding their own problems to solve and in designing their own procedures as they perceived they are required to simply follow the "recipe type" experiments. Inclusion of activities that allow students to find their own problems, investigate and design their own procedures to solve these problems is advocated. Moreover, promotion of real-life science education and the use of e-learning and ICT in science classes are areas that have greater potentials for improvement and advancements most especially in the modern and globalized world.

Keywords: *science education, inquiry-based learning, lower secondary schools.*

RESEARCH BACKGROUND

Science is one of the key subjects in all school curricula due to the knowledge and skills it aims to impart and develop among learners. In this modern time, the role of science education becomes even more relevant since it is considered to be the agent of change and the key to the future. Japan's science education is considered to be among the best in the world. TIMMS and PISA results showed that Japanese students are among the best performing internationally (Kimura and Tatsuno, GiFT,2017). The case in the Philippines, however, is different. The most recent PISA results revealed that Filipino students scored an average of 357 (level 1a) in Science which is way below the average of participating OECD countries which is 489 (level 3) (PISA 2018 Philippine National Report).

RESEARCH METHODOLOGY

The research incorporated both the qualitative and quantitative research methodologies. It included 2 science teachers and 205 students from grade 7 to grade 9 (Grades 1 to 3). It employed unobtrusive classroom observations, interviews, and researcher-made questionnaires for the students. Qualitative observations from the classes were utilized to formulate substantial and meaningful interpretations and conclusions. Frequency count, mean, rank, t-test, and One-way ANOVA were used to analyze the quantitative data from the questionnaire administered.

RESEARCH RESULTS AND DISCUSSIONS

Japan's science education is focused on transferring both skills and knowledge particularly on procedural and epistemic knowledge as evident on the activities done in the science classes. This is evident on the kind of activities commonly done in science classes as shown in Table 1.

Table 1. Mean scores and rank of the activities/strategies frequently used by the science teachers as perceived by the students

Activity	Mean
Group Experiment/Observation	3.79
Group Discussions	3.72
Practice Problems	2.90
Homework	2.63
Lecture	2.61

The conduct of group experiments/observations and group discussions oftentimes focuses on the acquisition and/or application of scientific knowledge and skills while the conduct of practice problems, giving of homework, and lectures provide opportunities to strengthen the skills and knowledge learned by the students. In the conduct of drills or practice problems, the teachers always make sure that they are available to check on the students' answers. Immediate feedback is given by the teacher to the students' outputs. Also, the use of inquiry-based teaching and incorporation of real-world science in the classroom are observed in the science classes. Students enjoy freedom in some parts of the inquiry process particularly in the formulation of hypothesis, inferences, and interpretation of results based on the data they gathered. However, they do not have the autonomy to find their own problems to solve nor they have the freedom to design their own procedures, as most of the time, they are asked to simply follow "recipe type" experiments. Promotion of the use technology in the science classes for enrichment and research purposes needs to be advanced as well since students appear to be apprehensive on using the technology in their science classes. Despite these, the motivation on learning science remains to be high among students with sex and age being the factors influencing it. Majority of the students also attend afterschool learning platforms (i.e. cram schools, tutorial centers), and most of whom take science classes. Having routines, seeking for assistance from classmates and teachers, taking responsibilities for their own learning, organizing, and developing personal memory strategies are evidences of high levels of self-regulation that were observed from the students.

CONCLUSIONS

From the research, it can be drawn that the viewed success of science education in the lower secondary school is grounded on the strong foundation on self-management, particularly on discipline and control of the students coupled with the support of the teachers by providing interesting and varied learning opportunities and activities for the students geared towards the realization of goals and standards. Despite the many tasks such as administrative tasks, dealing with parents, and taking responsibility for students' achievements (OECD, 2020), teachers remain dedicated and passionate about delivering the results expected of them.

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Acknowledgment

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CONSTRUCTING SCIENTIFIC EXPLANATIONS THROUGH DPIE: AN EXPLORATORY STUDY THAT SUPPORTS STUDENTS IN CONSTRUCTING CAUSAL EXPLANATIONS

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ABSTRACT

This paper reports on the design and testing of instructional strategies designed to support students in constructing causal explanations. Through the research of philosophy of science, microscopic painting representation and ODIE teaching strategy (Andrade et al., 2018), a teaching strategy named Description - Painting - Interpretation - Explanation (DPIE) has been conceptualized in junior science classes. In order to test the effect of DPIE teaching strategies on students' causal interpretation, a nine-lesson course based on DPIE teaching strategies was developed. Forty-two students in Grade 9 were selected as subjects. One-group pretest-posttest test design was adopted to collect students' drawing and scientific interpretation data through two semi-structured questions. Use focus group discussions to gather students' views on DPIE teaching strategies. The results show that DPIE strategy can significantly improve students' ability of causal interpretation and microscopic particle painting representation. There is a positive correlation between students' drawing level and their causal interpretation level. Students' level of causal interpretation is easily influenced by their macroscopic material learning experience. Finally, we reflect on and discuss the enlightenment of science education.

Keywords:*Scientific explanation;Causal explanation;DPIE strategy;Microscopic characterization;Painting representation*

Science is committed to understanding and explaining the natural world, and the goal of science education is to disseminate scientific knowledge to science beginners and non-scientists (Treagust & Harrison, 2000).One of the most important purposes of science is to try to explain what is happening in the world around us (Okasha, 2002).The New Science Education Standards require junior high school students to explain the properties of matter we see and feel in terms of interactions at the atomic and molecular level. Drawing in science class has many benefits (Ainsworth et al., 2011), and the relationship between painting and interpretation has also been explored by some scholars (Cooper & Stieff, 2017;Andrade et al., 2018).In order to explore this relationship, we conceptualized a teaching strategy named Description -- Drawing -- Illustration -- Explanation (DPIE) in junior science classes through the research of philosophy of science, microscopic painting representation and ODIE teaching strategy (Andrade et al., 2018).In this study, we will introduce and discuss the influence of DPIE on students' causal interpretation and the relationship between painting and students' causal interpretation construction.

Found from the previous research, the appropriate design visual characterization, can eventually guide students to use a more scientific point of view to explain the phenomenon (Hasan Ozgur Kap Architects: In Charge, 2012015).As one of the visual representations, painting has many advantages in scientific learning (Ainsworth et al.,2011).Well-designed drawing activities can help students develop attention to detail, organize and explore ideas, deal with abstractions, reason at multiple levels, and infer underlying processes (Cooper & Stieff, 2017;Prain & Tytler, 2012), which is expected to influence students' conceptual understanding and causal interpretation.

The so-called DPIE strategy is called Description - Drawing - Illustration - Explain. It consists of four components :(a) Description - Describe the observed macroscopic phenomena and explain them with rules or laws;(b) Painting - drawing and imagining "seeing" the structure and interaction of particles of matter;(c)

Explanation - the interpretation of phenomena by the structure and interactions of microscopic particles;(d) Explanation -- constructing scientific explanations that reveal the essential causes of phenomena.

In this study, the effects of DPIE strategy on students' causal interpretation ability and microscopic particle drawing representation ability were investigated by using Wilcoxon's sign rank test.In addition, in order to explore the relationship between students' drawing level and the level of causal interpretation, we analyzed the causal interpretation of task 1 and task 2 before and after the test.Post-survey drawing and pretest causality interpretation; Posttest causal interpretation, postmapping drawing, pretest causal interpretation, linear regression was used to test the mediating effect of drawing level on causal interpretation (Baron & Kenny, 1986;Frazier et al., 2004). Students' drawing and scientific interpretation data were also collected through two semi-structured questions, and focus group discussions were used to gather students' views on DPIE teaching strategies. The specific research questions are as follows:

1. What is the effect of DPIE strategy on students' causal interpretation ability?
2. What is the influence of DPIE strategy on students' microscopic particle painting representation ability?

In general, DPIE strategy can significantly improve students' ability of causal interpretation and microscopic particle painting representation.And there is a positive correlation between students' drawing level and their causal interpretation level.However, the study of scientific explanation needs teachers' long-term support and guidance.In the actual teaching, the teacher can strengthen the connection between the macroscopic and the microscopic of the students through the experiment teaching;Reasonable use of painting or multimedia technology to enhance students' visualization of the micro world;At the same time, teachers should make use of time to learn scientific explanation, change teaching ideas, improve their ability of scientific explanation, actively understand and use the new teaching mode of scientific explanation, so as to develop more teaching cases and materials, develop students' scientific explanation, and improve the quality of students' scientific thinking.

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The newly revised Course of Study for secondary schools and the Nature of Science in Japan

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ABSTRACT

Understanding the Nature of Science (NOS) is an important component of scientific literacy, and its inclusion in science education should be recognized. The implementation of the newly revised Courses of Study in Japan has recently begun. We will analyze which kinds of components is included in the newly revised Courses of Study through using the definition of the NOS proposed by Driver et al. (1996). First, the science working group of the Course of Study argued that the validity of the hypothesis and improvement measurement should be discussed in upper secondary schools, however, the Course of Study for upper secondary school science has not directly described such activities. Second, the Course of Study for lower secondary school science addresses the fact that science involves social and environmental issues. The content aims to make students recognize the importance of a sustainable society. Then, the ability to make decisions based on scientific evidence is advocated. The MEXT has enhanced the importance of scientific inquiry activities in every revision of the Course of Study for secondary schools. Regarding implementing scientific literacy-in-action, understanding the NOS is an essential component of science education in Japan for making decisions on global issues.

Keywords: *the newly revised Course of Study, secondary schools, Nature of Science*

Introduction - research question and method

Understanding the Nature of Science (NOS) is an important aspect of scientific literacy (e.g., Driver *et al.*, 1996; Jenkins, 2013), and its inclusion in science education should be recognized (e.g., Department of Education, 2014).

The implementation of the newly revised Courses of Study in Japan began recently in 2020. Some studies have claimed that the previous Course of Study for secondary schools did not directly describe NOS (e.g., Shida, Nozoe, and Isozaki, 2019). However, few studies discuss whether the newly revised Course of Study for secondary schools includes NOS. Hence, we will investigate the components that should be included in science education in Japan.

Next, we will adopt the NOS definition proposed by Driver *et al*. (1996). This definition can be divided into two aspects as follows: (1) It consists of "Epistemological basis for scientific knowledge claims". To raise awareness and promote understanding of the usefulness of science and the logical limitations, it describes, how claims to scientific knowledge are made. The aspect has three strands: "Evaluation of evidence", which states that "Knowledge claims in science are supported or refuted in the light of available evidence" (Driver *et al.*, p.144); "The evaluation of theories", which includes "it is necessary to appreciate that theory is distinct from date" (Driver *et al.*, p.145); and "The generation and evaluation of predictions from theories", which includes "Making predictions about the behavior of a natural phenomenon based on theoretical models is problematic" (Driver *et al.*, p.145). (2) It can be defined as "science as a social enterprise", in that it describes how science is embedded in social contexts. The aspect has three strands: "How science as public knowledge comes about", which includes understanding "the ways in which public knowledge in science is developed through individual and communal effort" (Driver *et al.*, p.146); "Scientific work is socially and politically embedded", which includes "scientific work always provides a partial story, …scientific knowledge claims may be made from particular standpoints and result from particular programmes of research" (Driver *et al.*, p.146); and "Scientific knowledge-in-use", which means "there are crucial differences between science in the laboratory and in the real-world. In the laboratory, situations are simplified …Real-world situation, by contrast, are usually much more complex, with many factors coming into play" (Driver *et al.*, p.146).

Using these definitions, we analyzed the newly revised Course of Study for secondary schools in Japan.

Results

The science working group of the Course of Study for secondary school science argued that the validity of the hypothesis and improvement measurement should be discussed in upper secondary schools (Ministry of Education, Culture, Sports, Science, and Technology [MEXT], 2016). However, the Course of Study for upper secondary school science has not directly described such activities.

The newly revised Course of Study for lower secondary school science addresses the relationship between science and daily life, and the fact that science involves social and environmental issues. While the former content intends to encourage students' interests, the latter content aims to make them recognize the importance of a sustainable society. Then, in the final learning contents of lower secondary school science, the ability to make decisions based on scientific evidence is advocated.

Conclusion

The MEXT has enhanced the importance of scientific inquiry activities in revision of the Course of Study for secondary schools with the aim of solving various global controversial issues, such as climate change, especially in recent years, due to the improvement of science, technology, engineering, and mathematics (STEM) education in Japan. Regarding implementing scientific literacy-*in*-action, understanding NOS is an essential component of science education in Japan for making decisions on global issues.

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Oral Session 1	Day1 (June18th) 14：30～16：00
Room3	C3-3
【Category】	3: Science Education for Middle or Secondary School and Related Areas

=Chairperson=

Prof. Anna Permanasari	Universitas Pendidikan Indonesia

=Presentation Program=

1	9-3-3-18-1（FXJW-TF4V-9P021） WENHUA CHANG（Grad. Inst. of Sci. Ed., National Taiwan Normal University） CHENCHEN YEH, PEYING TSAI, HOMEI CHEN *ADAPTING AND ENACTING CROSS-DISCIPLINARY TOPICS INSTRUCTIONAL MATERIALS ON HETEROGENEOUS SEVENTH GRADERS’ LEARNING PERFORMANCE*
2	10-3-3-18-2（FXP3-LBBG-Y4021） Daiki Nakamura（Hiroshima University） Hiroshi Unzai, Takuya Matsuura *Examining Factors That Influence the STEM Career Choices of Secondary School Students: Using Data from TIMSS 2019*
3	11-3-3-18-3（FXWS-GEA3-9R021） Yuyu Rahayu（Science Education, Indonesia University of Education, Indonesia） Irma Rahma Suwarna, Riandi, Eneng Rahmayanti and Santy Nurmalasari *INOVATE DEMONSTRATION METHOD ON STATIC ELECTRICITY TO IMPROVE STUDENT MOTIVATION*
4	12-3-3-18-4（FXYB-DOZC-RC021） ANNA PERMANASARI（UNIVERSITAS PENDIDIKAN INDONESIA） Anna Permanasari; Indarini Pursitasari; Bibin Rubini; Didit Ardianto; Irvan Permana *How Does Indonesia Student Reach PISA SCORE 500 on Science By 2025? Mutual Collaboration among Government, Professional Associations and Higher Education Institution for training Innovative science Learning*

ADAPTING AND ENACTING CROSS-DISCIPLINARY TOPICS INSTRUCTIONAL MATERIALS ON HETEROGENEOUS SEVENTH GRADERS' LEARNING PERFORMANCE

Chang, Wen-Hua

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ABSTRACT

The Natural Science Learning Area Framework for the New 12-year Curriculum has been actualized since 2019 in Taiwan. The described learning content, suggested pedagogy and assessment modes for the cross-disciplinary topics (CDTs) for junior high schools are challenging for school teachers. Both the Natural Science Framework and the supplementary Curriculum Guide were officially provided to assist school teachers understanding the ideal science curriculum, literacy-oriented teaching goals, rationale and content of cross-cutting topics, in order to support teachers enacting in their teaching settings. To make the curriculum reform promising, it is critical to facilitate teachers to unpack the Framework and the Guide, adapt the cross-disciplinary topics instructional modules (including "Matter and Energy", "Systems and Scale", "Structure and Function", "Change, and Stability") in order to satisfy the school context and students' needs. In this presentation, we report three junior high school teachers conducted collaborated with CDTIM compilers to plan their action researches. Based on the analysis results, we claim that the adapted CDTIMs have potential in exploring students' learning performance. However, we found that students needs more scaffoldings to establish adequate understandings. We suggest the CDTIM compilers should consider more exactment details to facilitate school teachers.

Keywords: *Collaborative Action Research, Cross-disciplinary Topics, Curriculum Adaptation*

INTRODUCTION

Literature indicates adapting curriculum materials is effective in promoting teachers' professional growth (Debarger, et al., 2017). This presentation is to share the results on adapting, enacting, and formatively evaluating the adapted CDTIM via conduct collaborative action research. We will present the features of the adapted and revised CDTIM, and the quality of student artifacts from learning the enacted CDTIM.

METHODOLOGY

This study is the first year of a research project funded by the Ministry of Science and Technology. Three volunteer junior high school biology teachers, with experiences in developing instructional modules, collaborated with the writers of the CDTIM in the Curriculum Guide to modify CDTIM. Students' artefacts were collected and analyzed to investigate the effectiveness of the enacted CDTIM. The artifacts collected from students with various cognitive preference (Cheng, et al., 1997) include infographics, multimodal essays, or reports were coded about how well the students use science content and argumentative thinking. Cross-checking with the classroom observation records and teacher interviews by applying the constant comparative method,

FINDINGS

We found that the three teachers applied teaching strategies including- Critical Reading of Science Related News, Collaborative Prediction-Observation-Explanation, Slowmation, Observe-Question-Explain, Design-Make-Observe-Reflect in designed curriculum materials and realized in classroom teaching.

Table 1. Cross-Disciplinary Topics Instructional Modules Developed by Case Teachers in Three Schools

	School A	School B	School C
Cross-Disciplinary Topics	System & Scale	Matters & Energy, Science & Daily life	System, Structure & Function
Approach	Extra	Extended-Embedded	Extended
Content	Lesson One What is "cross-disciplinary topics" Lesson Two Scope & Scale of Scientific Researches Lesson Three Microcosmo in Oyster Lesson Four Represent Your Selection of System	Lesson One Nitrate or No Nitrate in Sausage? Extra A semester-long course of critical reading of science news	Lesson One Make & Maintain Eco-Balls Lesson Two Dissect Fish & Squid
Duration	8 periods (360 mins)	3 periods (135 mins)	4 periods (200 mins)
Strategies	Predict-Observe-Explain, SSI, Slowmation	Critical Reading of Science News,, Visual Representation	Observe-Question-Explain, Design -Making-Observe-Reflect, Dissect
No. of Ss (*N*)	55	78	80

Table 1. Performance in Design Experiments of Heterogeneous Groups of Students in School A

Coding Scheme \ Group		1	2	3	4	5	6
1	Coordination of Independent & Dependent Variables	-	-	+	-	+	-
2	Manipulating Variable	+	+	-	-	+	+
	Controlling Variable	-	-	-	-	-	-
3	Evidence-Based Scientific Explanation	+	+	-	-	-	-

Table 2. Perception of Heterogeneous Students in School B

	F	P	A	Q	A, Q	P, Q	P, A	*Ave*	*SD*
N	13	12	9	37	2	3	2	3.62	1.92
Ave/SD	3.82/1.35	3.54/1.00	3.85/0.95	3.59/1.16	1.27/0.50	3.42/1.02	1.19/0.31		

Table 3. Task example from Teacher C

Task 1 Observation and frame questions

Example:

My Observation: Body color of squid is changing.

My Interpretation: Squids stretch muscle cells to expand or shrink pigment cells lead to changing body color

The analysis results of student artefacts show that the students' reasoning and arguments are improved progressively through the teaching sequences, thus, lead to conclusion that the adapted CDTIM- "Oyster Crisis", "Nitrite in Sausage" and "Fish and Squid", have potentials to explore heterogenous students' learning performance. In addition, junior high school students would benefit with identifying and supporting their arguments with evidence. We suggest the CDTIM in the Curriculum Guide needs to provide more pedagogical details to afford school teachers.

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EXAMINING FACTORS THAT INFLUENCE THE STEM CAREER CHOICES OF SECONDARY SCHOOL STUDENTS: USING DATA FROM TIMSS 2019

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ABSTRACT

To increase the number of people choosing STEM careers, we need to understand the factors that influence their choices. In this study, we focus on social cognitive career theory (SCCT: Lent et al., 1994, 2000) as a model to explain the STEM career choice process, and explore its generalizability in East Asia. We validated the goodness of fit of the SCCT using structural equation modeling on the public data from 8th grade students in Japan, Korea, Taiwan, the US, and the UK in the TIMSS 2019 survey. The results of the analysis showed that SCCT was a good fit in all regions, and that self-efficacy and outcome expectations of science learning positively influenced STEM career choice aspirations. Based on these results, increasing self-efficacy and outcome expectations through science and career education will contribute to increasing the number of students choosing STEM careers.

Keywords: *STEM career, Social cognitive career theory, TIMSS*

INTRODUCTION

Demand for STEM workforce

The demand for the science, technology, engineering, and mathematics (STEM) workforce is increasing due to intensifying international competition in science and technology. For example, the U.S. Bureau of Labor Statistics (BLS) employment projections for 2019-29 show a growth rate of +8.0% for STEM occupations, compared to +3.7% for all others (Zilberman & Ice, 2021). However, there is a shortage of STEM talent in the labor market to meet the demand of companies, and the supply-demand gap of STEM talent is a global challenge (e.g., CEDEFOP, 2018). Therefore, we need to increase the number of people choosing STEM careers to close these gaps.

STEM career choice models

Increasing the number of people who choose STEM careers requires analyzing the selection process and understanding the factors influencing the choices. There has been extensive prior research on factors that influence career choice, mainly in psychology. Among early studies, Hackett and Betz (1981) proposed a model showing the influence of self-efficacy on career choice, later supported by many empirical studies.

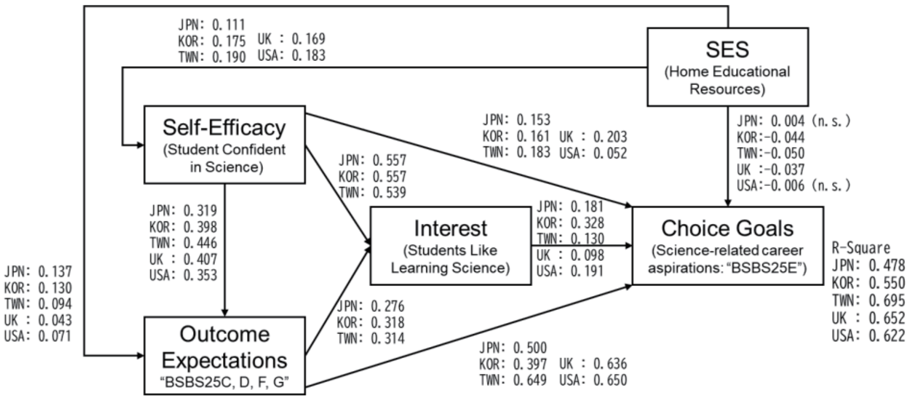
Recently, Lent et al. (1994, 2000) proposed the social cognitive career theory (SCCT), extending the self-efficacy model, which has been widely tested as an effective framework to explain career choice in STEM fields. SCCT assumes that self-efficacy and outcome expectations influence career choice through the mediation of interest. Precisely, if a person's abilities are related to a certain field, and they expect to use them for the same, then they will have interest along with continued efforts and choose that career. Lent et al. (2018) integrated 143 SCCT-based empirical studies using a meta-analytic approach and found that SCCT fits well regardless of gender or race. However, most of those were conducted in Europe and the United States, with a small sample from East Asia. It is necessary to examine the generalizability of SCCT using data from East Asia.

Purpose and method

This study aims to find how the SCCT fits in different countries using data from 8th grade students in Japan, Korea, Taiwan, the US, and the UK in the TIMSS 2019 survey.

RESULT

We validated the goodness of fit of the SCCT using structural equation modeling on the public data of the TIMSS 2019 questionnaire. The results showed that the model fit was satisfactory in five countries (CFIs [.996–1.000] and RMSEAs [.000–.055]). Path coefficients were also similar to Lent et al. (2018) for all countries; self-efficacy and outcome expectations record a positive influence on STEM career choice through interest mediation. The total effect on STEM career choice was about three times greater for outcome expectations (β= .203–270) than for self-efficacy (β= .646–.857). Besides, the coefficient of determination for STEM career choice was 47.8–69.5%.



Region	N	RMSEA	CFI	TLI	SRMR	Total SE to CG	Total OE to CG	Total SES to CG
Japan	4435	0.032	0.999	0.992	0.040	0.244	0.710	0.097
Korea	3855	0.042	0.999	0.990	0.053	0.270	0.646	0.081
Taiwan	4909	0.000	1.000	1.000	0.011	0.269	0.851	0.077
UK	3132	0.031	0.999	0.992	0.033	0.259	0.827	0.056
USA	8128	0.055	0.996	0.959	0.057	0.203	0.857	0.077

Figure 1. Standardized parameter estimates of the SCCT based on 8th grade data from TIMSS 2019.

DISCUSSION

These results suggest that to increase the number of students choosing STEM careers, enhancing their self-efficacy through science classes becomes necessary for providing them a sense of understanding of science content. Further, it is essential for boosting students' outcome expectations by showing them the application of science in STEM careers.

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INOVATE DEMONSTRATION METHOD ON STATIC ELECTRICITY TO IMPROVE STUDENT MOTIVATION

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ABSTRACT

This study aims to innovate a learning method. it involve teachers and students. This innovative demonstration method is presented in the form of a static electricity magic show. Static electricity is abstract science concept, which is difficult for students to understand. Through magic show demonstration, students are expected to more motivated learn this concept. The research method used ADDIE type R&D that consists of five stages (1) Analysis, (2) Design, (3) Development, (4) Implementation, and (5) Evaluation. Research respondents consisted 64 science teachers and 196 junior high school students, but only 20 students were included the limited trial. The data collection instruments in the form of a validation sheet for learning methods and a student motivation questionnaire. The validation results of the experts stated that innovative design of the learning method was feasible with an achievement level of 77.5% and the students motivation results questionnaire obtained a significant increase in science learning motivation before and after being given learning with the resulting innovative method design (t count = 5,865 > *t table = 1,725). Based these results, it can concluded that the innovative design of static electricity magic demonstration method is feasible to use and can improve students' motivation.*

Keywords: *Demonstration Method, Learning Motivation, Magic, Static Electricity.*

INTRODUCTION

The role of teacher in preparing learning so that students involved in learning activities is very important (Tobin et al., 2018). To achieve learning objectives, creative and innovative learning methods must be used to improve motivation students in learning process. One of the learning methods is demonstration method. The demonstration method can train students to think scientifically by linking factual knowledge of environment outside the classroom with knowledge learned in class (Taufiq et al., 2017). According to several studies, the demonstration method can improve students' understanding in classroom learning (Basri et al., 2018; Deese et al., 2000; Dilber, 2008), but from other research states that demonstration method is less effective than experimental method (Mckee et al., 2007; Rizkiana et al., 2016; Sola & Ojo, 2007). In the demonstration method, not all students actively involved in learning process, this is due the teacher-centered demonstration method without involving students. So demonstration method used needs to be innovated to method that involves students and teachers. one of the alternatives is presenting a magic demonstration method. magic in question is a demonstration of simple experiment that shows natural phenomena related to science concept being studied. Based on the problem above, formulation of the research problems in this study is.

How much increase student motivation in static electricity lessons with the magic demonstration method?

METHODS

Research and Development (R&D) with ADDIE development model which consists five stages, namely (1) Analysis, (2) Design, (3) Development, (4) Implementation, and (5) Evaluation was adapted in this research. In analysis stage, a curriculum analysis and analysis of the results of a questionnaire for demonstration learning method to 64 science teachers and 196 junior high school students was carried out. The next stage was make a design for a magic demonstration teaching method, followed by development of the design results to be adjusted the validation results of the experts. The results of design development then implemented in a limited trial for 20 students. Before and after limited trial students filled out a questionnaire on student learning motivation as many 25 question. In order to find out increase in student motivation, a one-sample t test was carried out using SPSS.

RESULTS AND DISCUSSION

Based on the results of the 2013 curriculum analysis for grade 9 junior high school level, the following are the design magic demonstration method.

Part 1

- Teacher shows a science magic about a piece plastic that is kept in palm of the hand (Figure 1). Then the teacher asks a question: What will happen to the plastic if the palm is facing down? (Figure 2).

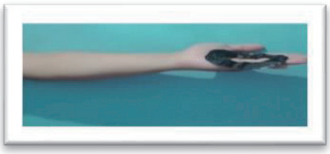

Figure 1 a piece plastic that is kept in palm of the hand

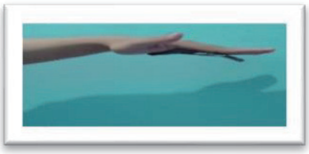

Figure 2 the plastic state if the palms are facing downwards

- Then students asked to make predictions written on prediction sheet.
- Teacher demonstrates by showing results of observations
  Result: The plastic stick to the hands and don't fall
- Teacher gives students opportunity to ask questions and have opinion
- Teacher discusses magic that is carried out with a scientific explanation the concept static electricity
- Students discuss in small groups (3-4 people) make designs for different magic shows for the next meeting, but still use the concept of static electricity with tools and materials around the student's environment.

Part 2

- Teacher explains the rules for the group presentation activities
- each group to do a magic show presentation

Results of the validation demonstration method innovation design from the learning design experts get a score 77, 5 % and are categorized as quite valid, but it suggested to add a magic demonstration assessment format that is presented by each group. After being declared valid, then this design were used in a limited trial. by involving 20 students who were taken randomly. At the beginning learning, students were given a science learning motivation questionnaire. Due to conditions of the Covid 19 pandemic, limited trials were carried out by means of blended learning, for the first meeting it was carried out directly at the school while for the second meeting, was carried online, each group made a magic demonstration video then collected to do an assessment.

Effectiveness of the magic demonstration method can be seen from the results of the student learning motivation questionnaire. The average value before 57.64 and average value after 62.08. analyzed based on the sample t-test using SPSS. The t value is 5.865 compared to the t price in the table for df 24 and with a significance level of 5% (α = 0.05) is 1.711. Thus price of t-count is greater than the price of t-table so that H_0 is ***rejected*** and H_1 is ***accepted***. That is, there is a significant difference in student learning motivation between before and after learning with the static electricity magic demonstration method.

CONCLUSION

Magic demonstration method in learning static electricity can improve learning motivation of students. But the results of this innovative magic demonstration learning method have only been tested on a limited basis, further research is still needed to see the effectiveness in learning for other science concepts and it is necessary to examine the strengths and weaknesses of this method further by comparing it with other learning methods.

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HOW DOES INDONESIA STUDENT REACH PISA SCORE 500 ON SCIENCE BY 2025? MUTUAL COLLABORATION AMONG GOVERNMENT, PROFESSIONAL ASSOCIATIONS AND HIGHER EDUCATION INSTITUTION FOR TRAINING INNOVATIVE SCIENCE LEARNING

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ABSTRACT

The Indonesian government and all science education professionals realize that there is one thing that should be done immediately so that Indonesian children can succeed in making scientific achievements on a world level. The 2018 PISA results put Indonesian children in a PISA score of 386. The Indonesian government is launching a PISA 500 in 2025 with various strategies and activity schemes. Preliminary survey results in several cities and districts in West Java, Indonesia show that the two aspects of competence in the indicators of explaining scientific phenomena as well as interpreting data and proving scientifically are still should be increased. The survey results for junior high school science teachers show that all teachers generally already knew various innovative learning models, such as STEM learning, Problem based learning, Discovery learning, Project based learning, or SETS learning. However, they actually do not really understand what distinguishes all these learning models/approaches and how to teach student with those models/approaches. The survey results show that only 20% of teachers really know how innovative learning is designed and taught. The training with a duration of 82 hours succeeded in at least building awareness of science teachers about how to design innovative learning, which encourages and trains students to think, do, and create creative work. The collaboration among Pakuan University with the government through P4TK, the science educator professional association (PPII) and the teacher Science community has implemented an innovative learning design for training science teachers. Even this professional development has not yet completed until the student's scientific literacy test, but at least it has given hope to realize the desire to achieve PISA score.

Key words: PISA Score for 2025, Scientific literacy, innovative science learning

Introduction

The Indonesia Government has pledged to achieve a PISA score of 500 for science, mathematics, and language by 2025.

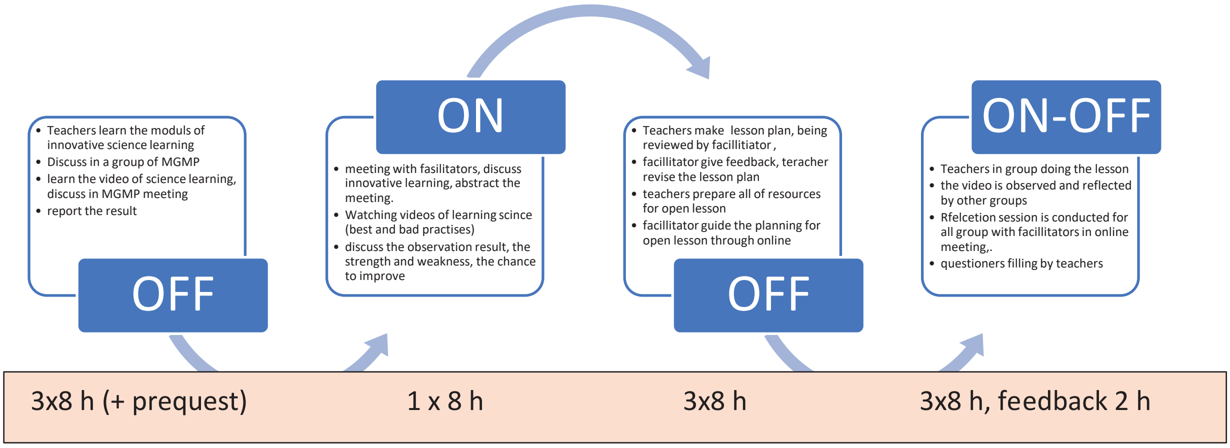
The accurate, systematic and sustainable program on strengthening teacher competence is needed. Teachers need to be introduced to various innovative learning models [1,2,3,4]. Many teacher development models are generally conducted with the pattern of 32 hours and 82 hours, where teachers must attend the full training. The constraints are: (1) If the activity is carried out during the school season, teachers has to leave their class; (2) competency training has not been implemented evenly, did not coverage all of fulltime teachers. The project to strengthen the competence of science teachers through systematic, structured and sustainable training has conducted In collaboration with the Association of Indonesian Natural Science Educators and ministry of education and Science teachers community (MGMP) in the districts and cities of Bogor-West Java, Pakuan University. The study was conducted to find out the extent to which training patterns can contribute to the ability of science teachers in teaching science based on scientific literacy.

Methods

The method used was descriptive method, which tries to portrait qualitatively the effectiveness and improvement of the teacher's ability to teach science based on science literacy. The 82 hours training mode is applied without having to sacrifice learning in the classroom. This program use MGMP meeting time as part of the training (Vescio, Higgins and Bautista [2,6,7]. A total of 40 science teachers were involved in the activity, which were divided into two different groups (a group of science teachers from the district and city of Bogor, 20 teachers each).

Result and discussion

The mode of training with on-off mode inserting by lesson study approach [5,6] has been applied along 82 hours duration.



- ✓ The good response came from trainees. As many as 20% of teachers understand the innovative learning before training, but they got fully understanding after they got the module and learn from it.
- ✓ Before training, most of teacher only used discovery learning as a model of teaching, even for the materials which actually can be taught in various of innovative models. After the training, as many as 85% teachers felt confidence to arrange the innovative class. Most of them said that the mode of training is very effective in time consume, without the need to leave the class.
- ✓ Most of them felt the benefit of online training, but they also happy with the one-day meeting offline with facilitator, for having the clearness about anything they still confuse. Only one teacher said that he could not follow the online learning, because the bad network. Instead of that, he asked his friend to make a video that can be shared after the session.
- ✓ Conclusion: The on-off training, combining with group task and focussing on how to arrange, implement and assess the learning science based on scientific literacy with 82 hours duration can enhance the understanding and capacity of teacher to organize the learning.
- ✓ Follow up program: Assessing the scientific literacy of student for achieving the PISA 500.

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Oral Session 1	Day1 (June18th) 14：30～16：00
Room4	C4-1

【Category】 4: Science Education for High School and Related Areas

=Chairperson=

Prof. Wei, Dong-Ying	Beijing Normal University

=Presentation Program=

1	13-4-1-18-1（FY5F-OZVW-9J021） Ratiporn Munprom（Kasetsart university） Sutasinee Kityakarn, Pattamaporn Pimthong, Tassaneewon Lertcharoenrit, Songchai Ugsonkid *Promoting Design Thinking of High School Student through STEM Partnership for Design-based Learning in PM 2.5 Crisis*
2	14-4-1-18-2（FY50-GSCW-KW021） Roseleena Anantanukulwong（Kasetsart University） Surasak Chiangga and Pongprapan Pongsophon *Investigating the Funds of Knowledge in Muslim Culture in the Deep South of Thailand for Culturally Responsive Physics Education*
3	15-4-1-18-3（FY6M-P290-OV021） Qingchen Yao（Xian Middle School of Shaanxi Province,） Wenhua Zhang *An empirical study on the influence of chemical concept teaching on students' model cognitive ability based on model cognition*
4	16-4-1-18-4（FY5S-VNLS-2V021） Naoko KOSAKA（Graduate School of Science and Technology, Shizuoka University） Yoshisuke KUMANO *Comparative Study of Japanese and American High School Biology Textbooks -Focusing on the impact of the STEM education reform by NGSS-*

Promoting Design Thinking of High School Student through STEM Partnership for Design-based Learning in PM 2.5 Crisis

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ABSTRACT

This study investigated the STEM partnership for design-based learning on student's design thinking. The design process and its framework in the design thinking process (empathize, define, ideate, prototype and test) were performed as a basis for the study. This study was conducted on 75 high school students from a large school in Bangkok. The students were challenged to design a PM 2.5 detector. Throughout all design-based learning units, STEM partnership worked collaboratively and closely with students to complete the design process. The collected data includes a questionnaire, students' worksheets, students' reflective journals, students' interviews, and the researcher's reflective journals. A thematic analysis was used to evaluate students' design thinking. The finding showed that most students (42.47%) explained that empathizing with others was essential to help them understand how to live with others and support each other. 57.00% of students gave definitions of the problem but did not clarify how to define them. In the concept of ideate, 54.79% of students showed their ability to identify new solutions to the problem by explaining step-by-step. Most of them (45.21%) chose a solution based on its impact and 28.77% of students indicated that their criteria for success was the outcome of their test results. The design process cooperated with the five stages of the design thinking process is an excellent way to develop design thinking in STEM class. Recommendations are made for the study to identify appropriate techniques for encouraging design thinking in STEM.

Keywords: *Design thinking process, STEM education, Design-based learning.*

INTRODUCTION

The design thinking process is a design process to promote a solution-based approach for problem solving (Goldman & Kabayadondo, 2016). It focuses on developing new ideas, creating products and services related to human-centered design and to understand users (Brown & Wyatt, 2010; Plattner, 2018 Wrigley & Straker, 2017). Previous research showed some effective findings of students' design thinking development through integrated STEM (Li et al., 2019). This study aims to investigate the STEM partnership for design-based learning on student's design thinking.

METHOD

This study is a collaborative action research of the STEM partnership to develop a STEM instructional unit on the PM 2.5 crisis. It is noteworthy that we modified a design thinking process (Plattner, 2018) by re-defining stages of our design thinking model according to design-based learning activities (Pimthong and Williams, 2018).

RESEARCH FINDINGS

The study shows that the students could design a P.M 2.5 detector prototype and test it. The student's response from the design thinking questionnaire was analyzed and categorized based on the stages in the design thinking process (Figure 1).

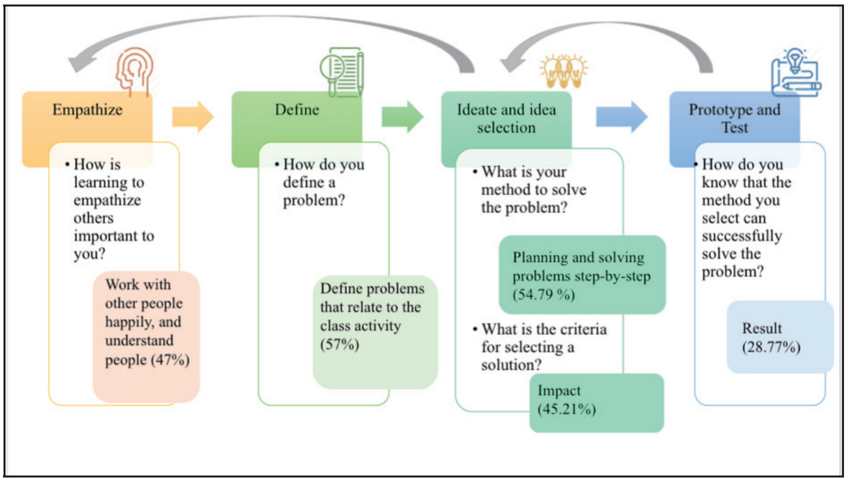

Figure 1. Summary of the students' responses from the design thinking questionnaire

Some students exhibited that the design thinking framework was not a single loop process. It requires iterative activities to redesign and improve prototypes.

DISCUSSION AND CONCLUSION

The design process cooperating with the four stages of the modified design-thinking framework is an excellent way to develop design-thinking in STEM. The students create and re-design prototypes in a non-linear, iterative process for solving problems (Brown & Wyatt, 2010; Plattner, 2018; Wrigley & Straker, 2017).

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Investigating the Funds of Knowledge in Muslim Culture in the Deep South of Thailand for Culturally Responsive Physics Education

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Abstract

The modern science owes debt of gratitude to Arabic Science during Medieval Era. Muslim scientists saved, thrived and passed on knowledge and process to the Western science. This shows curiosity and scientific habits of mind in the vein of Muslim people from the past till the present. Some of these knowledge, cultural artifacts and practices embedded concepts of physics that can be revisited and brought in to classroom as learning contexts to enhance conceptual understanding, motivate and raise self-efficacy to learn physics among high school students residing in the deep south of Thailand where there has been prolong unrest form insurgents making some students are losing interest in science, learning, hope and dream of life. This study aims to search for the fund of knowledge in three southernmost provinces of Thailand using ethnographic research. Cultural experts and "highly respected known" people were in-depth interviewed as well as document analysis was conducted to revive cultural memory bank. The fund of knowledge covering artifacts, practices, values and ways of living that have a great potential to be used in teaching difficult physics concepts such as Bulan kite (Force, motion, equilibrium), Raman Keris (Moment, lever, heat transfer), Kertok (sound wave; wavelength, amplitude, frequency, interference and resonance), Banor wang (sound wave; wavelength, amplitude, frequency, interference and resonance) just to name a few. The next phase of study, the invaluable funds of knowledge will be taken in to account in designing exemplary physics lessons guided by culturally responsive education framework. The professional development will be organized for interested physics teachers working in private Islamic schools to help them implement and create their own culturally responsive lessons. They will be followed up, their classroom will be observed, and the program and intervention will be examined whether and how they develop teachers' pedagogical understanding, students' conceptual understanding, self-efficacy in learning and scientific attitude towards physics.

Key words; Muslim culture, deep south of Thailand, culturally responsive science Education, Physics education.

Introduction

For the deep south of Thailand, the border provinces to Malaysia is the part of the country where Islam dominates and interweaves into daily life. Most of the population are Muslim. The education in deep south of Thailand has long been a big challenge because of centralized administration that does not fit the nature of the region. There is big contrast between national core curriculum and beliefs and culture in which students in the deep south lived in. The culturally responsive curriculum and instruction can help students' interest and understanding meaningfully, especially in Physics concepts that are abstract.

Research purpose

This research investigates the fund of Muslim culture in deep south of Thailand that embeds physics concepts.

Literature Review

Students' worldview and their cultural background necessarily impact on how they feel comfortable and welcoming in a science class. Culturally responsive teaching can get the student motivated to learn science in their own context (Cobern and Loving 2000). To improve indigenous students' interest and scientific understanding in school science, previous studies indicated that examining a problem from the perspective of a student's indigenous culture and the integration of Western science can complement to help them understand natural phenomena meaningfully (Mckinley, 2005). To make this happen, teacher would first require understanding of the cultural customs and worldview of indigenous people. Then, teacher could begin to incorporate indigenous knowledge into their science lessons with the support of local elders and knowledge keepers (Aikenhead, 2001).

Method of Study

An ethnographic method was used to discover community's funds of knowledge that is relevant to physics teaching and learning from deep south of Thailand. The researcher conducted in-depth interviews with three directors of the office of Private Islamic school, three provincial cultural experts and three local experts. Interviews were semi-structure focusing on the feasibility to the utilization of fund of knowledge such as cultural artifacts to integrate into physics teaching. In addition, document analysis was conducted from books about the culture of deep south of Thailand.

Results

a. b. c. d.

Figure 1. The Funds culture of deep south of Thailand : a. Bulan Kite, b. Raman Karis, c. Kertok, d.Banor wang

The results indicated that the funds of knowledge regarding Islamic culture applicable for physics teaching had a great potential to be used in teaching difficult physics concepts such as Bulan kite, Raman Keris, Kertok and Banor wang (Figure.1). Bulan Kite is related to physics concepts of force, motion and equilibrium. Raman Keris is related to concepts of moment, lever and heat transfer. Finally, Kertok and Banor are the behind physics concepts of sound wave; wavelength, amplitude, frequency, interference and resonance.

Implications

Thailand has released a policy that teaching should be in harmony with the context students living in. The invaluable funds of knowledge should be taken in to account in designing exemplary physics lessons guided by culturally responsive education framework. The professional development will be organized for interested physics teachers working in private Islamic schools to help them implement and create their own culturally responsive lessons.

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An empirical study on the influence of chemical concept teaching on students' model cognitive ability based on model cognition

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ABSTRACT

In the core literacy of chemistry, "evidential reasoning and model cognition" literacy is an important way of thinking, in which "model cognition" literacy can help students understand the relationship between things, and then understand the nature of things. The design and implementation of concept teaching based on Modeling Teaching in teaching is very beneficial to cultivate students' model cognition ability, in this study, we use the modeling teaching strategy to design the teaching design of the first class of " Amount of substance", and carry out the modeling teaching in a high school in Wuhan City, China. We use the four dimensions of the essence of the model to design the pre-test and post-test questionnaires to measure the changes of students' understanding of the essence of the model before and after the teaching, it is found that modeling teaching can improve students' understanding of the nature of models and cognitive ability of models.

Keywords: *Amount of substance, Model cognitive ability, Core quality of Chemistry.*

1. Research background

Under the background of China's new college entrance examination, the cultivation of core literacy of chemistry is one of the hot issues for researchers. Model based learning is an important way of thinking in the literacy of "evidential reasoning and model cognition". How to design modeling teaching in concept teaching and improve students' model cognition ability is the problem that this study wants to focus on. “Amount of substance " is an important bridge for senior high school students to understand macro matter and micro particles, an important tool for chemical quantitative calculation, and one of the important concepts in the new version of senior high school chemistry compulsory textbook published in 2019. It is of great significance to construct the conceptual model and formula model with " Amount of substance " as the carrier. The core issue of this study is what is the students' understanding of the nature of the model before and after the teaching of " Amount of substance" modeling, and whether there is a significant change.

2. Research design

In this study, an experimental class and three control classes were selected as the research objects. According to the modeling teaching strategy(Chiu & Lin,2019), the teaching design of "material quantity" is designed, and the first class of " Amount of substance" is used as the carrier for modeling teaching. According to the concept of model essence, the pre-test and post-test questionnaire are designed from four dimensions: semantic, ontology, epistemology and methodology of model essence(Liu,2011), which is used to evaluate students' understanding and development of model essence before and after teaching. The scores of the pre-test and post-test questionnaires are guided by university experts, and the weighted average total score is 99. The scores are given in a reasonable way, and Clonbach of questionnaire α The reliability coefficients were 0.833 and 0.920, respectively.

3. The influence of modeling teaching on students

The comparison of the average scores of the experimental class and the control class in the four dimensions of the essence of the model before the teaching of modeling is shown in Table 1:

Table 1. Comparison of pre-test questionnaire scores between experimental class and control class

	Control class	Experimental class
Semantic dimension	18.17	18.38
Ontological dimension	22.14	24.83
Epistemological dimension	10.98	11.58
Methodological dimension	17.68	20.71
Total score	**68.97**	**75.50**

It can be seen from table 1 that before modeling teaching, the difference between experimental class and control class is 0.014 < 0.050, but it does not reach the extremely significant level, and the difference is not significant.

After modeling teaching, the comparison of the average scores of the experimental class and the control class in the pre-test and post-test questionnaires is shown in Table 2:

Table 1. The scores of the experimental class and the control class in the pretest and posttest

	Pre-test	Post-test
Control class	68.97	69.93
Experimental class	75.50	90.21

According to the data from table 2, there is no significant change in the questionnaire score of the control class before and after the teaching (significant 0.668 > 0.050), while the questionnaire score of the experimental class before and after the teaching is significantly improved (significant 0.000 < 0.050), and the questionnaire score of the experimental class after the modeling teaching is significantly higher than that of the control class (significant 0.000 < 0.050).

In addition, this study also analyzes the students' course selection and gender ratio, and finds that there is no significant difference. At the same time, we use the classroom observation scale to transcribe the teaching video, and use the interview questionnaire to analyze the process of students' model construction, which proves the effectiveness of modeling teaching from the side.

4. Research conclusion and enlightenment

Through the research, the main conclusions are as follows: 1. Modeling teaching has significantly improved the semantics, ontology, epistemology and methodology of students' model essence, and students' model cognitive ability has been significantly improved. 2. The model cognitive ability of female students is higher than that of male students, but there is no significant difference. 3. There is no significant difference in the model cognitive ability of students with different subject combinations before class selection.

The following enlightenment is obtained in this study: 1. for the compilation of teaching materials, more pictures and formulas can be added to the teaching materials to supplement the complete modeling steps. 2. for teachers, teachers should improve students' understanding of the essence of model and improve their cognitive ability of model. In teaching, the class situation including the selection of subjects and the influence of gender ratio on teaching should be taken into account. 3. for students, we should try to construct a complete model in class, review and consolidate them in time after class, and use the model to learn concept knowledge and improve the cognitive ability of the model.

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Comparative Study of Japanese and American High School Biology Textbooks -Focusing on the impact of the STEM education reform by NGSS-

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Abstract

In the newest Course of Study for high school science announced in 2018, inquiry activities are further emphasized to develop the ability to explore the nature throughout life. In the US, Next Generation Science Standards (NGSS) was published as a new national science standard in 2013, and the Science and Engineering Practices were proposed as a new type of scientific inquiry and engineering activities. In this study, first, the changes in the contents of US high school biology textbooks before and after NGSS were investigated. Next, the Science and Engineering Practices in US biology textbooks newly published after the introduction of NGSS and the inquiry activities in Japanese high school biology textbooks were compared. As a result, the US textbooks that existed before the introduction of NGSS were divided into those that changed significantly under the influence of NGSS and those that did not change the existing framework. The changed textbooks incorporate new engineering elements. In American practices, social and medical issues were the themes, and literature research about how problems were solved using technologies were emphasized. Conversely, in Japanese inquiry activities, students work with results of experiments that required advanced skills.

Keywords: *high school biology textbooks, NGSS, inquiry activities, Science and Engineering Practices*

Background

In Japan, the word "inquiry" was first used in the goals of science in the Course of Study announced in 1956 (Ministry of Education, Science, Sports and Culture, 1956). In science education in Japan, it has long been considered especially important not only to acquire knowledge but also to learn the process of inquiry. In the newest Course of Study for high school science announced in 2018, inquiry activities are further emphasized to develop the ability to explore the nature throughout life (Ministry of Education, Culture, Sports, Science and Technology (MEXT), 2018). Now, science class reforms are required to realize these three kinds of learning: ① agentic learning with intrinsic motivation, ② deep communication, and ③ deep learning. In the US, Next Generation Science Standards (NGSS) was published as a new national science standard in 2013(National Research Council, 2013). According to NGSS, the Science and Engineering Practices were proposed as new type of inquiry activities.

Purpose

Japan is aiming for Society 5.0, which is an ultra-smart society with advanced science and technology (Cabinet Office, Government of Japan, 2016). In science education, cross-disciplinary learning connecting science with other subjects (for example, engineering elements and social science elements) will be required in the future. The purpose of this study is to clarify the recent changes in US textbooks and compare the differences between American Science and Engineering Practices and Japanese inquiry activities in order to examine new factors to be incorporated into future science education in Japan.

Method

For American high school biology textbooks, we used textbooks from three publishing companies (Pearson, Houghton Mifflin Harcourt, and McGraw Hill Education) with high market occupancy in high school science education in the US (Banilower et al., 2018). First, we clarified what kind of changes have occurred in recent revisions of textbooks that had been published before the proposal of NGSS. The table

“NGSS correlation” presented by each textbook company was used for the analysis. It showed the relationship between textbook content and NGSS. Next, we compared the Science and Engineering Practices of American biology textbooks and the inquiry activities in Japanese textbooks. For Japanese high school biology textbooks, we used textbooks from five Japanese publishing companies (Tokyo Shoseki, Keirinkan, Jikkyo Shuppan, Suken Shuppan, and Daiichi Gakushusha).

Results

Miller and Levine Biology from Pearson and *HMH Biology* from Houghton Mifflin Harcourt have been affected by NGSS, and the contents of these textbooks have changed significantly in recent years. On the other hand, McGraw Hill Education’s *Glencoe Biology* showed little changes in textbook contents in recent revisions. In *Miller and Levine Biology* and *HMH Biology*, some learning contents have been deleted (for example, the nervous system, muscular/skeletal system, and so on), and new activities relating to engineering design have increased as disciplinary core ideas. As changes from the old version, there were 54 new activities in *Miller and Levine Biology* and 24 in *HMH Biology*. Table 1 shows the results of examining which disciplinary core ideas of NGSS other than Life Science correspond to these activities. Both textbooks include engineering elements in their new activities. There were differences between Japanese and American textbooks regarding the subjects in inquiry activities and the activities conducted by students. In American textbooks, social issues and medical issues were the focuses, and there was a lot of emphasis on literature research. Conversely, in Japanese textbooks, there were some inquiry activities to consider from the results of experiments requiring advanced skills.

Table 1: The number of activities, including each disciplinary core idea.

Disciplinary core ideas other than Life Science	*Miller & Levine*	*HMH*
ETS1: Engineering Design	41	10
ESS1: Earth's place in the universe	1	-
ESS2: Earth's systems	3	-
ESS3: Earth and Human activity	4	-

Discussion

While Science and Engineering Practices in the US included engineering elements and social issues, Japanese inquiry activities did not yet include those elements. The Japanese textbooks analyzed in this study were developed based on the Course of Study announced in 2009 (MEXT, 2009). Soon, textbooks that comply with the new Course of Study, which emphasizes inquiry activities announced in 2018, will be published. It will be interesting to find out how many engineering elements and social issues these new textbooks will contain. In addition, in preparation for the next revision of the Course of Study, it is necessary to consider introducing cross-disciplinary concepts, such as engineering elements, into science in Japan, which is aiming for Society 5.0. Also, in US textbooks, some learning contents were deleted. This could be to make time for the practices in science classes. Even in Japan, which has begun to focus on inquiry activities, it will be necessary not only to add new inquiry activities but also to review what has been considered learning contents so far, as in the US.

Acknowledgments

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Oral Session 1	Day1 (June18th) 14：30～16：00
Room5	C5-1
【Category】	5: Science Education for Undergraduate or Graduate School Students

=Chairperson=

Prof. Chin-Fei Huang	National Kaohsiung Normal University

=Presentation Program=

1	17-5-1-18-1（FXWO-UIAG-C6021） Riandi RIANDI（Universitas Pendidikan Indonesia） Irma Rahma Suwarma, Anna Permanasari, Yoshisuke Kumano *Exploring the Obstacles of Prospective Science Teachers in Developing STEM Lesson Plans*
2	18-5-1-18-2（FXJT-VHZO-RX021） Ngoc-Huy Tran（National Kaohsiung Normal University） Chin-Fei Huang *Orientation of Educational Content for Science Pedagogy Students to Fulfill the Teaching Requirements of Sustainable Development Goals*
3	19-5-1-18-3（FXIB-Z3O3-SG021） HU TAO（East China Normal University colledge of teacher education） Jing Yang *A learning cycle approach to promote Pre-service Science Teachers' NOS Views*
4	20-5-1-18-4（FY18-KMTM-ZB021） Eni Nuraeni（Universitas Pendidikan Indonesia） Irma Rahma Suwarna *IDENTIFYING STUDENTS COLLABORATION SKILLS ON SOLVING FOOD SUSTAINABILITY ISSUES THROUGH STEM COURSE*
5	21-5-1-18-5（FY84-ASEV-M1021） Yu Lei（National Engineering Laboratory For Educational Big Data, Central China Normal University） Wenhua Zhang, Ye Chen *Atomic Structure Core Concepts Learning Progressions*

EXPLORING THE OBSTACLES OF PROSPECTIVE SCIENCE TEACHERS IN DEVELOPING STEM LESSON PLANS

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ABSTRACT

The increased demand of human resources with required literacies in 21st century, have been triggering reformation in many sectors of life. Based on the fact and triggered by high demand of literates' human resources, we proposed Science, Technology, Engineering, and Mathematics (STEM) education to solve the problem. In this study, we were developing professional learning program for prospective teachers. It began from introducing STEM perspective and theory from Japan Expert, and then followed by making lesson plan. This research was conducted in collaboration with Kumano Lab that have been developing STEM Education since 2013. The purpose is to analyze the difficulties of 19 prospective teachers in developing STEM lesson plan. The difficulties was digging up through questionnaire consist of three multiple-choice questions and one open-ended question. The data analyzed qualitatively as a case study research method took places. The results showed that half of them faced difficulties in integrating Technology and Engineering (42,1%) as well as integrating Technology, Engineering, and Mathematics (42,1%). No one who have experiences in integrating Technology, Engineering, and Math (0%) on the lesson plan. One of them wrote that the obstacles are in determining suitable technology for learning and what technology will be able to train critical and creative thinking skills, and in determining engineering practices for students. However, they thought that integrating Science, Technology, and Mathematics is easy (68.4%). These results indicated that most of prospective teacher were difficult in determining how to integrate Technology, Engineering, and Math into lesson plan.

Keywords: STEM integration, lesson plan, professional learning program.

1. BACKGROUND

We have been developing STEM Education since 2013, and we are focusing in STEM outcome for students. For instance, it was found that implementation STEM in Learning Cycle 5E in direct current electricity improved the concept understanding of students who received LC 5E combined with STEM higher than students who had learning LC 5E without STEM (I.R Suwarma et,al, 2017). Other research evaluation showed that most of STEM based learning was conducted through media and technology. The media and technology was invited into electricity learning. 92 students were involved as samples of this study that cane from two different classes. The analysis result showed that most of student enjoyed the lesson and eager to engage in other STEM based learning. Moreover, they agree that media and technology can help them in understanding the concept. It convinced by the students understanding improvement after the learning processes (I.R Suwarma, 2019). It was supported by Permanasari (2016), who said that development of contextual science learning framework from Hoolbroke (1998) supported by interactive media can improve science literacy and learning relevancies at schools.

Science literacy and learning relevancies at schools can't be developed without teacher's roles. Teachers in Indonesia were produced at education-based universities, such as UPI. Based on new ministry policy, not only UPI that can produce teacher but also other educational collage or universities. These facts triggered UPI to create professional and qualified teachers, so that the graduate could compete well. However, we realized that we are facing challenge in preparing the STEM teachers (I.R Suwarma, 2019). Therefore, we developed professional learning program for prospective teachers. We collaborated with Japan STEM expert to introduce STEM to teachers, and then asked teachers to develop lesson plan. Along the learning program, we found that teachers face some obstacle in developing lesson plan. This study will be focused on exploring the obstacles. It was conducted to enhance prospective teachers quality in teaching and learning experiences.

2. METHOD

Nineteen prospective physics teachers were invited to participate in this study. They were selected based on their interest and experiences in STEM education practices. They developed lesson plan based on content subject mater in curriculum 2013. They were grouped of two and each group picked one content matter. We collected nine-lesson plan, three for every grade in senior high level. After finishing lesson plan, they were asked to fill in the reflective questionnaire that consists of three STEM integration type questions, and one open question related to the obstacles/difficulties in developing the lesson plan.

3. RESULTS AND DISCUSSION

In the beginning the participant face difficulties on integrating STEM into lesson plan, they feel lack of information of implementation samples. After having discussion with researcher, and having guided with STEM integration framework, they revised the lesson plan draft.

The questionnaire results showed that half of them faced difficulties in integrating Technology and Engineering (42,1%) as well as integrating Technology, Engineering, and Mathematics (42,1%). No one who have experiences in integrating Technology, Engineering, and Math (0%) on the lesson plan. One of them wrote that the obstacles are in determining suitable technology for learning and what technology will be able to train critical and creative thinking skills, and in determining engineering practices for students. However, they thought that integrating Science, Technology, and Mathematics is easy (68.4%). The obstacles information that explored from open question showed that most of participant have difficulties in deciding the technology and engineering practice, and two of them feel that it took much time. The detail information describe in **Table 1**.

Table 1. Obstacles criteria in developing lesson plan

Obstacles criteria	Number of response
deciding the technology and engineering practice	5
integrating STEM	4
lack of school facilities and support	5
take much time	2
lack of lesson plan information	1
deciding engineering practice	2

4. CONCLUSION

These results indicated that most of prospective teacher were difficult in determining how to integrate Technology, Engineering, and Math into lesson plan. In addition, they also face obstacles in deciding technology and engineering practice that could lead interactive STEM learning activities. Lastly, they perceived that school support and facilities is needed in STEM learning implementation.

5. ACKNOWLEDMENT

This study was supported by *International Research Collaboration Grant* from Post-Graduate School Universitas Pendidikan Indonesia.

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ORIENTATION OF EDUCATIONAL CONTENT FOR SCIENCE PEDAGOGY STUDENTS TO FULFILL THE TEACHING REQUIREMENTS OF SUSTAINABLE DEVELOPMENT GOALS

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ABSTRACT

The aim of this research is to determine what science and environmental education materials should be included when teaching science pedagogical students to reach educational SDGs after they graduate. Seven experts were consulted for this study, and 70 high school teachers and 75 undergraduate pedagogical students from Taiwan and Vietnam were polled (all experts and survey participants were in the field of science education). After learning about the 17 SDGs, respondents were required to complete the "Teaching Orientation to SDGs Questionnaire". According to the findings, the most directly linked goals to science education and environmental education in school, which are also the goals that survey participants believe should be prioritized in science pedagogical student teaching, are SDG 6 (clean water and sanitation), SDG 7 (affordable and clean energy), SDG 13 (climate action), SDG 15 (life on soil), and SDG 14 (life below water). In addition, experts are consulted to have their perspectives on these topics. Based on the findings, the research intends to further explore pedagogic students' comprehension of science materials, attitudes, ability to handle and practice and willingness to apply STEM skills in solving certain practical problems related to the SDGs.

Keywords: *sustainable development goals; science pedagogy students; science education; environmental education*

INTRODUCTION

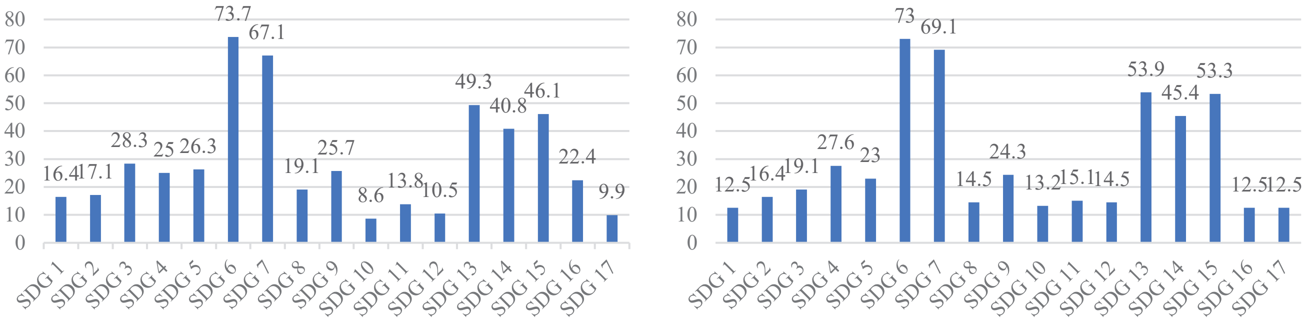
Since all United Nations Member States adopted the Sustainable Development Goals (SDGs) from 2015 to 2030 (UN General Assembly, 2015), preparing all people, particularly K-12 students, for the SDGs has become a global imperative; and education is recognized as an important pillar (Kioupi & Voulvoulis, 2019). Many prior research has revealed that higher education plays an active role in SDG implementation, and universities have several advantages in moving towards the SDGs through functions and operations such as research, innovation, and academic prowess. However, little guidance on how they might contribute to SDG implementation is available (Hernández-Barco et al., 2020; Mawonde & Togo, 2019). Although there are a lot of items combining science and environmental issues, some items such as energy (SDG 7), water (SDG 6), and climate change (SDG 13) receive very little attention in the sum of UN flagship publications (Vladimirovaa & Le Blanc, 2015). In addition, Walid and Luetz (2018) argue that the notion of environmental sustainability is not explicitly integrated within SDG 4 on education. In other words, SDG 4 makes no single explicit reference to any concern related to environmental sustainability. As a result, there is a lack of clear orientation on the scientific and environmental content that should be taught at universities in general, and universities of pedagogy in particular. So, it's necessary to explore which SDGs are most relevant to science and environmental education in schools, and which should be highlighted in university science pedagogy teaching.

METHOD

This research aims to determine what science and environmental education materials should be included when teaching science pedagogical students to reach educational SDGs after they graduate. Seven experts were consulted for this study, 70 high school teachers and 75 undergraduate pedagogical students from Taiwan and Vietnam were polled (all experts and survey participants were in the field of science education). After learning about the 17 SDGs, respondents were required to complete the "Teaching Orientation to SDGs Questionnaire", in which they were asked to choose the five goals in the SDGs that are most closely relevant to science education and environmental education in school, and which five should be prioritized in university science pedagogy teaching. In addition, experts are consulted to have their perspectives on these topics.

RESULT AND DISSCUSSION

Figure 1 shows the results obtained after surveying all three subjects who are experts, teachers, and pedagogical students in the field of science education. According to the findings, the most directly linked goals to science education and environmental education in school, which are also the goals that survey participants believe should be prioritized in science pedagogical student teaching, are SDG 6 (clean water and sanitation), SDG 7 (affordable and clean energy), SDG 13 (climate action), SDG 15 (life on soil), and SDG 14 (life below water). This is consistent with the conclusions of Wibowo & Sadikin (2019), that new biology, as a sub-discipline of the natural sciences, not only can potentially enact quality education goal, but also some other goals of SDGs, like SDG 6 and SDG 7.



(a) (b)

Figure 1. Rate (%) of the goals in SGSs that are (a) most closely relevant to science education and environmental education in school, and (b) should be prioritized in university science pedagogy teaching, according to the survey result.

From the perspective of experts, they believe that increasing the effectiveness of innovation and encouraging the use of active and interdisciplinary training approaches in university to assist pedagogical students in preparing the next generation to meet global environmental challenges are very important. STEM education is one form of successful education that experts suggest. Furthermore, experts argue that the current school curriculum continues to place a strong emphasis on knowledge transmission; more emphasis should be placed on cooperation and action. Based on the findings, the research intends to further explore pedagogic students' comprehension of science materials, attitudes, ability to handle and practice and willingness to apply STEM skills in solving certain practical problems related to the SDGs.

CONCLUSION

This research aims to determine what science and environmental education materials should be included when teaching science pedagogical students to reach educational SDGs after they graduate. Experts, high school teachers and undergraduate pedagogical students in the field of science education from Taiwan and Vietnam, after learning about the 17 SDGs, were required to complete the "Teaching Orientation to SDGs Questionnaire". According to the findings, the most directly linked goals to science education and environmental education in school, which are also the goals that survey participants believe should be prioritized in science pedagogical student teaching, are SDG 6, SDG 7, SDG 13, SDG 15, and SDG 14. According to experts, greater emphasis should be focused on cooperation and action; active and interdisciplinary training approaches at universities should be enhanced and encouraged.

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IDENTIFYING STUDENTS COLLABORATION SKILLS ON SOLVING FOOD SUSTAINABILITY ISSUES THROUGH STEM COURSE

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ABSTRACT

Collaboration skills are one of 21st century that should be owned by students. This study aim to identify collaboration skills on solving problem related to food sustainability issues that delivered in Science, Technology, Engineering, and Mathematics (STEM) course. Food sustainability is a global issues that become a part of SDG's of UNESCO. The STEM course used problem-based learning for scientific practice, and project based learning in engineering practices. Participants on this study are 31 first year undergraduate students that come from different major; physics, physics education, math, math education, chemistry, chemistry education, biology, biology education, computer science, and computer science education. They were divided into eight-mixed group. Peer assessment of collaboration skills were used to collect data that analyzed qualitatively. The results showed that most students have good collaboration skills, they respects other opinion in group (4.54), give contribution on creating idea solution (4.45), and have good responsibility to solve the problem (4.32). However they were not good on group leadership (3.9).

Keyword: *collaborative skills, STEM course, food sustainability*

1. INTRODUCTION

Collaboration skills have been considered as important skills that needed in facing 21st century challenges and demand in the workforce (Partnership for 21st Century, 2011). In addition, collaboration is an important instructional strategy especially in delivering problem based and project based learning environment (D.Lee, et all, 2015). These views leads some researchers to study the impact of collaboration into learning outcomes '*collaborate to learn'* and to study how the collaboration can be learned *'learn to collaborate*' (Littleton &Miel, 2004; in D.Lee et all, 2015). For instance, M. Rachmaniah et.al (2019) developed web based assessment tools to measure students' Collaborative Problem Solving (CPS) skills, the results showed that it could measure CPS valid, accurate and described most of students' collaborative skills were in level 2. It mean that there still need further learning environment that could develop students collaboration skills.

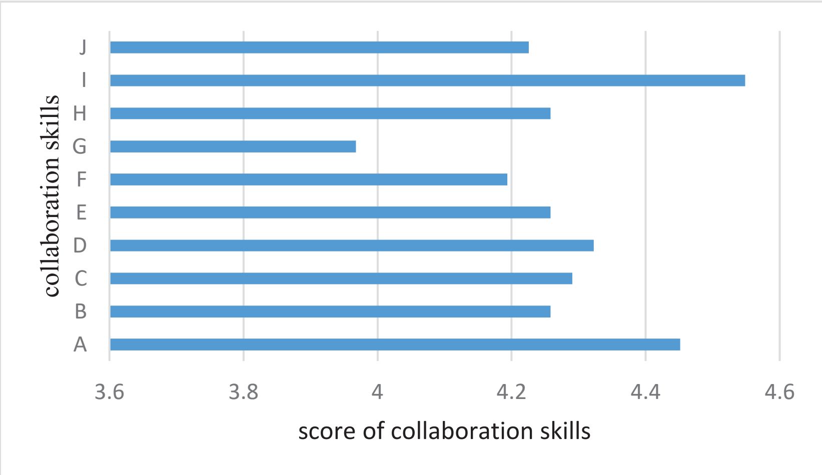
Collaboration was embedded in undergraduate courses learning environment in order to sharpen students' skills. A STEM course was developed to integrate science, technology, engineering, and mathematics discipline. It consists of scientific practice in identifying why the issues occurred, and engineering practice in generating idea to solving the problem. The theme of food sustainability is one of discussed issues in this course. It became a part of Sustainable Development Goals (SDG's) that proposed by UNESCO, the goal is to create 'zero hunger'. Students asked to identify how is food sustainability occurred in their surrounding, weather it is well managed or not, what problem occurred related to the food issues, what is the impact on social, environment and economic aspect, and how to solve the problem so that the food sustainability occurred. They were asked to collaborate; they can discuss, share and test their ideas. This study aims to identify how students learn to collaborate in solving food sustainability issues that delivered through STEM courses for first semester undergraduate students.

2. METHOD

Thirty-one undergraduate students who come from ten major were involved in this quasi experiment research. They were grouped in eight that consists of four students from different major. The discipline interest differences could lead various perspective of food sustainability issues and ideas solution. It create active discussion environment among students. It also can create conflicts among them, but they should solve it as a part of they learn how to collaborate in team. Collaboration skills were divided into three domain; participation, perspective taking, and social regulation task. Each student will assess his or her friend in the same group. The data analyzed qualitatively based on simple statistic calculation with 5-scale.

3. RESULTS AND DISCUSSION

Several statements represented all domains as shown in **Figure 1** that served in a peer assessment design. According to Figure 1, all the indicator of collaborative skills have been developed through STEM course with means score 4.2 (84% of the ideal maximal score). The highest score of collaboration skill is I (Respect the opinion of group members). The students very respects other opinion in group (4.54), they also good in give contribution on creating idea solution (4.45), and have good responsibility to solve the problem (4.32). However they were not good on group leadership skill (3.9).



Graphic description:
A. Contribution of thought to the benefit of the group
B. Provision of facilities for group assignment
C. Contribution in doing group assignments
D. Responsibility to the group
E. Ability to cooperate with group members
F. Ability to convey and respond to ideas
G. Leadership in group work settings
H. Social interactions with group members
I. Respect the opinion of group members
J. Commitment to doing quality assignments and on

Figure 1. Students' collaboration skills performance

Data in figure 1 shows that formulating problems and solving food security problems in collaboration between students from various majors has proven to have increased the need to collaborate efficiently. These findings suggest that PBL and project based learning are catalysts for collaboration as stated by(D.Lee, et all, 2015). That social interdependence theory suggests that social skills play an important role in enhancing collaboration and resolving conflict.

4. CONCLUSION

This finding shown that the strategy that implemented in STEM course included problem-based learning for scientific practice, and project based learning in engineering practices proved to be efficacious in improving students'collaboration skills.

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Atomic Structure Core Concepts Learning Progressions

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ABSTRACT
This research adopts Questionnaire survey, interview method, Pencil-and-paper method, text analysis method and other methods.Atomic Structure is one of the three major topics of Material Structure, and it is one of the important bridges linking the macroscopic and microscopic structure of matter. It is of great significance to construct the Core Concepts system and Learning Progressions of Atomic Structure. The main issues studied include: (1)What is the Core Concepts system in the theme of Atomic Structure? How is the Core Concepts expressed? (2) How to measure and analyze the student's understanding of the Core Concepts of this lesson in the teaching of a lesson under the theme of Atomic Structure?
Through the research, the following conclusions have been drawn:(1)Define the Core Concepts of Atomic Structure and its expression:Particles: Atom is composed of smaller particles.Force: There is a certain "force" in the atom.Space layout: Particles inside atom have a certain space layout.(2)Build a Hypothetical Learning Progression of Atomic Structure.(3)Design the evidence-centered the Learning Progressions instructional design and the Core Concepts assessment methods of "Nuclear and Nuclides", which form a one-to one teaching and evaluation system of claims, evidence and tasks. Post-test results of empirical studies indicate the method improve the understanding of Atomic Structure among different types of students, but student with high academic level have the greatest improvement, followed by those with low academic level. In order to adapt to different levels of students, the author proposes the modification method of "space layout", "nuclides" and "atomic symbols".
Keywords: *Atomic Structure，Core Concepts，Learning progression，Instructional design*

The Core Concepts and Learning Progressions have achieved a great deal of success in the new round of American Science Education Curriculum Reform. It is of theoretical and practical value to combine the research results of the United States with science education curriculum system in China.

1 Design of research on the development of Atomic Structure Core Concepts Learning Progressions

Collate the concepts of "atomic structure" in Chinese curriculum standards and middle school chemistry textbooks, list all relevant general concepts, and then sort out the conceptual framework of these "atomic structure" , this paper analyzes the cognitive structure of students' knowledge of atomic structure, defines the core concept of "atomic structure" , constructs the core concept system, and assumes an advanced framework of learning core concept of "atomic structure" .

According to the framework of advanced learning hypothesis and the results of pre-test analysis, students' "atomic structure" cognitive starting point, based on the theory of Constructivism, design the evidence center of "Nuclear and Nuclides" learning advanced teaching.

Select a certain type of students as the study object, "Nuclear and Nuclides" practice teaching. Design an evidence-based assessment tool to make a formative assessment of students'understanding of each concept in the classroom and adjust teaching strategies in time. Finally, the posttest is used to track the progress of students'core concepts before and after class hours, and to revise and adjust the hypothesis framework of learning progress according to the assessment results, to get the most suitable for this type of students, "Nuclear and Nuclides" class time learning advanced framework.

2 Data collection

The school studied was identified as a level 1 secondary school in Xiamen, Fujian Province.An empirical study on overtime work in a high school. Judging from the final grades of the class in the first semester of senior one, the average chemistry grade of the class is about 59.8.According to the definition of the core concepts of atomic structure and the hypothesis of advanced learning, this study adopts the method of Empirical Research to carry out the advanced learning design of "atomic nucleus and nuclide" . The University of Michigan School of Education, Shawn Y. Stevens et Al. coded the scale, to get the atomic structure coding scale, pre-test, determine the starting point. To "Nuclear and Nuclides" this class time carries on the teaching design, after "atomic nucleus, nuclide" class time ends, after using the class time after the class ends, carries on the test to the student in the classroom. And listen to the teacher Chen teacher for a talk, from the academic level of high, medium, low three students were selected for interviews.

3 The research conclusion

The conclusions of this study are as follows:

The core concepts of "atomic structure" are: Atoms are made up of smaller particles, there are interactions within atoms, and the particles within atoms have a certain spatial arrangement. The author thinks that these three concepts as the core concepts can dominate other general concepts in atomic structure. The two most important core concepts of atomic structure in middle school are "atoms are made of smaller particles" and "atoms have a certain spatial distribution of particles inside them" , which explain most of the facts, can Dominate most general concepts. Although "interatomic interaction" is a low requirement in atomic structure, without it, the core concept system of "atomic structure" lacks logical coherence, it also has a positive effect on the subsequent learning of "Chemical Bond" and "intermolecular force".

(2) According to the textbook and the curriculum standard as the blueprint, this paper defines the starting point and the ending point of the "atomic structure" of the students in the middle school stage, and in turn serves as the guidance, refining the three core concepts of the "atomic structure" , it forms the scientific description of the advanced hypothesis of "atomic structure" learning.

(3) Using the design method of evidence center, a set of objectives, evidence and task system of "Nuclear and Nuclides" is designed, developed a set of advanced teaching design of the concept of "nucleus, nuclide" class hour and assessment method of students' cognitive level, can help teachers in the "nuclear, nuclear" teaching process in time according to student performance adjustment strategy.

(4) Advanced teaching achievement of "Nuclear and Nuclides":①From the results of the impact on

students of different academic levels, the author's advanced teaching has a significant impact on students of high academic level, but little impact on students of high academic level.②According to the scores of different concepts, most of the students reached the first level of "Foshan" , but the two contents of nuclide and isotope in understanding level did not reach the intended teaching effect.

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Oral Session 2

Day1 (June18th) 16：30～18：00

Room1	C3-4	Science Education for Middle or Secondary School and Related Areas
Room2	C3-5	Science Education for Middle or Secondary School and Related Areas
Room3	C3-6	Science Education for Middle or Secondary School and Related Areas
Room4	C4-2	Science Education for High School and Related Areas
Room5	C5-2	Science Education for Undergraduate or Graduate School Students

Oral Session 2	Day1 (June18th) 16：30～18：00
Room1	C3-4
【Category】	3: Science Education for Middle or Secondary School and Related Areas

=Chairperson=

Prof. Indarini	Universitas Pakuan

=Presentation Program=

1	22-3-4-18-1（FY4G-GKXB-3Z021） Yamashita Shuichi（Chiba National University） Matsuda Kazukuni, Sugeno Hitomi *Development of digital worksheets for Japanese science lessons*
2	23-3-4-18-2（FY4G-RMJK-GB021） PINIT KHUMWONG（Srinakharinwirot University） Pinit Khumwong1, Navara Seetee, Chanyah Dahsah, Theerapong Sangpradit, Chaninan Pruekpramool, Tepkanya Promkatkaew *The Expanding STEM Education by Integrating Languages, Social, and Moral Aspects: Its Pros and Cons*
3	24-3-4-18-3（FY4W-LD7H-JD021） NURUL FARACH（Indonesian Education university） Parsaoran, Irma Rahma, Arizaldy, Linda kusumawati *THE URGENCY OF STUDENT NEEDS THROUGH STEMS (SCIENCE, TECHNOLOGY, ENGINEERING, MATHEMATICS, AND SOCIAL) LEARNING APPROACHES BASED ON ENVIROMENTAL INSIGHTS IN THE PANDEMIC PERIOD*
4	25-3-4-18-4（FXII-5NZP-RO021） Yuki Aono（Hiroshima University） Tetsuo Isozaki *THE FEATURES OF “BIOLOGY” AS ESTABLISHED IN JAPAN’S SECONDARY EDUCATION IN 1942*

Development of digital worksheets for Japanese science lessons

Yamashita Shuichi[1], Matsuda Kazukuni[2], Sugeno Hitomi[3]

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3. Chiba National University Student

ABSTRACT

The purpose of this study was to develop new digital worksheets for science lessons. To meet this need, on-site observation and interviews were done at schools. One of the examples comes from qualitative and quantitative research revealed that both digital textbooks and notebooks were frequent used in science lessons. The problem is whether to use paper notebooks or notebooks integrated into digital textbooks in science lessons. We developed new digital worksheets for science lessons which using with digital textbooks. However, there are still room for improvement in the worksheet such as writing space and structure.

Keywords: *Science Lesson, Digital Textbook, Digital Worksheet*

1. INTRODUCTION

From 2021, Japanese government introduced the GIGA (Global and Innovation Gateway for All) School Program that ensure "1 devise for 1 student with a high-speed network in schools" which bring optimized and creative learning to all students, who will live in the Society 5.0.

Japanese law mandates the use of physical textbooks in classrooms. However, the 2019 revision of the law allows partial incorporation of digital textbooks in the curriculum. Japan removed the limit on the amount of time that digital textbooks can only be used in under half of classroom times to introduce digital textbooks to all schools by 2024. Currently, only printed textbooks are distributed free to elementary and junior high schools, only 8.2% of schools are using the digital textbooks due to worries student's health would be affected by looking at the screen long time.

In this situation, Japanese Ministry of Education (2021) also updated the digital textbook guidelines. The guidelines pointed out the following merits of using digital textbooks:

1. Students' understanding and interest can be deepened and improved.
2. Teachers' preparation time be reduced.
3. Students' learning and understanding level can be grasped.

Yamashita et al. (2018) did on-site observation and interviews at schools. One of the examples comes from qualitative and quantitative research revealed that both digital textbooks and notebooks were frequent used in science lessons. The problem is whether to use paper notebooks or notebooks integrated into digital textbooks in science lessons.

2. PURPOSE

The purpose of this study was to develop new digital worksheets for science lessons which using with digital textbooks.

3. RESULTS

Firstly, we developed the new digital worksheets to store students' science learning information on the cloud and reflect past learning easily.

1. Link to the digital worksheets in conjunction with digital textbooks.
2. Fill in the information on each worksheet according to the order of problem-based learning.
3. Each worksheet is automatically integrated into the final worksheet.

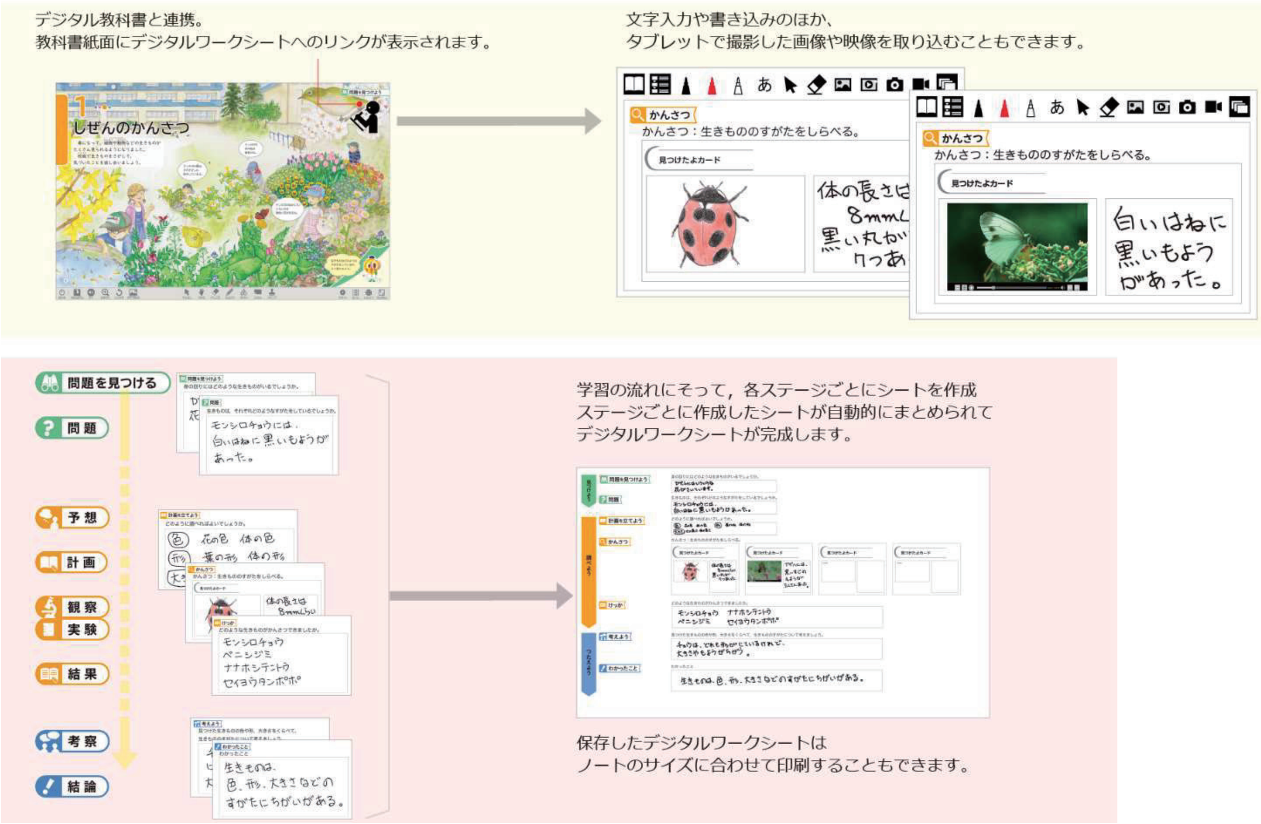

Figure 1. Newly developed science digital worksheet (Dainippon tosho, 2019)

Secondly, we asked science teachers in Tsukuba city to use the digital worksheet and give us comments.

◯: Simple and easy to write.

◯: It's good to put on photos easily.

◯: Stamp function is good.

◯: It's good to be able to share with the whole class.

×: I can't switch the camera in / out.

×: It would be better if there was more space to write.

×: It's better to use more sophisticated worksheet such as the insertion position of the photo and the table structure are included in advance.

4. DISCUSSION

There are still room for improvement in the newly developed science digital worksheet such as writing space and structure. We had simplified the writing space to use in various units, but it may need to be more structured.

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THE URGENCY OF STUDENT NEEDS THROUGH STEMS (SCIENCE, TECHNOLOGY, ENGINEERING, MATHEMATICS, AND SOCIAL) LEARNING APPROACHES BASED ON ENVIROMENTAL INSIGHTS IN THE PANDEMIC PERIOD

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Arizaldy[2] and Linda Kusumawati[2]

1. Indonesia University of Education, Indonesia
2. Indonesia University of Education, Indonesia

ABSTRACT

5.0 is human-centered with the support of a system that integrates the virtual world with the real world to eliminate gaps between humans and the resolution of social problems that aim for human and social progress. The purpose of this study is to determine the urgency of students' needs for an environmental insight-based STEMS approach that leads to 21st-century skills to be able to facilitate the learning process and provide more complex knowledge to students during a pandemic. This study used a survey research method. The research sample consisted of 25 science teachers. The instruments in this study were questionnaires, literature studies, and documentation studies. The results obtained from this study are in the frequency distribution table the statement "always" has a result of 0, the statement "often" has a value of 1, the statement "sometimes" has a value of 14, and the statement "never" has a value of 22. These results indicate that science teacher tend to only choose the content of the science material that is given to students but not in the application of how technology is done to tackle environmental pollution, how or techniques are done by making a product, evaluating the results of the product with the correct calculation for applied in order to tackle pollution in the environment during a pandemic as an urgent need for student learning in independent learning at home.

Keywords: *STEMS approaches, social learning, skills environment*

INTRODUCTION

The learning approach can be interpreted as a reference in implementing learning. Real education for the progress of a nation. Education is ready to create a future that is able to support technological developments. Science educators need to develop and develop learning that is oriented towards preparing students to be better prepared for the use and development of technology that can help human work and to make life easier and does not exist in society. So that the STEMS approach is an innovative approach that aims to instill social values that collaborate in the teaching strategies of teachers in class. The formation of morals by applying social values and the foundation of religious values is a must for teachers.

Society 5.0 aims to develop social structures and help human needs. The framework for thinking society 5.0 is actually based on the industrial revolution 4.0 (Ferreira & Serpa, 2018). Teachers, as well as science educators still need to be developed to train 21st-century skills that support society 5.0. The learning must fulfill the principles of 21st-century learning skills, including the following. the use of technological developments to support increased learning and increased creativity skills (Saavedra & Opfer, 2012). The purpose of this study is to see the urgency of the importance of approaches that lead to 21st- century skills that can facilitate the learning process and provide more complex knowledge to students through the latest STEMS innovation based on environmental insights in this pandemic era to tackle pollution in the environment of each student.

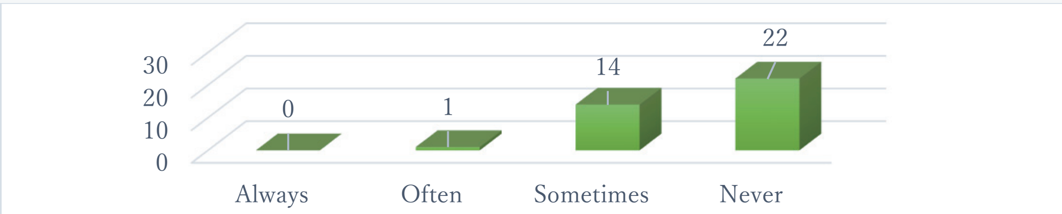
METHODS

This research study lies in a descriptive research framework, which aims to capture and present facts, facts, symptoms, and events that are desired to be raised appropriately (Raco, 2010). This type of research is descriptive qualitative which aims to make a systematic and factual description of data collection. This study took a sample of 25 science teachers in the City and Regency of Cirebon. They were asked to fill out an online survey and interpret the urgency needed for teaching environmental insight topics using the STEMS approach in the form of statements for teachers consisting of 20 statements using a Likert scale to measure an object. The instruments in this study were questionnaires, literature study, and documentation study.

FINDINGS AND DISCUSSION

This STEMS an approach is an approach that wants to try to be developed in learning during this pandemic with an effort to combine several or four STEM and Social subjects into one lesson based on the relationship between subjects and the application of problems in the real world. Kelley & Knowles (2016) defines STEM as an approach to teaching two or more STEM subjects related to authentic practice so as to increase the learning interest of students who explore two or more STEM subjects and one or more subjects in schools. The results of the responses of the teachers in the questionnaire frequency distribution results table are as follows.

Figure 1. Results of the Frequency Distribution of the Questionnaire.



The results obtained from this study are in the frequency distribution table the statement "always" has a result of 0, the statement "often" has a value of 1, the statement "sometimes" has a value of 14, and the statement "never". "It has a value of 22. These results indicate that science teachers tend to only choose the contents of the science material given to students but not in the application of how technology is done to tackle environmental pollution, methods or techniques that are done by making a product, evaluating the product results with the correct calculation. to be applied to tackle environmental pollution during a pandemic as an urgent need for student learning in independent learning at home. This means that the urgency of student learning needs is still considered minimal by the teacher with how students can carry out practical learning through simple research that can be done at each student's home during a pandemic. not effective, doing a simple practicum will help. to answer the problems that occur in the environment today.

CONCLUSION

The result show that science teacher tend to only choose the content of the science material that is given to students but not in the application of how technology is done to tackle environmental pollution, how or techniques are done by making a product, evaluating the results of the product with the correct calculation for applied in order to tackle pollution in the environment during a pandemic as an urgent need for student learning in independent learning at home.

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THE FEATURES OF "BIOLOGY" AS ESTABLISHED IN JAPAN'S SECONDARY EDUCATION IN 1942

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ABSTRACT

"Biology" is one of the science subjects in Japan's upper secondary schools. The emergence of Biology as an integrated science subject occurred in 1942, when the school curriculum was reorganized due to social changes resulting from the war. Before establishing Biology, natural things and phenomena of the living world and parts of non-living world were taught in the department of Hakubutsu (Natural History), which included subjects such as Botany, Zoology, Hygiene, and Mineralogy/Geology. We will analyze the ideas of those who committed to reorganizing the Science and Mathematics departments, and compared the regulations of Hakubutsu in 1931 with those of Biology in 1942. The purpose of revising of regulations for science subjects was to reorganize science and mathematics education for improving science understanding of the Japanese, and then to promote science in Japan (Kobayasi,1942). By comparing Biology and Hakubutsu, we found that Hakubutsu emphasized cognitive goals, where Biology emphasized skills and emotional goals to develop scientific attitudes and abilities. Biology, which was established in 1942 from the perspective of Japan's social conditions and traditional culture, aimed to develop scientific attitudes and abilities, and focused on inquiry activities, such as observation and experiment in the living worlds.

Keywords: *Biology, Hakubustu (Natural History), secondary education*

INTRODUCTION

"Biology" is taught as a science subject in Japan's upper secondary schools. It emerged as an integrated science subject in 1942, when the school curriculum was reorganized due to social changes resulting from the war. Japan's Ministry of Education divided the sciences in secondary education into Biology and *Busshou* (Physical Sciences). Biology dealt with natural things and phenomena in the living world, whereas *Busshou* dealt with natural things and phenomena in the non-living world. Before establishing Biology, natural things and phenomena of the living world and parts of non-living world were taught in the department of *Hakubutsu* (Natural History), which included subjects such as Botany, Zoology, Hygiene, and Mineralogy/Geology. We analyzed the ideas of those committed to reorganizing the Science and Mathematics departments and compared the regulations of *Hakubutsu* in 1931 with those of Biology in 1942.

Table 1. Transition of science subjects from *Hakubutsu* to Biology (1942)

	1886 ~ 1942		1942 ~1947	
subject	***Hakubutsu*** (Natural History)	**Physics and Chemistry**	**Biology**	***Busshou*** (Physical Sciences)
contents	Botany Zoology Hygiene Mineralogy/Geology	Physics Chemistry	Botany Zoology Hygiene **[living world]**	Physics Chemistry Mineraligy/Geology **[non-living world]**

RESULT

The purpose of the revision of revising regulations for science subjects was to reorganize science and mathematics education for improving the science understanding of the Japanese, and then to promote science in Japan (Kobayasi,1942). For these purposes, Shiono (1942) told that it was necessary to establish a new subject based on the traditional Japanese view of nature. By comparing Biology and *Hakubutsu*, we found that *Hakubutsu* emphasized cognitive goals, where Biology emphasized skills and emotional goals to develop scientific attitudes and abilities. Additionally, the contents of animals, plants, and the human body, in which *Hakubutsu* was considered separate entities, were integrated into Biology as one content, namely "organisms."

CONCLUSION

Biology, which was established in 1942 from the perspective of Japan's social conditions and traditional culture, aimed to develop scientific attitudes and abilities and focused on inquiry activities such as observation and experimenting in the living world.

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Oral Session 2	Day1 (June18th) 16：30～18：00
Room2	C3-5
【Category】	3: Science Education for Middle or Secondary School and Related Areas

=Chairperson=

Mr. Ari Syahidul Shidiq	Universitas Pendidikan Indonesia

=Presentation Program=

1	26-3-5-18-1（FY3R-80X7-VS021） PONGPRAPAN PONGSOPHON（Kasetsart University） *MODELING OF THE STUDENT-RELATED FACTORS AFFECTING SCIENCE ACHIEVEMENT OF EIGHTH GRADE SINGAPOREAN STUDENTS IN TIMSS 2019*
2	27-3-5-18-2（FY3O-EGYJ-IZ021） Hina Morishige（Graduate School of Education, Chiba University） Tetsuya Kato, Kazunori Yoshimoto *DEVELOPMENT OF TEACHING MATERIAL FOR RADIATION PROTECTION THROUGH A MODEL EXPERIMENT IN JUNIOR HIGH SCHOOL USING ULTRAVIOLET LED*
3	28-3-5-18-3（FY3U-D88N-HP021） Supansa Khansumrit（Srinakharinwirot University） Navara Seetee *CREATIVE PROBLEM-SOLVING ABILITIES OF THAI MIDDLE SCHOOL STUDENTS IN SPECIAL SCIENCE-MATH CLASS*
4	29-3-5-18-4（FY3X-TJKX-YW021） Heesoo Ha（Center for Educational Research, Seoul National University） *Exploring the features of argumentation subsequent to hands-on activities in the biology classroom*

MODELING OF THE STUDENT-RELATED FACTORS AFFECTING SCIENCE ACHIEVEMENT OF EIGHTH GRADE SINGAPOREAN STUDENTS IN TIMSS 2019

Pongprapan Pongsophon

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ABSTRACT

The purpose of this study is to investigate factors that determine Grade 8 Singaporean students' science achievement in TIMSS 2019. Singapore is ranked the first of all participating countries on Grade 8 Science. Some affective characteristics of students and home educational resource were taken as the predictive variables of the model and validated using path analysis. The data management and analysis were conducted in R using Dplyr and lavaan packages. This study examined the TIMSS data collected by an achievement test and a context questionnaire with the sample size of 4,853 and retrieved from TIMSS 2019 International Database. The results indicate that the hypothetical model fit well with the empirical data (CFI = 0.99, TLI = 0.99, RMSEA = 0.028, SRMR = 0.013). The home educational resource is the most influential predictor to explain the achievement (beta = 0.41) while the affective factors have trivial effect including value in science, enjoyment on learning science and confidence in science. It is noticeable that these affective predictors have strong relationship to each other—the value positively relates to confidence and this relationship is mediated by the enjoyment on learning science confirming Stern's Value Belief Norm (VBN) theory. The validated model could explain the variation in endogenous variables in model moderately; achievement in science by 27 percent, enjoyment on learning science by 40 percent, and confidence in science by 48 percent. Some suggestions for future research studies were proposed.

Keywords: *Science Achievement, TIMSS, path analysis*

RATIONALE AND SIGNIFICANCE OF STUDY

Singapore has the highest Grade 8 science achievement in The Trends in International Mathematics and Science Study (TIMSS) for the 3 recent consecutive cycles. TIMSS studies the mathematics and science achievement of a great number of participating countries. TIMSS also investigates factors determining mathematics and science achievement. The information is collected by questionnaires filled up by students, teachers, school principals, and parents. In the present study, student-related factors were selected−guided by literature review− and analyzed using path analysis to explain grade 8 science achievement in Singapore. The findings would guide other education systems to restructure their systems to improve science achievements in their countries.

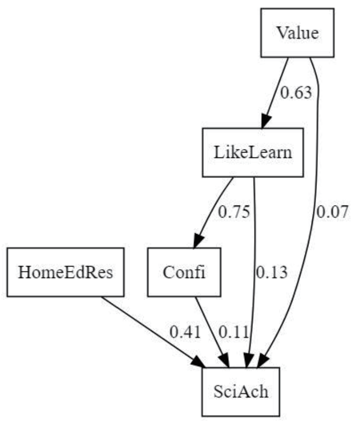
LITERATURE REVIEW

Bronfenbrenner (1979) proposed the Bio-ecological model that consists a multi-layer of factors that impact students' learning and development. The microsystem locates at the core and macrosystem at the outermost and mesosystem in between. The microsystem are the traits within the students such as resilience, metacognition, motivation, and readiness. Mesosystem is the interactions that surround each learner such as school climate, parental involvement, professional development for teachers, peer culture. The macrosystem is characterized by the societal and systemic factors such as Socioeconomic disparities between families within schools as well as disparities between communities and states, racism, child abuse and neglect policies. In the present study, only microsystem factors are selected to explain achievement.

METHOD OF STUDY

This study is a secondary data analysis. The data were retrieved from TIMSS 2019 international data base. The data were in SPSS or .sav extension. They were imported and read in R using haven package haven and managed using Dplyr package. The variables in model were selected including outcome variables which were five possible values of grade 8 science score, predictive variables which were derived variables. The derived variables were calculated from a set of relevant variables. They included home education resource (HomeEdREs), value in learning science (Value), like to learn Science (LikeLearn), instructional clarity (InClar), sense of belonging (Belong), bullying (Bully), and confidence in learning science (Confi). Hereafter, these variables will be referred to by their abbreviations. Descriptive statistics was conducted, then their inter-relationship was examined by correlation matrix. The pair of variables that have correlation coefficient approximately 0.3 or higher was selected for path analysis. To analyze the path analysis, package lavaan was employed. Path analysis is a statistical technique that is used to examine, and test purported causal relationships among a set of variables. First, a model suggested by literature review was specified. There are number of 13 parameters to be estimated. There were 2 variances of two exogenous variables (HomeEdRes and Value), 3 residual variances associated with three endogenous variables (LikeLearn, Confi, SciAch), 1 covariance between 2 exogenous variables (HomeEdRes, Value), 1 residual covariance between endogenous variables (LikeLearn and Confi), and 6 path coefficients. The model was estimated using maximum likelihood. The output consisted of fit indices and estimated parameters. The path diagram was drawn using SemPlot package.

RESULTS



The correlation matrix was calculated. The pair of variables that has coefficient closed to 0.3 or higher were selected to be included in the hypothetically model. Accordingly, InClar, Belong, and Bully were dropped. The results indicate that the hypothetical model fit well with the empirical data (CFI = 0.99, TLI = 0.99, RMSEA = 0.028, SRMR = 0.013). The home educational resource is the most influential predictor to explain the achievement (beta = 0.41) while the affective factors have trivial effect. These affective predictors have strong relationship to each other (Figure 1). The validated model could explain the variation in endogenous variables in model moderately; achievement in science by 27 percent, enjoyment on learning science by 40 percent, and confidence in science by 48 percent. This indicates that there must be other prominent variables from microsystem, mesosystem and macrosystem omitted from modelling. This is recommended to include in a model for further studies.

Figure 1. Validated path diagram

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DEVELOPMENT OF TEACHING MATERIAL FOR RADIATION PROTECTION THROUGH A MODEL EXPERIMENT IN JUNIOR HIGH SCHOOL USING ULTRAVIOLET LED

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ABSTRACT

Knowledge about three methods of radiation protection, i.e., "shortening time", "shielding", and "distance from the source", is so important that should be acquired through experiments and other experiences. However, it is not easy to conduct experiments using radiation sources in schools due to safety concerns and the high cost of equipment such as Geiger counters. Therefore, we have developed experimental materials on "shielding" and " distance" for model experiments on radiation protection using a near-ultraviolet (UV) light-emitting diode (LED). The UV light partially penetrates acrylic and glass plates that can use as optically transparent absorbers. In addition, the radiation is fully absorbed by polycarbonate plates, thus that the experiments were safely performed wearing safety glasses made of polycarbonate.

In this report, we firstly describe the properties of the UV source and sensor and then present the results obtained by the junior high school students in addition to the data obtained by the authors. By measuring the gradual weakening of the absorber as the distance to the sensor and the thickness of the absorber increased, the students were able to confirm the properties of the invisible UV radiation.

Keywords: *experiment of radiation, UV LED, model experiment, junior high school.*

Introduction

In the Courses of Study in Japan (published in 2017), it was clearly stated that radiation should be covered in the science education of both the second and third grades in junior high school. Since the Great East Japan Earthquake 2011, public interest in radiation has remained so high that this field must be included in compulsory education. The essential idea of radiation protection is the three principles, i.e., ‘time shortening, ‘shielding,’ and ‘evacuation distance from the source.’ Ideally, students should acquire such important knowledge through experience through experimentation. However, in schools, it is not easy to conduct experiments on ‘distance’ and ‘shielding’ using radiation sources due to the safe treatment and the cost of instruments such as Geiger counters. Therefore, we developed a teaching material of a model experiment on radiation protection using a UV (ultraviolet radiation) source. Here, we avoid using far UVs because they are known to have ionizing effects and damaging DNA. Instead, a near UV LED light should be selected.

Procedure

Power LED with output wavelengths in the near-ultraviolet and visible regions around a peak wavelength $\lambda_{\mathrm{peak}} =$ 370 nm was used as the light source. The light sensor is sensitive just to the region of the near-ultraviolet but not to that of the visible light. This property makes the UV measurements possible to conduct under the bright illumination of the classroom. It makes a deep impression for students to treat the invisible radiation. Additionally, the students usually wear safety glasses, which are made of polycarbonate because of enough strength and optical transparency. Then their UV exposure was minimum because the UV radiation is fully absorbed by polycarbonate plates. Therefore, the students’ experiments can be performed safely under the instruction of wearing the usual safety glasses. On the other hand, transparent acrylic plates, or soda glass plates, are known to slightly absorb ultraviolet rays. We adopt this property to demonstrate the shielding effect that relates to the thickness of the number of plates, N.

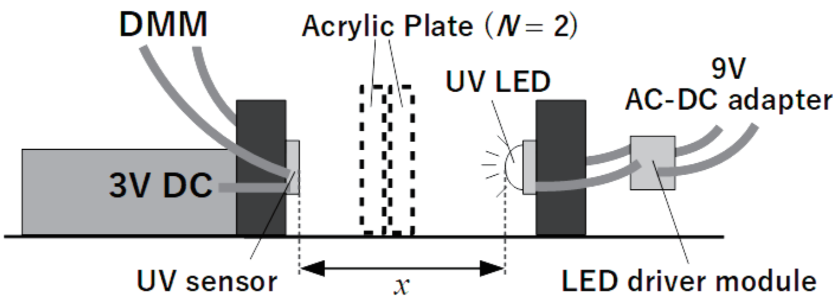

Fig. 1: Apparatus setting

Evaluation of the teaching materials

The separation of the distance x between the UV LED and the sensor, as shown in Fig.1, was changed from 1 to 18 cm. The output voltage from the sensor was measured with a Digital Multi-Meter (DMM) where the UV emission was controlled in a constant current mode using an LED driver module. It must be noted that the highest output of 2.1 V showed the saturation of the sensor so that the measurements were meaningful only if $x > 3.5$ cm. The obtained data were shown in Fig.2. The behavior of the UV intensity well obeyed the expected rule of x^{-2}.

As for the shielding experiment, some acrylic plates with 5-mm thickness were placed at the middle of the both fixed UV light source and the sensor, as shown in Fig. 1. We kept the separation distance $x = 3.0$ cm and changed the number of the plates N. The output voltage of the sensor showed an exponential decrease with N, as shown in Fig. 3. Note that, again, the highest output of 2.1 V at $N = 0$ should be thought of as over-saturation.

These results showed that our "distance" and "shielding" experiments using the near-UV light and the UV sensor can be substituted for the ionizing radiation experiments.

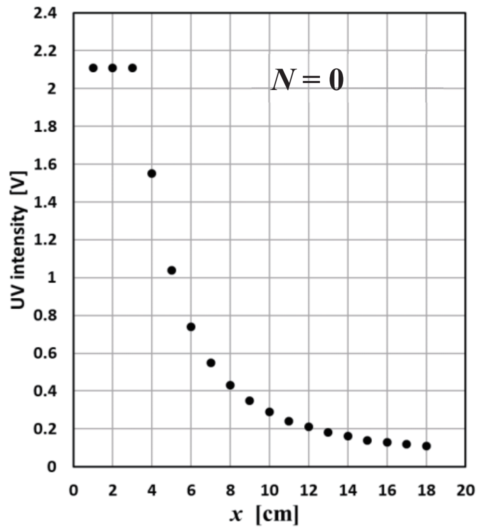

Fig. 2: Distance x dependence of the output voltages of the intensity.

Result and discussion

In the class, students first formulated their hypothesis of the effective reduction of external exposure to radiation under various conditions. Then, they conducted a model experiment using the present apparatus as the teaching material, and considering the method to verify the hypothesis experimentally. From the experiments, the students were able to derive that it is required to keep distances from radioactive materials and put shielding material in front of them. From these results, it can be said that this teaching material is suited for a model experiment for radiation protection for junior high school students.

It remains that the additional experiment for the third way of protection, i.e., "shortening the exposure time", is not available here. Moreover, since this is only a model experiment, it is necessary to add an explanation that the effective materials for radiation shielding differ depending on the type of radiation.

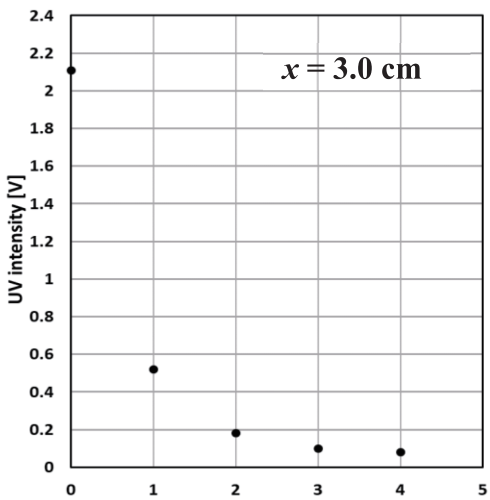

Fig. 3: The UV absorption due to the number of acrylic plates *N*.

CREATIVE PROBLEM-SOLVING ABILITIES OF THAI MIDDLE SCHOOL STUDENTS IN SPECIAL SCIENCE-MATH CLASS

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ABSTRACT

The ability to solve the problem creatively is essential for developing an innovation. Especially talented students in a special science-math class are expected to innovate in the future. However, there is no research survey about creative problem-solving abilities of Thai middle school students in the special classroom. Thus, this research aimed to explore creative problem-solving abilities of the seventh to ninth grade students in a special science-math class, and to compare the abilities between grade levels. This study was a survey using the test of creative problem-solving abilities developed by a researcher. The reliability (Cronbach's alpha coefficient) of the test was 0.60. Creative problem-solving abilities were composed of four components: understanding the problem, creating a solution, preparing for action, and planning your approach. The samples are 107 seventh to ninth grade students in special science-math class from a school at Samutprakarn province by purposive sampling. Mean, standard deviation, percentages, and Kruskal-Wallis H test were used to analyze the data. It was found that middle school students' creative problem-solving abilities were at a medium level. There was a statistically significant difference at the level of .05 in their abilities among three grades. Higher grader, higher creative problem-solving abilities. Ninth-grade students were higher scores than eighth graders, and eighth graders were higher scores than seventh graders. Additionally, all graders have lowest scores in the component of creating a solution. The results are suggested that teachers should help the students improve their creative problem-solving abilities, specifically creating a solution component.

Keywords: *Creative problem solving, Junior high school, Talented students*

INTRODUCTION

The creative problem-solving (CPS) abilities is thinking that requires elements of problem solving and creativity. It helps to expand mindset and free from traditional way producing innovative methods or solutions (Charoenwongsak, 2007). People who have these abilities can create a novel method for managing a complex problem in everyday lives effectively (Mitchell & Kowalik, 1999). The CPS abilities are essential for people who develop an innovation (Suksawang, 2020). Especially, talented students in a special science-math class are expected to be an innovator in the future (Ministry of Education, 2020). Previous research studies have explored CPS abilities of talented students in grade 4-6 (Kampoo Na Ayudhya, 2017). However, there is no research report on the CPS abilities of middle school talented students in the special classroom. Therefore, the objectives of the research were to explore creative problem-solving abilities of the seventh to ninth grade students in a special science-math class, and to compare the abilities between grade level. Empirical information on CPS abilities of the students are background for designing and development of teaching and learning for the special science-math class students in the middle school effectively.

METHOD

This study is a survey research. The instrument was CPS abilities test developed by a researcher with Cronbach's alpha coefficient .06. The CPS abilities were defined as integrating creative thinking and critical thinking to solve problems in any situation creatively. It was composed of four dimensions: understanding the problem (UTP), creating a solution (CAS), preparing for action (PFA), and planning your approach (PYA). The test were administered to seventh to ninth grade students in special science-math class (totally 107 students) in the first semester of 2020 academic year. The data were analyzed using descriptive statistics (mean, standard deviation, percentages) to report student's abilities. Then the mean scores were classified into three levels high level (56 – 75), moderate level (36 – 55) and low level (0-35). The mean score of each grade were used to test the difference between grade levels using Kruskal-Wallis H test.

RESULTS

The creative problem-solving abilities of the students were shown in Table 1.

Table 1
Creative problem-solving abilities of the students

Grade level	n	Full score	$\bar{x}$(S.D.)	Level	Percentage of scores for each components			
					UTP	CAS	PFA	PYA
Grade 7	35	75	51.14 (3.90)	Moderate	95.00	48.33	86.00	62.66
Grade 8	36	75	52.94 (3.43)	Moderate	95.33	49.33	89.33	68.66
Grade 9	36	75	55.19 (3.74)	Moderate	98.66	52.16	91.33	74.66

The Kruskal-Wallis H test revealed that there was a statistically significant different in mean score at the .05 level between the three grades, $\chi^2(2) = 18.977$, $p = .000$, with a mean rank score of 37.73 for grade 7, 54.14 for grade 8, and 69.68 for grade 9.

CONCLUSIONS

The students' creative problem-solving abilities were at the moderate level. The component with the lowest percentage was creating a solution. The higher grader, higher creative problem-solving abilities. Based on Piaget's cognitive development theory, its seems that students' CPS abilities are come from their development by age. Therefore, teachers should design or develop learning process to improve their creative problem-solving abilities to prepare them ready for being an innovator in the future.

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Exploring the features of argumentation subsequent to hands-on activities in the biology classroom

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ABSTRACT

The purpose of this study was to explore features of students' discussion and argumentation subsequent to hands-on activities in the biology classroom. To this end, the practices of seventh-grade students during two argumentation tasks in a unit about photosynthesis – one with a hands-on activity and the other without one were video-recorded and transcribed for analysis. The analysis was conducted based on the qualitative case study method and from the theoretical viewpoint of material agency. Students' practices in the hands-on activity were explored, their practices in the two tasks were examined and the influence of the hands-on activities on students' discussion and arguments produced in the two argumentation tasks were compared. The results showed that, although students' discussions during the hands-on activity focused on the procedures of the activity, the hands-on activity allowed students to share resources that could be used as data in the subsequent argumentation task. This facilitated students' construction of alternative claims and rebuttals and increased persuasive discussion among group members. The findings of this study contribute to developing instructional strategies to support students' argumentation to make sense of natural phenomena and reframing the position of materials in the practice-based design of biology classroom activities.

Keywords: *argumentation, hands-on activity, materiality*

INTRODUCTION

With the practice turn in science education that suggests incorporation of disciplinary practices into classroom instruction, significant attention has been given to practices such as argumentation that highlight epistemic and social aspects of scientists' endeavor to construct evidence-based knowledge about natural phenomena (Driver et al., 2000). In this process, hands-on activities in which students directly interact with the material world and construct explanations of it are mostly eschewed (Furtak & Penuel, 2018). However, hands-on activities are still one of the preferred means of increasing students' participation in classroom activities. The use of hands-on activities is supported by claims for the benefits of refocusing on materiality in scientific endeavor (e.g. Furtak & Penuel, 2018). Dialogical discussions among scientists are important parts of scientific endeavor employed in science education, but interactions between natural phenomena and scientists are also a crucial part. This way of thinking supports a re-emphasis on developing instructional strategies to utilize hands-on activities for students' engagement in scientific practices of knowledge construction.

In the light of the literature, this study was conducted based on the data collected in research into argumentation activities in the biology classroom. A collaborating teacher added a hands-on activity in one of the lessons, with argumentation activities designed by researchers, in order to give students opportunities to develop skills in employing experimental tools and observing phenomena by themselves. She chose to implement this activity even though it might mean decreased time for an argumentation activity, expecting that students could learn more through such activities. This study reflectively examined differences in students' engagement in an argumentation activity subsequent to a hands-on activity, in order to explore features of argumentation activities subsequent to the hands-on activity in the biology classroom. The specific research questions were as follows: (a) How do students' discussion types and argument construction differ in the argumentation task subsequent to a hands-on activity? (b) How did the hands-on activity influence these differences?

METHODS

This study is a reflective study based on data collected from research that explored students' engagement in dialogical argumentation activities in the biology classroom. A biology teacher in a Korean middle school, Ms. K, and 57 students in two classes participated in the research. The students were divided into 14 groups, of which four were selected for this study. Argumentation activities were designed to support students' engagement in the social construction of knowledge in the biology classroom. The classroom activities were video-recorded and transcribed. Interviews were conducted with the teacher after each lesson to reflect on the lesson and discuss the design of the subsequent lesson. These interviews were also audio-recorded and transcribed.

The transcripts and collected videos were iteratively reviewed, and a lesson with an argumentation activity designed for students to construct evidence-based explanations of natural phenomena was selected for comparison with a lesson with a hands-on activity. Student groups' discussion types were coded according to whether and how arguments were developed and whether interactions were concentrated on one of the group members or the teacher. The proportion of each type of discussion in the argumentation activities was identified. The process of argument construction in student discussions was also analyzed. The discussion types and argument construction process in each activity were compared to understand how hands-on activity influenced students' performances in the two argumentation tasks.

FINDINGS AND DISCUSSION

Features of students' argumentation subsequent to a hands-on activity

The analysis revealed that the proportion of persuasive discussion was higher (27.6%) in the argumentation subsequent to the hands-on activity compared with 5.5% in the argumentation without hands-on activity, and the contributions of group members was relatively less concentrated in the discussion subsequent to the hands-on activity. Dependence on the teacher for leading the discussion and developing the reasoning was lower. Two features of student-constructed arguments were identified. First, observations in the hands-on activity were used as evidence, which enabled students drawing on this evidence to easily get agreement from other group members. Second, students suggested more alternative claims, which led to more sophisticated reasoning, as students used discussion to evaluate the validity of these alternative claims.

Influence of the hands-on activity on the students' subsequent argumentation

Students jointly engaged in observations of natural phenomena in the hands-on activity. This provided students shared resources that could be used in the subsequent argumentation, thus giving credence to the reasoning that they presented in the group discussion. It seemed that this allowed students to be less dependent on someone who was known to possess more "correct" knowledge, such as a teacher, and their participation was less concentrated on a particular person. In addition, students' direct interaction with materials often allowed them to explore outside the target phenomena specified for the hands-on activity. These observations contributed to students' construction of alternative claims raised in the subsequent argumentation. These findings shed light on the potential of hands-on activities to enable students to engage in the scientific practice of interacting with materials. The analysis of data in this study will be further described in the presentation. The findings of this study could contribute to designing hands-on activities in scientific practice to facilitate students' active participation in collaborative sense-making.

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Oral Session 2	Day1 (June18th) 16：30～18：00
Room3	C3-6
【Category】	3: Science Education for Middle or Secondary School and Related Areas

=Chairperson=

Prof Anna Permanasari	Universitas Pendidikan Indonesia

=Presentation Program=

1	30-3-6-18-1（FY3F-DPLC-R6021） Chanyah Dahsah（Srinakharinwirot University） Chaninan Pruekpramool, Navara Seetee, Pinit Khumwong, Tepkanya Promkatkeaw, Theerapong Sangpradit, Siwaporn Lamainil *A GUIDELINE FOR GIFTED AND TALENTED MIDDLE SCHOOL STUDENTS IN SCIENCE, MATHEMATICS, AND TECHNOLOGY PROJECT COURSES*
2	31-3-6-18-2（FY4H-IYK7-KN021） Indrawati（The University of Jember） Sutarto *THE EFFECT OF STUDENTS’ CRITICAL THINKING AND COLLABORATION SKILL THROUGH GI-GI (GROUP INVESTIGATION-GUIDED INQUIRY) LEARNING MODEL*
3	32-3-6-18-3（FY68-IIKS-N4021） Arizaldy（Science Education, Indonesia University of Education, Indonesia） Irma Rahma, Harry Firman, Linda Kusumawati, Nurul Farach REPRESENTATION OF ENVIRONMENTAL POLLUTION CONCEPT THROUGH MEDIA WITH LUBUK LARANGAN LOCAL WISDOM IN JUNIOR HIGH SCHOOLS
4	33-3-6-18-4（FXJF-ZBKX-0T021） Yuya Nakanishi（Hiroshima University） Tetsuo Isozaki, Takehiro Hayashi *THE PURPOSES AND CONTENTS OF NATURAL RESOURCES EDUCATION AT SECONDARY SCHOOLS IN JAPAN BEFORE WORLD WAR II*

A GUIDELINE FOR GIFTED AND TALENTED MIDDLE SCHOOL STUDENTS IN SCIENCE, MATHEMATICS, AND TECHNOLOGY PROJECT COURSES

Chanyah Dahsah, Chaninan Pruekpramool, Navara Seetee,
Pinit Khumwong, Tepkanya Promkatkeaw, Theerapong Sangpradit, and Siwaporn Lamainil

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ABSTRACT

This research study was initiated to develop a guideline for Science Schools and Science Oriented Program to be used in creating project courses for gifted and talented students in science, mathematics, and technology. The data was qualitatively collected by in-depth interviews from 14 students, 15 teachers, and 4 schools' administrators who won national and international SMT project rewards. Then, the data were code and categorized by content analysis for developing the guideline. The draft of a guideline was sent to teachers and school administers who involve in project courses of 12 Regional Science Schools for evaluating the guideline. There were 35 teachers and school administrators responded and that all items were rating in an absolutely appropriateness level with some suggestions for improvement. As a result, the guideline provides the detail of subject courses, extra-school curriculum activities, roles and responsibility of participants, and alternative methods of instruction. This guideline will be useful for all schools, not only science schools, to be used for developing effective project courses that enhance students' essential skills for 21st century, and also to gain project rewards in national and international competitions.

Keywords: *Gifted and Talented Students, Project, Middle School, Science and Mathematics.*

INTRODUCTION

Princess Chulabhorn Science High School (PCSHS) is a group of twelve regional science schools focuses on developing the talents students in science, mathematics, technology, and environment in secondary school level (Grade 7 – 12). This aims to support science and technology professionals in Thailand. One of the six focuses of the school curriculum is to emphasize the invention design, creative thinking, and project work. In a middle school (Grade 7 – 9), students must learn eight subject areas based on the National Basic Core Curriculum, and additional courses related to the goals of regional science schools include academic writing, seminar in science, and project. Thus, project is one of the most important courses to achieve the goal of the school curriculum. Therefore, it is believed that there should be a research study to develop a guideline for effective project teaching and learning.

OBJECTIVE

The objective of this study is to develop a guideline for Science Schools and Science Oriented Program to be used in creating project courses for gifted and talented students in science, mathematics, and technology.

METHODOLOGY

A mixed method with exploratory sequential design is used. Starting from qualitative study by in-depth interviewing of 14 students, 15 teachers, and 4 school administrators who purposive selected based on their project rewards. After the guideline developed, the quantitative data were collected to evaluate the appropriateness of the guideline using a five-Likert scale questionnaire. The participants were 35 teachers and school administrators who involve in the project courses from 12 regional science schools. The qualitative data were code and categorized by content analysis. The quantitative data were analyzed by means, standard deviation, and interpreted using level of appropriateness.

RESULTS

The guideline provides the detail of subject courses; extra-school curriculum activities, roles and responsibility of participations, and alternative methods of instruction for lecturers and project supervisors.

There are five subject courses suggested includes Inquiry & Engineering Design Process, Introduction to Projects, Project 1, Project 2, and Project Communication and Presentation. These courses should be taught from Grade 7 to Grade 9. In each subject, the guideline provides course description, learning outcomes, learning processes, roles of course instructors, students' tasks, and course evaluation.

The extra-school curriculum activities include introduction to the project camp, instruments for science and engineering work camp, and open-house. The first camp should be before students starting their first semester of Grade 7 which aim to inspire and provide students fundamental concepts. The second camp should be the end of Grade 7 to prepare students for doing their projects because students already have a project topic and questions. The open-house should be at the end of the first semester of Grade 9 which students will present their project at the end of the project communication and presentation course.

The guideline also provides methods for supervisors in coaching and mentoring students during project work step by step, include identifying project topic and questions, searching literatures, planning and carrying out the project, analyzing and interpreting project data, writing proposal and project report, presenting projects, and preparing for project competition.

The quantitative data from teachers and school administrators suggested that the guideline is appropriate for science and technology project course of middle school students in science schools. It was rated in an absolutely appropriate level in all aspects.

CONCLUSION

This guideline developed based on the research findings and also the definition and essential features of project-based learning. It is a systematic learning experiences that engages students in learning knowledge and skills through an extended inquiry process structured around complex and authentic questions (Pecore, 2015). Since project-based learning is a constructivist and authentic in nature (Jumaat, et. al, 2017, Roessingh & Chambers, 2011), it is a student-driven investigation guided by the teachers and focuses on a problem or issues that meet real world situations or the products that students create can be used by real people (Larmer, 2012). In addition, the learning activities would allow students to work in a group and work collaboratively with their peers (Eskrootchi & Oskrochi, 2010).

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THE EFFECT OF STUDENTS' CRITICAL THINKING AND COLLABORATION SKILL THROUGH GI-GI (GROUP INVESTIGATION-GUIDED INQUIRY) LEARNING MODEL

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ABSTRACT

Critical thinking skills and collaboration skills are part of the 21st-century skills demands that students must possess. The GI-GI model is a learning model that focuses on students' ability to find science products in groups with teacher guidance. The purpose of this study was to examine the impact of the application of the GI-GI model in science learning on students' critical thinking skills and collaboration skills. This research was a true experiment with a Post Test Only Control Group design applied to 63 total students in grade eight who were taken randomly in a junior high school in East Java. The total students were divided into 32 students as the experimental class and 31 students in the control class. The data collection technique was a test for critical thinking skills and a questionnaire for collaboration skills. The results of data collection were analyzed by Mann-Whitney Test. The research results show that critical thinking skills and collaboration skills both meaning that Ho was rejected. This research shows that students' average critical thinking and collaborative skills differ significantly between the experimental and control classes, with the experimental class average being higher than the control class. Thus, the implementation of Science Learning with the GI-GI model has a significant effect on students' critical thinking and collaboration skills.

Keywords: *GI-GI learning model, critical thinking, collaborative skill*

INTRODUCTION

The development of science and technology in this century requires human resources to have knowledge and skills so that they are able to live in accordance with the demands of the times. These skills are commonly known as Four-C (creativity, critical thinking, collaboration, and communication). These skills can be developed through learning activities, including in science learning in junior high schools, although not always the four skills are developed simultaneously. Efforts to develop these skills can be done through the application of a learning model. Therefore, teachers must be able to choose a learning model that allows them to be used to develop these skills. This research focus on the development of critical thinking skills (Alismail & Mcguire, 2015; Brown, 2015; Changwong, 2018) and collaborative thinking skills (Trilling & Fadel, 2012). Those skills have been investigated in the implementation of Gi-Gi Learning Model (Indrawati, 2015).

METHOD

The kind of this research is a true experiment research. The research population consisted of students in a junior high school in East Java class VIII odd semester. The research sample was 63 students who were taken randomly, 32 students each as the experimental class and 31 students as the control class. The research design used the Post Test Only Control Group. The treatment used is the GI-GI learning model. Critical thinking skills data were obtained through a critical thinking test with six indicators. Each indicator consists of two subjective questions and in total 12 items. The students' collaborative skills determined by questionnaire. The validity and reliability of the questionnaire values were 0.74 and 0.78 respectively, both of which belong to the high validity and reliability category.

RESULTS

Based on the distribution of data both on critical thinking skills and collaboration skills, both of which are not normally distributed. Therefore, the analysis of the mean difference test was used nonparametric, namely the Mann-Whitney Test.

Table 1. Statistics test in the critical thinking skills

	Score
Mann-Whitney U	207.500
Wilcoxon W	703.500
z	-4.044
Asymp. sIg. (2 tailed)	0.000

Table 2. Statistics of Collaborative Skills

	Score
Mann-Whitney U	176.500
Wilcoxon W	672.500
z	-4.945
Asymp. sIg. (2 tailed)	0.000

Conclusion

The implementation of Gi-Gi learning model in the critical thinking skills and collaborative has significant results. The implementation of Gi-Gi learning model is important to be implemented when investigated students' critical thinking skill and collaborative skills.

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REPRESENTATION OF ENVIRONMENTAL POLLUTION CONCEPT THROUGH MEDIA WITH LUBUK LARANGAN LOCAL WISDOM IN JUNIOR HIGH SCHOOLS

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ABSTRACT

One of the factors determining the achievement of learning objectives is the media used in the learning process. Learning media are all tools (aids) or objects used in learning to convey educational messages (information) from sources (educators and other sources) to (students). In this study, the media were in the form of a pictorial game (quartet) presenting natural science subjects of environmental pollution material. The representation of the content material in the quartet image media was taken from national basic competencies (KD3.8), namely "analyzing the occurrence of environmental pollution and its impact on the ecosystem," which was then linked to the conservation of Lubuk Larangan. This research developed a product, namely a quartet game-based image media containing local wisdom, which is expected to represent environmental pollution material. This study employed a development model proposed by Thiagarajan, Sammel, and Sammel (Abba, 2000) known as the Four-D Model: define, design, develop, and disseminate. This article discussed one of the stages in the design, namely the readability test. This readability test was conducted to determine whether students could use the quartet image media's language, material, and layout to understand the materials contained in it. The readability test results found that the quartet learning media containing Lubuk Larangan local wisdom was valid and could be used for the next step, namely testing in class.

Keywords: *Representation, Media, Lubuk Larangan, Environmental Pollution*

INTRODUCTION

In this study, a pictorial game (quartet) was utilized as the media to present natural science learning on environmental pollution material. This material is vital to be presented attractively through the quartet because students are usually not interested in a written textbook. Hence, in addition to teaching environmental pollution material, the design of this quartet game learning media could be used to disseminate the local wisdom culture of *Lubuk Larangan* from an early age. The representation of the material in the quartet image media was taken from KD 3.8, namely "analyzing the occurrence of environmental pollution and its impact on the ecosystem," which was then linked to the conservation efforts of *Lubuk Larangan*. In its implementation, this game has a storyline starting from the causes of environmental pollution to efforts to overcome environmental pollution through *Lubuk Larangan* conservation. This quartet card has five contents with their respective color identities: environmental pollution (purple), *Lubuk Larangan* (blue), biotic components (green), abiotic components (red), and overcoming environmental pollution (yellow). Based on this description, it can be seen that the importance of learning media for this quartet game is not only teaching environmental pollution material but, more than that, to instill an environmental care attitude filled with *Lubuk Larangan* local wisdom from an early age at the junior high school level.

METHOD

Natural science learning media represented environmental pollution with *Lubuk Larangan* local wisdom, including two things: 1) how *Lubuk Larangan's* customary regulations play a role in preserving the ecosystem and 2) building children's knowledge through traditional quartet games to educate the dangers of environmental pollution on the ecosystems in the environment around *Lubuk Larangan*. This learning media was made so that students could be happier to learn by using the traditional quartet game.

This media directs students to observe, think, and instill a caring attitude towards the environment. Data were collected and analyzed using a media development research methodology, focusing on readability testing related to language use and the content of the material used.

RESULTS AND DISCUSSION

The readability test of natural science learning media to represent environmental pollution with *Lubuk Larangan* local wisdom includes (Arsyad, 2016) (1) readability: easy-to-understand language; (2) easiness: written form, typography, such as letter size and space width relating to word recognition speed, error rate, number of eye fixations per second, clarity of writing (writing shape and size); (3) attractiveness: reader's interest, accuracy of ideas in reading, beauty of writing style; (4) comprehension: the characteristics of words and sentences, such as short length and frequency of use of words or sentences, sentence structure, and paragraph structure.

The readability test in the natural science learning media to represent environmental pollution with *Lubuk Larangan* local wisdom was given to five junior high school teachers in Batanghari Regency, Jambi Province, who had teaching experience for more than five years. The instruments used can be seen in Table 1 below.

Table 1. The instrument for testing the readability of natural science learning media to represent environmental pollution with *Lubuk Larangan* local wisdom

No	**Description**
1	The learning media uses easy-to-understand language (vocabulary, sentences, paragraphs, and discourse).
2.	The written form and the letters used are clear, making it easier to read pictorial media (quartet).
3.	There are no typographical errors in the text listed on pictorial media (quartet).
4.	The graphic aspects used in pictorial media (quartet) are interesting.
5.	The presentation of pictorial media (quartet) is attractive according to the material and the reader's age (student).
6.	The pictorial media (quartet) uses standard Indonesian grammar.
7.	The density of ideas and information contained in the reading material is easy to understand.
8.	The system of presenting material on pictorial media (quartet) makes it easier for readers to understand.

Descriptively, the readability test results given to the five junior high school teachers can be seen in Table 2 as follows.

Table 2. The readability test results of the natural science learning media to represent environmental pollution with *Lubuk Larangan* local wisdom

Item Number	**Result**
1	100 %
2	60%
3	80%
4	80%
5	80%
6	100%
7	80%
8	80%
Mean	82,5%

The suggestions given are that (1) it is necessary to improve the writing of the concept material to be more explicit, and no misconceptions in the image media (quartet), and (2) the colors need to be highlighted.

CONCLUSION

Based on the readability test results above, it could be concluded that (1) the natural science learning media to represent environmental pollution with *Lubuk Larangan* local wisdom was valid based on the readability test, and (2) the natural science learning media to represent environmental pollution with *Lubuk Larangan* local wisdom was ready to be used for the next stage of development, namely testing in class.

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THE PURPOSES AND CONTENTS OF NATURAL RESOURCES EDUCATION AT SECONDARY SCHOOLS IN JAPAN BEFORE WORLD WAR II

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ABSTRACT
The purpose of education in natural resources was already part of the Japanese school curricula before World War II, even though it is not referred to in the Course of Study for upper secondary schools at present. However, recent social and industrial pressures require the education sector to rethink its curriculum material. In today's drastically changing world, identifying content about natural resources as part of science education in schools is important for scientific literacy. We analyzed the science textbooks of the subject "Mineralogy/Geology" used before World War II (WWII) (1886-1941) in Japan, relying on both quantitative and qualitative approaches. In addition, we analyzed professors' ideas about teaching natural resources based on the textbook content. From our analysis, three facts are clear. First, the number of natural resources included in textbooks was maintained even though the laws and ordinances of secondary school science curricula were changed. Second, the social changes brought about by industrial development necessitated teaching about natural resources in schools. Third, natural resources education aimed to contribute to the betterment of human life, since professors had ideas about improving the well-being of Japanese citizens.
Keywords: *natural resources education, historical perspective, secondary school in Japan*

INTRODUCTION

Although natural resources education has been re-introduced into the earth science curriculum at the upper secondary school level in Japan when the Course of Study revised (MEXT, 2009, 2018), the purpose of this type of education had not been referred to in their Course of Study. Even though its purpose has not been explained in the curriculum, it was taught before World War II (WWII). However, recent social and industrial pressures require educators to rethink it as one the curriculum material.

In today's drastically changing world, it is important to identify what content involving natural resources in science education should be taught in schools to develop scientific literacy. For this reason, we investigated the purpose and content of natural resources education in Japan before WWII.

We set the following two research questions:

- What type of natural resources content was included in science textbooks and in how many volumes?
- Why was the subject of natural resources taught in schools?

METHODS

To answer these research questions, we analyzed textbooks written prior to WWII (1886-1941) using both quantitative and qualitative approaches. In addition, we investigated textbooks written by professors of Tokyo and Kyoto Imperial Universities, such as Kotaro Jinbo, Tadasu Hiki, and Takeo Kato. We analyzed their concepts about teaching natural resources in the textbooks.

RESULTS

Three facts are clear from our analysis. First, the number of natural resources that was included in textbooks was maintained even though the laws and ordinances of science curricula of secondary schools changed between 1886 and 1941 (Figure 1). Figure 1 shows that an increase in both the number of natural resources content and the page count was the general trend between 1886 and 1931. Thereafter, the content was maintained while the number of pages decreased. Second, we found that social changes brought about

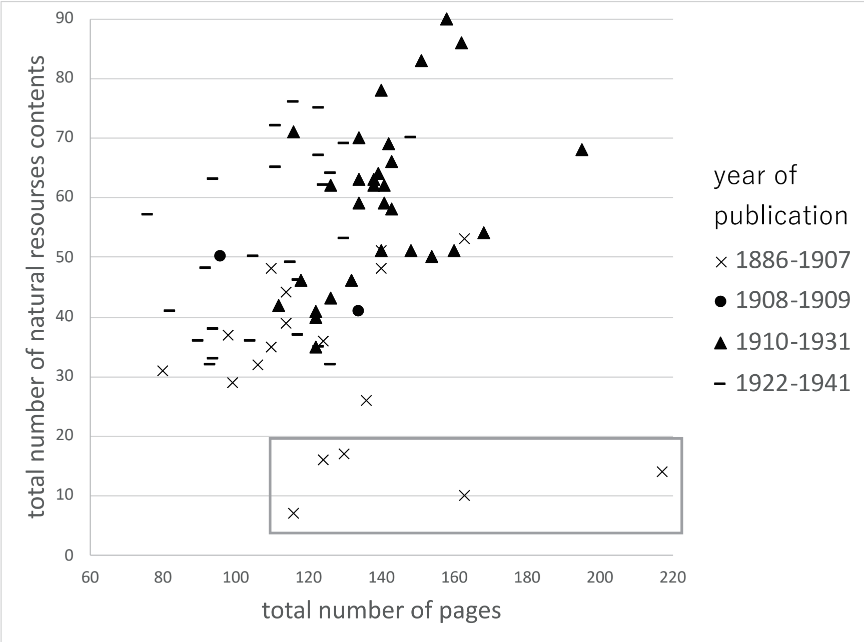

FIGURE 1: Number of natural resources content covered in *Mineralogy/Geology* textbooks (the lowest five cross marks in the square are *General natural history*) in relation to overall textbook size measured in pages. Different markers represent different historical periods.

by industrial development required geological education to teach natural resources in schools. Moreover, the professors had ideas about how to improve the well-being of Japanese citizens, which was outlined in the unit "*Mineral and Human Life,*" included at the end of the "*Mineralogy/Geology*" science textbooks. In this unit, the focus changed from teaching how to exploit domestic resources efficiently to promoting a need for technological advancement due to the social and industrial changes that occurred in Japan when compared to other countries. Jinbo (1896), who initially added this unit to the textbook, argued that students should not only learn the science of knowledges by rote but also understand the interrelationships between knowledges. Third, it became clear that natural resources education contributed to the betterment of human life. Though it focused on how natural resources were used and their significance to society, the purpose of natural resources education included social and cultural aspects.

From a historical perspective, we argue that the purpose of teaching natural resources in science education should not only be from a practical perspective but also from social and cultural perspectives.

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Oral Session 2	Day1 (June18th) 16：30～18：00
Room4	C4-2

【Category】 4: Science Education for High School and Related Areas

=Chairperson=

Prof. Li, Gao-Feng	Shaanxi Normal University

=Presentation Program=

1	34-4-2-18-1（FXJY-Z8HL-1U021） Erkki T. Lassila（University of Oulu） Manabu Sumida *THE PLACE-BASED NATURE OF THEMATIC RESEARCH ACTIVITIES IN JAPANESE SUPER SCIENCE HIGH SCHOOLS (SSH)*
2	35-4-2-18-2（FXNU-04T3-1T021） Hsuang-Ming Tseng（National Changhua University of Education） Hsiao-Lin Tuan *Development and Discussion of the Acceptance Model of Emerging Technology Courses: Take the artificial intelligence course for high school students as an example.*
3	36-4-2-18-3（FXWT-843A-12021） Sucie Nuryani（Student, Indonesia University of Education） Irma Rahma Suwarma, Dadi Rusdiana *FEASIBILITY ANALYSIS OF THE DEVELOPMENT OF STEM-BASED PHYSICS MODULE WITH SELF REGULATED LEARNING FOR SENIOR HIGH SCHOOL*
4	37-4-2-18-4（FY35-JQMV-88021） Ujang Fahmi Abdillah（University of Jember） I Ketut Mahardika, Indrawati *THE EFFECT OF THE TPACK-BASED PHYSICS MODULE AND THE MULTI-REPRESENTATION OF WORK AND ENERGY MATERIALS TO IMPROVE CRITICAL THINKING SKILLS AND LEARNING OUTCOMES OF GRADE 10th OF HIGH SCHOOL STUDENTS*

THE PLACE-BASED NATURE OF THEMATIC RESEARCH ACTIVITIES IN JAPANESE SUPER SCIENCE HIGH SCHOOLS (SSH)

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ABSTRACT
In this research, through the concept of place-based education and case examples from three Super Science High-schools located in Ehime-prefecture Japan, we examine how the thematic research activities of the schools are connected to the local environment in ways that benefit both the community and the learning of the students. Place-based education has been seen meaningful in linking education to issues of the surrounding community and creating emotional connection. In earlier research, we have highlighted different networks of collaborators and environments as one of the key strengths of the program (Lassila & Sumida, 2020). Here, we illustrate different ways schools use curricular design to guide the student's interest toward regional themes, such as limiting the choice for topics and designing visits and guest lectures to peak interest in the local issues. The location of the school also plays a role in how prominent the place becomes regarding the research activities.

Keywords: *Japan, place-based education, STEM, Super Science high-schools,*

BACKGROUND

Super Science High Schools (SSH) is a government mandated program, which aims to nurture high-talent in the STEM field. Schools are nominated and funded for 5-year periods. They share overall objectives and defining features of thematic research (*kadai kenkyû),* curriculum development, school networking (also abroad), and cooperation with universities, but can individualize their approaches (Sumida, 2017). The SSH program emphasizes use of high-level techno-science related to regional perspectives through for example environmental protection, disaster prevention and local industries (JST, 2018). This echoes place-based education, where the local cultural and ecological environments are seen as fundamental to the purpose and process of schooling, influencing science learning (Buxton & Provenzo, 2012).

CONDUCTING THE RESEARCH

We present a case of the three SSH schools at Ehime prefecture: 1) Saijô, 2) Uwajima Higashi and 3) Matsuyama Minami. The data consists of schools' progress reports, students' research paper collections and thematic interviews with teachers. We focus on the curricular design for the first-year students to how the themes and regional collaboration reflect the idea of place-based education. The thematic research should be approached through student's self-directed approaches and interests, but for cultural and educational reasons (Lassila & Sumida, 2020), the schools intentionally guide the student's choices.

CURRICULUM DESIGN & EXAMPLES OF PLACE-BASED EDUCATION

Saijô's goal is to "*progress culture scientific thinking starting from 'why?'*". They start with lectures by city representatives on disaster prevention, economics, internationality and healthcare to help students understand local issues and their own role in finding solutions. Their first research must be done within these themes. Pre-thematic research activities train necessary research skills, including how to collaborate locally. ***Example:*** The students conducted research on a local tea variant, famous for its double-fermentation process. They analyzed its chemical composure together with Ehime University's Faculty of Agriculture to see if the tea had allergy suppressing qualities.

Uwajima Higashi's goal is *"Regional innovation – changing the area through scientific ability"*. They start with a course, where in addition to research skills, the aim is to foster love for the home-area and attitude of giving back through one's skills. Lecture visits and sessions for deciding the research themes are organized. The students are allocated into three sub-themes on fundamental science, 'living environment' and general science, under which students do their research. ***Example***: Student's conducted research examining the origin of stones of the local castle. Together with the castle's staff, combining knowledge of history and geology, they managed to identity the origin to nearby areas.

Matsuyama Minami aims to "*foster human resources capable of contributing to new cultural creation and development*" and starts with a course, where in collaboration with Ehime university (visits to 3 research centers) and international partner schools, the students learn natural sciences through cutting-edge examples. Regionality is not really emphasized. The students choose their themes freely, although visits and activities are likely planned to inspire them. ***Example:*** Students collaborated with branch-school and local craftsmen to create a new color of glazing and design for traditional Tobe-yaki pottery, that would appeal to younger generations. They incorporated ash from maidenhair trees to strengthen local flavor.

DISCUSSION

The students research themes can be directed towards the place via limiting the scope of student's research topics or choosing specific guest lecturers, places for research visits, and materials available. Some themes however are connected to specific circumstances such as the vicinity of cultural heritage sites as in Uwajima. Matsuyama Minami, being located in more urban setting and removed from nature environments, directs students towards fields IT, engineering, medicine less concretely connected to the place. Place is present as collaboration with local experts and as concrete connection to land via natural materials. The level of emphasis varies between the schools, but research connected to traditional culture or local produce can foster 'meaningful place-based learning'. Contributing to one's community deepens the commitment towards science studies and emotional connection can also make the student's also more likely to stay or return after graduation, contributing to the areas' vitality and longevity.

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Development and Discussion of the Acceptance Model of Emerging Technology Courses: Take the artificial intelligence course for high school students as an example

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ABSTRACT

With the rapid development of science and technology, the subjects and content traditionally learned in schools are no longer adequate under the challenges of global competition. On the contrary, the learning of related emerging technologies will become more important in the future. This study period takes the artificial intelligence course for high school students as an example, hoping to use the TAM (Technology Acceptance Model) that has been widely used in the field of business management as a reference blueprint and foundation to verify the factor structure of the "Emerging Technology Course Acceptance Model" . This research expects that this model can be used as a reference for predicting or explaining students' decision-making when facing emerging technology-related courses. At the same time, it can assist teachers to understand the participation status of learners and the degree of acceptance of the subject's knowledge and whether they are willing to continue to devote their efforts and time to extended learning in the future when teaching courses at the teaching site. The Emerging Technology Curriculum Acceptance Model is mainly composed of 12 questions in three dimensions: Perceived ease of learning(PEL), Perceived usefulness(PU), and behavioral learning intention(BI). The results of this study have significant and good performance in terms of reliability and validity, which shows that this model can be used as an important reference tool for course teachers and education units in planning or developing courses related to emerging technologies.

Keywords: *Emerging Technology, Technology Acceptance Model, Artificial Intelligence.*

1.Introduction

This research takes the artificial intelligence curriculum as an example, and uses the TAM (Technology Acceptance Model) that has been widely used in the field of business management as a reference blueprint and foundation to develop and validate the emerging technology curriculum acceptance model. It is expected that this development model can explain students' decision-making factors when facing emerging technology-related courses, and provide course teachers and education units as an important tool for course development and revision.

2. Literature Discussion

The Technology Acceptance Model (TAM) is a theoretical model proposed by Davis in 1985. The model is mainly used to predict users' acceptance of emerging technologies and continue to use theoretical models. Davis is based on the Theory of Reasoned Action (TRA) (Fishbein & Azjen, 1975), and introduced perceived usefulness (PU) and perceived ease of use (PEOU). Two important potential variables are used as causality to develop the TAM model. According to the results of Davis's research, there is a causal relationship between perceptual ease of use and perceptual usefulness, and the model confirms that the user's attitude will influence whether to accept and use emerging technologies in the end.

3. Research Structure and Process

Based on the research purpose and literature discussion, the researcher has drafted the research framework as follows:

Step1.

- Formal Test.
- A total of 242 valid samples (male: 142, female: 100).

Step2.

- Sequential quantitative analysis and screening questions.

Step3.

- Technology Acceptance Model be a reference blueprint.
- Develop and confirm the acceptance model of emerging technology courses in three dimensions: PU, PEL, and BI.

4.Results

The results of this research after quantitative analysis are as follows: Measurement model parameter estimation(Table 1.) and Hypothesis path(Figure 1.)

Latent Variable	Item	Outer Loadings	Cronbatch's α	CR	AVE
BI	BI_1	0.954	.876	.941	.889
	BI_2	0.932			
PEL	PEL_1	0.933	.968	.975	.887
	PEL_2	0.927			
	PEL_3	0.950			
	PEL_4	0.955			
	PEL_5	0.943			
PU	PU_1	0.935	.974	.979	.905
	PU_2	0.957			
	PU_3	0.957			
	PU_4	0.955			
	PU_5	0.952			

Table 1. Measurement model parameter estimation table.

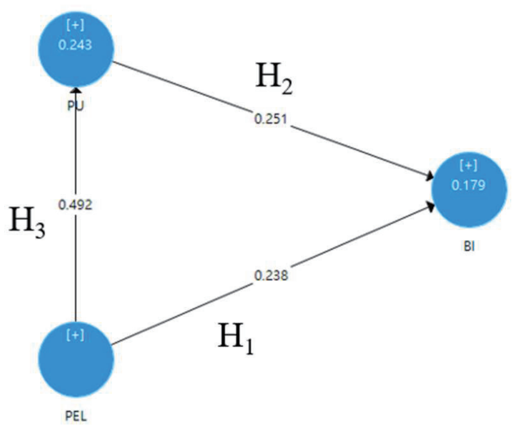

Figure 1. Hypothesis path.

5. Conclusion

The 15 questions in the three dimensions in the original model were deleted and confirmed as 12 questions based on quantitative statistical analysis. The reliability and validity, internal consistency (CR value), convergence validity (AVE value), and discriminative validity (cross-loading) between each topic and construct in the three dimensions are all higher than those recommended in the literature, which clearly shows that this developed measurement tools have good and appropriate evaluation capabilities. Through the analysis results of PLS-SEM, it can be found that the three structures(PEL, PU, BI) of TAM can be applied to the development of emerging technology curriculum acceptance models.

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FEASIBILITY ANALYSIS OF THE DEVELOPMENT OF STEM-BASED PHYSICS MODULE WITH SELF REGULATED LEARNING FOR SENIOR HIGH SCHOOL

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ABSTRACT

This study aims to feasibility analysis of the development of STEM (Sains, Technology, Engineering, and Mathematics) based physics module with Self Regulated Learning (SLR) for senior high school. The STEM-based module developed is equipped with an SLR agent that helps students learn the material. This reseach is a R&D (Research and Development) with The research sampel refers to 2 experts assessments, 3 online students responses, and 3 offline students responses. The instrument used are expert validation sheet and legability tests of the main idea of the module on each page. The results of the analysis show that the validation of expert judgment for STEM-based modules with SLR is in the very high category. Meanwhile, the readability test results for online and offline student responses were in the category of good. There were differences in the results on the readability test, then the Q-Cochran Test was carried out in Asymp. Significance with α = 5%, so there was no difference in the results of the online and offline students. This shows that the development of physics module base on STEM with SLR is 'feasible' to widely implemented.

Kata Kunci : Module, STEM, Self-Regulated Learning; Feasibility

1. INTRODUCTION

The development of science and technology is increasing rapidly in the 21st century. Good education is one of the ways to create active, creative and innovative learning in using media, technology, information and communication [1]. STEM is an integrated learning approach capable of facing the challenges of the 21st century and improving the quality of the learning process which will then improve the quality of graduates [2][3]. In addition, the integration of STEM aspects has a good impact on the student learning process, especially in the process of achieving science and technology[2]. The use of STEM can be applied in models, teaching materials, and work sheets as well as improving 21st century skills [4].

The existence of learning media is very important in the teaching and learning process. One of the learning objectives is not achieved because the learning media isn't good for the student learning process [4]. In line with this, the current condition with the issue of the Covid 19 pandemic has a bad impact on education so that there must be other alternatives[5]. Students are required to learn independently. Self Regulated Learning (SRL) as the ability of learners to actively participate in the learning process, both metacognitively, motivatively and behaviorally [6]. Based on the descriptions that have been described, this study aims to analyze the feasibility of developing STEM-based modules with SLR for high school students.

2. METHOD

The research method is a R&D by using 3 design consists of : Research and information collecting, planning, and develop preliminary form of product. The research instrument used was the feasibility test of the module from the results of 2 experts assessments and the legibility test of the results of student responses to the main idea of each page in the module with 3 students conducted online and 3 students carried out offline. Analysis of the feasibility level of the module using the Aiken validation technique if the answer choices from the instrument consist of several choices with a certain score and then the Q-Cochran Test is carried out.

3. RESULT AND DISCUSSION

STEM-based module development with SLR refers to modules that already exist in schools and then adapted to STEM. The module is equipped with an icon called the SLR Agent which helps students understand the material.

The results of the research analysis were carried out by a validation process by 2 experts assessments who were experienced and competent in their fields, using instruments that had been made using Aiken's validation. The results of module validation by experts are shown in table 1.

Table 1. Module Validation Analysis by Experts

No	Components	Validation	Category
1	Material suitability instruments and STEM	0,767	High
2	Module compatibility with SLR	0,86	Very High
3	Feasibility of teaching materials	0,84	Very High

Based on table 1, it shows the results of the analysis of the 3 components in the module. It is concluded that the feasibility of the module by expert validators is in the 'good' category. Thus the module is suitable for use and can then be tested on students for legibility tests.

Furthermore, the analysis of the readability test of 3 students online and 3 students offline. Students read each page in the module and measure the time required for each page, then students are asked questions about the main idea on the page. The results of the student readability test analysis are shown in table 2.

Table 2. Online and offline readability test results

	Readability average (%)	Average time per page (detik)	Category
Online	94,62	47, 67	Good
offline	95,7	58,73	Good

Based on table 2, it shows that the average time it takes students online and offline to read the module on each page which has a difference of 11.06 seconds for each page. While the average readability test for online and offline student responses was in the good category even though it had a percentage difference value as shown in table 2.

Based on this description, there are differences in the readability of student responses, so the Q-Cochran Test is carried out to find out whether there is a significant difference or not, as shown in table 3..

Tabel 3. Validation Results Module Readability Test

<table>
<tr><td rowspan="2">Statistics</td><td colspan="2">Module Validity</td><td rowspan="2">Category</td></tr>
<tr><td>offline</td><td>online</td></tr>
<tr><td>N</td><td>3</td><td>3</td><td rowspan="4">a. 1 is treated as a success</td></tr>
<tr><td>Cochran's Q</td><td>39,452[a]</td><td>28,636[a]</td></tr>
<tr><td>df</td><td>30</td><td>30</td></tr>
<tr><td>Asymp. Sig.</td><td>0,116</td><td>0,537</td></tr>
</table>

Table 3 test results of the module readability test with Q-Cohran statistics obtained Asymp. Significance respectively 0.116 and 0.537 are greater than α = 5% so accept H_0. It can be concluded that there is no difference in the module readability test results for students.

4. CONCLUSION

The results of the feasibility test of the module showed that the module was in a good category and was feasible to be widely implemented and no significant difference was found for the use of modules both online and offline.

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THE EFFECT OF THE TPACK-BASED PHYSICS MODULE AND THE MULTI-REPRESENTATION OF WORK AND ENERGY MATERIALS TO IMPROVE CRITICAL THINKING SKILLS AND LEARNING OUTCOMES OF GRADE 10th OF HIGH SCHOOL STUDENTS

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ABSTRACT

This study analyses the effect of the TPACK-based and multi-representation physics module on improving critical thinking skills and learning outcomes of grade 10th in high school students on Work and Energy. The type of research used was quantitative descriptive with 30 respondents of grade 10th of Senior High School students at SMAN 3 Jember. The research method used one group pre-test and post-test design that gave a pre-test and post-test before and after using the module in each lesson. The research data obtained were analyzed by looking for the N-gain value to determine the categories of increasing critical thinking skills and students learning outcomes. The N-gain value obtained for each critical thinking component covers interpretation of 0.54, analysis of 0.47, evaluation of 0.63, inference of 0.50, explanation of 0.69, and self-regulation of 0.50. It has an average critical thinking component N-gain value of 0.55, indicating an increase in critical thinking skills in the medium category. Simultaneously, the N-gain value of student learning outcomes was obtained at 0.46, which indicates an increase in student learning outcomes in the medium category.

Keywords: *Physics Module, TPACK, Multi-representation, Critical Thinking, and Learning Outcome.*

1. INTRODUCTION

The study aimed to develop a teaching material specifically in the physics module based on TPACK and a multi representation in Work and Energy for class 10th grade to improve students' critical thinking skills. The characteristic of TPACK was for integration between technology knowledge, pedagogy, and content knowledge (Nurhidayah & Suyanto, 2020). Technology integration could be seen in using QR (Quick Response) code to utilize internet resources such as photos, images, videos, animations, simulations, and website pages. The integration of pedagogy knowledge was implementing a scientific approach, covering observing, questioning, gathering information/trying, associating/reasoning, and communicating in learning activities. Content integration could be seen in the suitability of the material presented with the competency demands on the syllabus. The use of multi-representation in the module emphasizes all types of representations in verbal, mathematical, pictures, and graphics given in each learning activity (Mahardika, 2013). Meanwhile, the Implemented indicators in the critical thinking skills follow Facione (2015): interpretation, analysis, evaluation, inference, explanation, and self-regulation. Critical thinking skills is one of the skills that students must have in 21st-century learning (Wardani & Jatmiko, 2021).

2. METHODOLOGY

The participants were given a pre-test and post-test when they used the module in each lesson. The module was designed for four learning activities. Each student learning activity does on each of the three pre-test and post-test questions in the form of multiple choices. The total number of questions was 12 multiple choice that tested with critical thinking indicators. The data analyzed were obtained by looking for the N-gain value on each indicator of critical thinking and student learning outcomes to determine the categories of increasing the critical thinking skills and student learning outcomes. The N-gain criteria consulted with Hake (1998) that stated if N-gain <0,3 is low; 0,3 ≤ N-gain < 0,7 is medium; N-gain ≥ 0,7 is high.

3. RESULT

The results of data analysis get the N-gain value for each critical thinking indicator can be seen in table 1.

Tabel 1. The Critical thinking analysis of each indicator

No.	Indicators	N-gain	criteria
1.	Interpretation	0.54	Medium
2.	Analysis	0.47	Medium
3.	Evaluation	0.63	Medium
4.	Inference	0.50	Medium
5.	Eksplanation	0.69	Medium
6.	Self-regulation	0.50	Medium
	Average	0.55	Medium

The comparison of the pre-test and post-test grades is describing in figure 1.

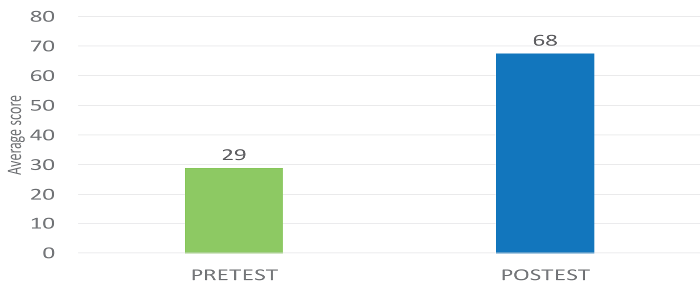

Figure 1. the comparison between pre-test and post-test

TPACK and multi representation affected improving student learning outcomes. This result is in accordance with Husnah's (2017) research, which states that there was a relationship between critical thinking skills and increased student learning outcomes.

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Oral Session 2	Day1 (June18th) 16：30～18：00
Room5	C5-2
【Category】	5: Science Education for Undergraduate or Graduate School Students

=Chairperson=

Prof. Chin-Fei Huang	National Kaohsiung Normal University

=Presentation Program=

1	38-5-2-18-1（FY63-7PBK-GK021） Tomotaka KURODA（Shizuoka University） *Evaluation of a First-Year Experience Program Developed on the Basis of Learning Characteristics of STEM Human Resources: A Focus on the Elements of a Generic Competency Model*
2	39-5-2-18-2（FY5H-D6K2-KZ021） Wanpen Kamtet（Kasetsart University, Kamphaeng-Saen Campus, Thailand） Tussatrin Wannagatesiri *The Development of Biology Student Teachers’ Scientific Explanation Abilities by using the Problem Solving of Context - rich Problems Model*
3	40-5-2-18-3（FY5M-ZTC6-H8021） Duangjan Kaewkongpan（Kasetsart University, Kamphaeng Saen Campus） Tussatrin Wannagatesiri *The Development of Pre-service Science Teachers’ Pedagogical Content Knowledge: Case of Adapting and Designing Learning Materials*
4	41-5-2-18-4（FY4L-4DH7-RF021） Yong XIE（Beijing normal university） Chun-ping LIU, Chang-qiu YI, Xin-yue JIAO and Ning MA *RESEARCH ON THE PATTERNS OF COLLABORATIVE SCIENTIFIC ARGUMENT IN DIFFERENT COGNITIVE STYLE GROUPS*

Evaluation of a First-Year Experience Program Developed on the Basis of Learning Characteristics of STEM Human Resources: A Focus on the Elements of a Generic Competency Model

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ABSTRACT
This study examined whether the elements of a generic competency model could be enhanced to expand the learning experience of the first-year program for science, technology, engineering, and mathematics (STEM) human resources. To achieve its purpose, it incorporated a design focusing on the contents and learning environments of courses of STEM human resources. A survey comprising five categories and 12 factors was administered to students to investigate the elements of a generic competency model created by the target university. The responses obtained on the comprehension of course contents and the self-assessment of the enhancement of competencies were compared with the previous year's (2018) results. All categories relating to understanding course material were higher for 2019, and the t-test revealed a significant difference at the 0.1% level for three of the five items. All categories probing the self-assessed growth in competencies also registered higher scores for 2019, and the t-test revealed a significant difference at the 0.1 % level for four of the five items. These findings suggest that generic competencies can be improved, and a sense of growth can be inculcated in students by developing programs based on the STEM human resources context. Future studies must collect more data through questionnaires and perform analyses to elucidate student opinions on learning and learning environments.

Keywords: *Higher Education, STEM Education, Curriculum*

INTRODUCTION

Japan is currently transforming its higher education policies and educational system. The paradigm shift particularly aims to foster "zest for life" and indoctrinate "three elements of academic proficiency" in students, besides competencies and abilities (Central Education Council of Japan, 2008 and 2014; Ministry of Education, Culture, Sports, Science, and Technology, 2007). These policy changes mandate the cultivation of advanced levels of social skills in learners in addition to discipline-specific knowledge and skills to develop the necessary human resources for science, technology, engineering, and mathematics (STEM) careers. This study examined whether the elements of a generic competency model could be enhanced to expand the learning experience of the first-year program for STEM human resources. To achieve its purpose, it incorporated a design focusing on course content and contexts required from STEM human resources.

OVERVIEW OF THE CASE

Ehime University is a national university in Japan. Subjects related to the first-year experience program were reorganized in 2009, and a new subject entitled Freshman Seminar A was introduced. This subject was individually managed by the concerned faculty and department. The faculty was reorganized in 2019, and Freshman Seminar A was extensively amended. It was redesigned to offer students the fundamental skills required to succeed at academics and cope with difficulties associated with university life. Thus, the following aspects were incorporated into the course content: (1) acquiring foundational academic skills, (2) strengthening first-year education through an initial "short term" schedule that allowed cost reduction by reducing the number of teachers-in-charge and shortening the introductory period, (3) increasing opportunities for learners to speak and ensuring educational efficacy by reinforcing active learning in small groups, and (4) utilizing senior students. In addition, the class objectives, goals, and contents of this program were created and examined based on the science and engineering practices of the next-generation science standards (NGSS). A total of 239 students enrolled in Freshman Seminar A in 2018, and participated in a survey conducted in 2019.

METHOD

The questionnaire survey attended to the competency elements of a generic competency model created by the target university. The instrument comprised five categories and 12 factors: I: ability to apply knowledge and skills, II: ability to think logically and make decisions, III: ability to communicate with diverse people, IV: ability to survive autonomously, and V: ability to belong and contribute as a member of an organization or society. This study examined the participants' comprehension of course materials and their self-assessment of the development of competencies, comparing the results obtained from students who attended the program in the previous year (2018). The items were rated using a five-point Likert scale (5 = very much; 4 = much; 3 = some; 2 = not much; and 1 = not at all). The number of respondents belonging to the 2018 cohort was 228. In 2019, the numbers were 236, 232, and 231 before, midway (13th class out of 15), and after the program, respectively.

RESULTS AND DISCUSSION

All responses were positive. The t-test results revealed that three items displayed a significant difference at the 0.1% level. The increased awareness resulting from the course may be attributed to the impact of sustained motivation achieved through the class design based on STEM human resources context. The t-test results for the self-assessment of the sense of growth indicated a significant difference at the 0.1% level for four items. These results also confirmed that designing lessons based on the learning environments acquired from STEM human resources strengthened the generic competency model (skillsets). Thus, the outcomes of this study highlight the importance of considering the learning background of STEM human resources to develop generic competency models or skillsets. Therefore, it is vital to consider the learning contexts of STEM human resources to improve educational effectiveness.

CONCLUSION

The study examined whether the elements of a generic competency model could be ameliorated through the inclusion of a course design focused on content suited to the learning contexts of STEM human resources. A significant difference ($p < .001$) was noted in three out of five tested items with respect to the understanding of course content. A similar significant difference was observed for four of the five items relating to the self-assessment of the sense of growth. The findings suggest that effective learning can occur if the course content is focused on the knowledge acquired from STEM human resources. However, the study admits to some limitations. Future studies must collect more data through questionnaires and perform analyses to elucidate student opinions on learning and learning environments.

ACKNOWLEDGMENTS

The research document and data were supported by the Faculty of Science of Ehime University.

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The Development of Biology Student Teachers' Scientific Explanation Abilities by using the Problem Solving of Context – rich Problems Model

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1. Kasetsart University, Kamphaeng-Saen Campus, Thailand

ABSTRACT

The main purpose of this research was to develop the biology student teachers' scientific explanation abilities by using the problem solving of context – rich problems model. The model is composed of 4 main steps; 1) analyze context – rich problems, 2) design, plan and implement for more scientific data, 3) create scientific explanation and 4) reflect and feedback. This study is a quasi-experimental research; one group only pretest- posttest design. Research participants were 29 third year biology student teachers in tertiary level. The research instruments consisted of 1) scientific explanation ability test and 2) biology conceptual understanding test. The data was analyzed by using arithmetic mean, standard deviation, dependent sample t-test and Pearson's correlation coefficients. A set of CRPs; realistic scenarios which provided the biology student teachers plausible motivation for solving the problem was created and introduced to the biology student teachers during the Biology in Upper Education II course (6 weeks). The data showed that post-biological conceptual test was higher than pre- at significant level .01. Post-scientific explanation ability test average score was higher than pre- at significant level .01. There was a significantly high relationship between biology student teachers' scientific explanation ability and biology conceptual understanding at 0.01. The findings reveal that CRPs that include excess information, or require the biology student teachers to recall important background information, and conduct experiments, were able to drive scientific explanation abilities of biology student teachers.

Keywords: *Biology Student Teachers, Scientific Explanation Abilities, Problem Solving, Context – rich Problems Model*

INTRODUCTION

Improving students' scientific explanations is one major goal of science education. Scientific explanation is essential not only for scientists, but also for the students (NRC, 2000). When students develop and critique explanations it helps them learn the science content and motivates them to study science as they realize learning science is more than memorizing facts. Especially in everyday life, the students have to be prepared for examining the claims of others and to communicate their own ideas with supporting evidence and reasoning. Hence, as a part of the teacher development program, the main purpose of this research is to develop the biology student teachers' scientific explanation abilities by using the problem solving of context – rich problems model.

METHODOLOGY

This study is a quasi-experimental research; one group only pretest- posttest design. The research instruments consisted of 1) scientific explanation ability test and 2) biology conceptual understanding test. A set of 9 context – rich problems scenarios; Collagen, Long Neck Karen, Baby Milk, Pine Forest, Upside Down, Chlorophyll Beverage, Alcohol and Cold Exposure, Color of Sashimi, and Wound Healing by

Honey, is introduced to motivate 29 third year biology student teachers for solving the problem by using the problem solving of context – rich problems model during the Biology in Upper Education II course (6 weeks). The model comprises of 4 main steps; 1) analyze context – rich problems, 2) design, plan and implement for more scientific data, 3) create scientific explanation and 4) reflect and feedback. The data was analyzed by using arithmetic mean, standard deviation, dependent sample t-test and Pearson's correlation coefficients.

RESULT

The data shown that post- biological conceptual test is higher than pre- at significant level .01. Post-scientific explanation ability test average score is higher than pre- at significant level .01. There is a significantly high relationship between biology student teachers' scientific explanation ability and biology conceptual understanding at 0.01 (Table 1).

	Claim (total score = 20)			Evidence (total score = 20)			Reasoning (total score = 20)			Scientific explanation ability (total score = 60)			Biology conceptual understanding (total score = 20)			r
	Mean	S.D.	p	Mean	S.D.	p	Mean	S.D.	p	Mean	S.D.	p	Mean	S.D.	p	
Pre-	12.93	2.45	.000*	9.42	3.62	.000*	3.44	2.31	.000*	25.41	7.70	.000**	12.22	3.12	.000**	.736**
Post-	17.33	1.75		16.04	2.37		13.56	4.78		46.38	8.51		18.00	2.40		.706**

*p < .05, **p < .01

Table 1. Pre- and Post-test Result

DISCUSSION

To be able to share problem solutions, the biology student teachers were encouraged to making claims, searching/ experimenting evidence and providing related scientific reasoning (Cheng, She, & Huang, 2017; McNeill & Krajcik, 2012). The research results revealed that biology student teachers were able to analyze concepts related to context – rich problems and necessary information for the claim. They could operate to obtain more scientific information as evidence for supporting the claim. More complete scientific explanation could be created after receiving feedback from the instructor (Konold, Miller, & Konold, 2004). The findings reveal that CRPs that include excess information, or require the biology student teachers to recall important background information, and conduct experiments, were able to drive scientific explanation abilities of biology student teachers.

CONCLUSION

The results showed that the problem solving of context – rich problems model is useful to support science student teachers' learning scientific explanation. The results also support the idea that student teachers can learn scientific explanations through well-designed problems which start from simple to more complex problems. As series of problems in the study provided the student teachers experience in searching and conducting their own experiments for finding out the evidence to support their own claim.

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The Development of Pre-service Science Teachers' Pedagogical Content Knowledge: Case of Adapting and Designing Learning Materials

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ABSTRACT

This research aimed to 1) develop a tool for assessing the pre-service science teachers' Pedagogical Content Knowledge (PCK) in 5 dimensions; content knowledge, curriculum knowledge, pedagogical knowledge, knowledge of learners, and assessment knowledge, 2) reflect the effectiveness of using PCK development model in the context of science learning materials production, 3) enhance the knowledge and understanding of PCK in the context of science learning material production, and 4) compare pre-test and post- test self-confidence about using PCK development model in the context of science learning materials production. The research was divided into 2 phases. The first phase of research was probing the pre-science teachers' PCK by using an interview-about-instances technique. The IAI interview was conducted based on the discussion of science learning materials, which were designed by the pre-service science teachers themselves. The individual interviews were 18 fourth year pre-service science teachers. The interview results revealed some scientific misconceptions held by the pre-service science teachers. They were unable to design teaching activities and learning assessment of the learning materials which were used in the interview. Most pre-service science teachers were not able to utilize the learning materials for seemingly performing constructivism as their core paradigm for teaching and learning. The second phase of the research was developing the pre-service science teachers' PCK via a context of adapting and designing learning materials. The PCK development model consisted of 2 main stages: 1) introduction of PCK and 2) development of PCK. The research participants were 23 fourth year pre-service science teachers who enrolled in the creating innovative science learning media course. The results of the research revealed that the pre-service teachers were able to create innovative science learning media and related to the five elements of the PCK at a high level (Mean = 4.30, S.D. = 0.60). They also had high confidence of their PCK (Mean = 4.14, S.D. = 0.67).

Keywords: *Pre-service Science Teachers, Pedagogical Content Knowledge, Designing Learning Materials*

INTRODUCTION

Pedagogical content knowledge (PCK) is generally accepted as positively impacting teaching quality and student learning. Lesson plans are the most important component in preparing quality learning. Teachers' low understanding of pedagogical content knowledge affects their skills in designing learning (Maryani, Martaningsih, Bhakti, 2017). Several research studies tried to increase the engagement and skills of future teachers in designing lesson plans using modules based on pedagogical content knowledge. In contrast to earlier studies on PCK sources, this study aims to develop pre-service science teachers' PCK via the context of adapting and designing learning materials. The research believed that knowing PCK and its components, content knowledge, curriculum knowledge, pedagogical knowledge, knowledge of learners, and assessment knowledge, could start with designing learning materials as the small piece of jigsaw to more concrete before designing the whole lessons.

METHODOLOGY

This study is a quasi-experimental research; one group only pretest- posttest design. The research instruments consisted of 1) the development of pedagogical content knowledge model, 2) Interview questions about PCK and its components, and 3) a 5-points rating scale questionnaire about per-service science teachers' confidence on PCK. The pre-science teachers' PCK were probed by using an interview-about-instances technique. The IAI interview was conducted based on the discussion of science learning materials, which were designed by the pre-service science teachers themselves.

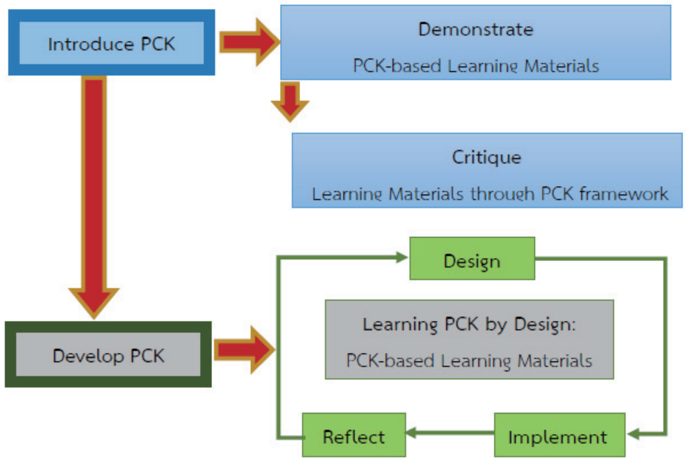

Figure 1. The PCK development model

The PCK development model consisted of 2 main stages: 1) introduction of PCK and 2) development of PCK as shown in Figure 1.

RESULT AND CONCLUSION

The interview results before using the model revealed some scientific misconceptions held by the pre-service science teachers. Most pre-service science teachers were not able to utilize the learning materials for seemingly performing constructivism as their core paradigm for teaching and learning. After the model, the results of the research revealed that the pre-service teachers were able to create science learning material and related to the five elements of the PCK at a high level (Mean = 4.30, S.D. = 0.60). They also had high confidence of their PCK (Mean = 4.14, S.D. = 0.67).

Figure 2. Adapting and Designing Learning Materials

CONCLUSION AND DISCUSSION

In general, a lesson plan could be defined as a set of lesson programs that directs teachers to what lesson material to teach and how to teach it. A good lesson plan at least has the following three components: (1) the purpose of learning, (2) learning activities, and (3) strategy to determine students‟ understanding (Milkova, 2016). However during the process of adapting and designing learning materials would provide the pre-service science teachers to do so within a smaller frame of specific science content and help them to develop PCK before going to designing the whole lessons in their further study program.

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RESEARCH ON THE PATTERNS OF COLLABORATIVE SCIENTIFIC ARGUMENT IN DIFFERENT COGNITIVE STYLE GROUPS

Yong XIE[1], Chun-ping LIU[1], Chang-qiu YI[1], Xin-yue JIAO[1] and Ning MA[1]*

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ABSTRACT

Scientific argument is a form of collaborative learning, which plays an important role in science education. The performance of argument usually varied by different cognitive style. However, the studies have not drawn enough attention to the patterns and effects of students' collaborative argument in different cognitive style groups. Therefore, this study investigates this research gap in order to shed a light on this research topic. Specifically, Participants who were grouped by cognitive styles conducted oral argument on socio-scientific issues and wrote down group argument texts. Their oral argument and written argument texts were coded and analyzed based on Toulmin's Model of argument. The results indicate (1) in the textual argument, the all-analytical cognitive style groups performed best; (2) in the oral argument, the all-analytical cognitive style groups were easy to extend to the argument of adjacent topics, while the all-intuitional cognitive styles group tended to generate echoing words; (3) all groups had few Qualifier elements. This study shows differences in patterns and effects of collaborative scientific argument by cognitive style groups, which could provide educators insights in selecting organizational strategies and scaffolding for scientific argument.

Keywords: *evidence-based argument, collaborative learning, cognitive style*

1 INTRODUCTION

Evidence-based argument is one of the key components in science education practices emphasized by NGSS, which is associated with many benefits in students' science learning, such as developing critical skills and enhancing conceptual understanding (Osborne, 2010). Scientific argument refers to the argument on the socio-scientific issues, which provides an effective environment for the development of scientific knowledge. Toulmin's Argument Pattern (Toulmin, 1958) is a general model in science education research. It proposed that argument contained six elements, including claim, data, backing, qualifier, warrant and rebuttal. Lin et. al used Toulmin's argument model as a scaffolding for science teaching (Lin, 2020).

There are many types of cognitive styles, such as field-independent and field-dependent (Witkin, 1964), intuitional and analytical (Allinson, 1996), etc. Students' cognitive style varies from person to person, but all contribute to their learning. Intuitional one usually makes immediate judgment from a global perspective, while analytical one tends to psychological reasoning. Previous studies have shown that cognitive style affects information integration, collaboration ability, etc., but there is limited research on its effect on argument performance. Therefore, we hypothese different cognitive style groups will affect patterns in scientific argument. Specific questions are put forward as follows.

(1) What are the argument level differences among different cognitive style groups?
(2) What are the feature of argument sequences among different cognitive style groups?
(3) What are the argument elements differences among different cognitive style groups?

2 RESEARCH DESIGN

In this study, three graduate students were selected to conduct a preliminary experiment to adjust the difficulty of socio-scientific issues and the argument time. In the formal experiment, 24 graduate students from a certain university in Beijing were randomly selected. After introducing the experiment and measuring their cognitive style, they were divided into groups according to the results. In the formal

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experiment, students read information related to the theme, put forward their own claims, and conducted oral argument with group members. Some socio-scientific argument questions were required to answer together in argument. After the experiment, oral and textual argument were coded according to Toulmin's argument model and Zhang Wenjun's argument coding standard separately. The cognitive style groups had four types with three persons, including the all-analytical group, the all-intuitive group, 2 intuitional and 1 analytical group and 1 intuitional and 2 analytical groups.

3 RESULT AND DISCUSSION

A descriptive analysis of oral argument elements found that the number of other elements in the argument was more than 40% in the all-analytical and all-intuitional groups, while the mixed group was about 10%. It seems that mixed groups' arguments were more efficient. All groups had few Qualifier elements, which was consistent with Lin's research that high school students had basically difficulty in using Qualifier (Lin, 2020).

GSEQ5.1 was used to conduct sequence analysis of the encoded oral argument elements, and the results showed that there were four significant argument sequences in the all-analytical groups, including Claim to Claim, Data to Data, Rebuttal to Rebuttal and Backing to Backing. When the claims were inconsistent, the group members would constantly refute. While consistent, they would put forward a lot of data and backings to support the claims together. Qualifier to Claim, Rebuttal to Rebuttal, Rebuttal to Backing and Data to Data were argument sequences in the all-intuitional groups. When they contradicted, they would not agree with each other until someone offered persuasive backings. And all-intuitional one tended to add qualifier words before making claims based on personal experience. The significant argument sequence of the 2 intuitional and 1 analytical groups was Data to Data and the 1 intuitional and 2 analytical groups was Rebuttal to Qualifier.

The average score of text argument in four types of groups was 17.6. The all-analytical group got the highest scores with an average of 20.5, while the all-intuitional group got the lowest scores with an average of 14.5. The score of mixed groups were around the mean, 2 intuitional and 1 analytical groups were 17.5 and 1 intuitional and 2 analytical groups were 18 averagely.

4 CONCLUSION

(1) In the oral argument, the all-analytical cognitive style groups were easy to extend to the argument of adjacent topics, while the all-intuitional cognitive styles group tended to generate echoing words;

(2) The number of oral argument discourses in the heterogeneous groups was much more than that in heterogeneous groups, and all groups had few Qualifier elements.

(3) In the textual argument, the all-analytical cognitive style groups performed better, the mixed cognitive style groups were average, while the all-wholistic cognitive style groups performed weaker;

To sum up, educators can group students according to their cognitive styles in scientific argument, and provide scaffoldings according the patterns of different cognitive style groups, which help their students to argue particularly towards high level.

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Oral Session 3

Day2 (June19th) 14：30～16：00

Room1	C1-1	Science Education for Young Children and Related Areas
Room2	C2-1	Science Education for Elementary School and Related Areas
Room3	C3-7	Science Education for Middle or Secondary School and Related Areas
Room4	C3-8	Science Education for Middle or Secondary School and Related Areas
Room5	C4-3	Science Education for High School and Related Areas
Room6	C4-4	Science Education for High School and Related Areas
Room7	C5-1	Science Education for Undergraduate or Graduate School Students
Room8	C6-1	Science Education for Informal Setting or Life-Long Learning or In-Service Teacher training

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Oral Session 3	Day2 (June19th) 14：30～16：00
Room1	C1-1
【Category】	1: Science Education for Young Children and Related Areas

=Chairperson=

Assist. Prof. Witat Fakchareonphol	Kasetsart University (Kamphaeng saen campus)

=Presentation Program=

1	42-1-1-19-1（FY5Y-Y7CB-3Z021） Rossama Lumputha（Srinakharinwirot University） Chanyah Dahsah *The Effects of Online Inquiry - Based Learning on Upper Secondary School Students' Collaboration Skills*
2	43-1-1-19-2（FY62-GCWF-N5021） Wei Hung, Huang（NTNU Univwesity） Chun-Yen Chang, Wan-Ching Tseng *Advancing children's engaging in hands-on Mathematics Classroom*
3	44-1-1-19-3（FY6Z-CJVT-BZ021） Yu Wang（Hefei No.6 Middle School, Anhui Province, China） Wenhua Zhang, Qinping Hu, Guangming Zhu *From the perspective of PCK, a comparative study on the discourse analysis of college students' volunteer teaching -- a case study of the college students' volunteer teaching classroom discourse analysis of the "Sunshine Volunteer teaching" activity sponsored by Central China Normal University*

The Effects of Online Inquiry - Based Learning on Upper Secondary School Students' Collaboration Skills

Rossama Lumputha[1] and Chanyah Dahsah[1]

1. Srinakharinwirot University, Thailand.

Collaborative is one of the 21st century skills identified in the learning and innovation skills. It is the teachers' role to preparing students to have a positive attitude when working with a team and be able to work with other happily and successfully. Even, when students need to work in a team remotely while learning online in this pandemic situation. The purpose of this research was studying the effect of online inquiry-based learning on upper secondary school students' collaboration skills. The results indicated that the online inquiry-based learning could promote collaboration skills with a class normalized gain (N - gain = 0.59) at a moderate level. When considering individual students, after learning student's collaboration skills improved at a moderate and a high level, which most of them (76.19%) were at a moderate level (N-gain = 0.33-0.69). The findings of this study highlight the effective inquiry-based learning in online platform and that science teachers could be used to promote students' science learning and 21st century skills, especially during the long-lasting pandemic situation of the COVID-19 where most of the schools use online learning.

Keywords: *collaboration skills, inquiry-based learning, online, upper secondary school*

Introduction

Partnership for 21st century (2019) defines collaboration skills is a fundamental skill necessary for enabling students to live happily in 21st century society. Therefore, teachers are responsible for encouraging students' collaboration skills by giving students opportunities to collaboratively work with others. But due to the pandemic situation of COVID-19, students have to learn at home via online platforms. Teachers have to provide online learning which is not just internet distance learning, but the online learning activities must promote students the necessary skills similar to the learning in the classroom. Thus, this study is interested in studying the effect of online inquiry-based learning on student collaboration skills.

Objective

The objective of this research was to study the effects of online inquiry-based learning on upper secondary school students' collaboration skills.

Methodology

This research is a quantitative analysis using one group pretest-posttest design. The participants were 21 students studying in Grade11 from a school in Bangkok. The research instruments were five online inquiry-based learning lesson plans and collaboration skills observation form adapted from Scoular, Duckworth, Heard and Ramalingam (2020). The collaboration skills consisted of three components: building shared understanding, collective contributing, and regulating. The data analyzed by mean, percentage, and normalized-gain.

Results

The average score of students' collaboration skills after learning ($\overline{X}$ = 23.48) was higher than before learning ($\overline{X}$ = 13.95). The class normalized gain was at a moderate level (N-gain = 0.59), according to the components found that building shared understanding was at a high level (N-gain = 0.74), while, collective contributing, and regulating were at a moderate level (N-gain = 0.63 and 0.47, respectively).

Table 1. The values N-gain of components students' collaboration skills

Components of collaboration skills	Score	Average score		N-gain	Level
		Pre-test	Post-test		
Building shared understanding	9	4.43	7.81	0.74	High
Collective contributing	9	4.29	7.24	0.63	Moderate
Regulating	12	5.24	8.43	0.47	Moderate
Over all	30	13.95	23.48	0.59	Moderate

In addition, the analysis of N-gain of collaboration skills of individual student indicated that 16 students (76.19%) were at a moderate level (N-gain =0.33-0.69), and 5 students (23.81%) were at a high level (N-gain = 0.71-0.90).

Conclusions

According to the results, it could be concluded that online inquiry-based learning could promote students' collaborative skill as same as inquiry-based learning in a classroom (Putri, Anggraito, & Alimah, 2018). The results also suggested that an exploration step is the most powerful step in order to promote collaboration skills because students need to share resources and data they observed with others, and that allow students to determine the role of group members, discuss and exchange their opinions (Chantama, Kijkuakul, & Nakkuntood, 2020). In addition, when students have different opinions or ideas, they need to argue or debate and that their collaboration skills were improved. As Lai (2011, pp. 40) stated *students with strong disposition, including the ability to consider multiple perspectives, may be better collaborators*.

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Advancing children’s engagement in hands-on Mathematics Classroom

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ABSTRACT

The aim of this study is to understand how did the teacher enhanced students’ engagement in the classroom in the context of using Mathematics Grounding Activities (MGA) modules. We applied a mixed method. Participants are 28 third grades students from urban schools and a teacher who has been teaching for 20 years. Data collection included observation videos with five lessons, semi-structured interviews, and a learning attitude scale. The preliminary results revealed that the teacher used MGA modules can improve students’ learning attitudes and engagement in the classroom. Qualitative results show that in eliciting part: (i) teacher encouraged students to solve problems in activities and explain their own problem-solving process through encouragement, questioning, and follow-up questions; (ii) flexible used of students’ problem-solving results as teaching materials for peer assessment and discussion; (iii) worked in groups to solve problems; (iv) used the socio-mathematics norm and walked around when students doing the hands-on activities and so on can help students engaging in the class. In supporting part: (i) helped students to clarify the content of the question and their problem-solving process and methods; (ii) remind students of conceptually similar problems; (iii) helped students clarify the rules of the game in the activity; (iv) mentored individual student (groups). In extending part: (i) all students are required to try to solve difficult problems and try a variety of problem-solving methods; (ii) cultivated students' love of challenging high-level problems.

Keywords: *engagement; hands-on; mathematics teaching*

Introduction

In recent years, Taiwanese students achieved good results in international assessments. However, international comparative studies of students’ mathematics assessments show that several severe educational problems in Taiwan regarding students’ cognitive and noncognitive performances which are students’ cognitive polarization and their low attitudes in mathematics (Lin, 2015). To improve this situation, setting up an environment that can enhance students' interest in mathematics learning, engaging in the classroom, and master the concepts of mathematics has become the teaching goal of most primary school teachers in Taiwan. An efficient way to motivate students to learn mathematics is to provide interesting and meaningful activities that offer students not only fun but also meaningful learning (Lin & Chang, 2019). MGA modules provided teachers a possible way to advance students’ engagement. Hands-on in general means learning by experience. It is assumed that working in a hands-on way provides a more realistic and exciting experience of the content (Franklin and Peat 2005; Nott and Wellington 1996). In this case study, the teacher used MGA modules to teach the concept of decimals. It gave students a sense of abstract numbers through the manipulation of concrete objects. We are interested in how teachers used those strategies to facilitate student engage in the classroom. Especially younger learners conduct hands-on activities in limited classroom time. And we emerged the question that: What strategies did teachers use to improve students’ engagement in hands-on mathematics classroom?

Table 1. Teaching and activity goals of the concept of one-digit decimals

Course order	Teaching objectives	MGA	Activity content
2	Understanding the place value, decomposition and synthesis of one-digit decimals	Try to place it	Through the placement of the decimal board, understand the relationship between 0.1 and 1.
			Use 0.1 as the unit to perform decomposition and synthesis of one-digit decimals
			Recognize "decile" and its place value
3	Compare the value of one-digit decimals	Line up one-digit decimals	Compare the value of one-digit decimals through the placement of the decimal board and the record of the decimal positioning board.
4	Convert the representation to the straight form to solve the problem of the addition of one-digit decimals.	Who is closest to 10	Through the placement of the decimal board and the record of the decimal positioning board to familiar with using straight form to solve the problem of adding one-digit decimals place.
5	Convert the representation to the straight form to solve the problem of the subtraction of one-digit decimals.	Who is closest to 0	Through the placement of the decimal board and the record of the decimal positioning board to familiar with using straight form to solve the problem of subtracting one-digit decimals place.

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From the perspective of PCK, a comparative study on the discourse analysis of college students' volunteer teaching -- a case study of the college students' volunteer teaching classroom discourse analysis of the "Sunshine Volunteer teaching" activity sponsored by Central China Normal University

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3. Hefei No.6 Middle School, Anhui Province, China
3. Hefei No.6 Middle School, Anhui Province, China

ABSTRACT
This study introduces the perspective of "PCK" and connects the discourse analysis with the "PCK" research which is widely used in the world to explore the effective teaching ability of teachers. In combination with the actual situation of our country, many college students participate in the short-term volunteer teaching activities every summer.This study firstly defined the core concepts of "PCK" and "classroom discourse analysis" by literatures, summarized the framework of classroom discourse analysis, and then introduced the perspective of "PCK" to connect the component dimensions of PCK with the discourse analysis framework. Then, four members of a group participating in the 2019 "sunshine volunteer teaching · Confucius walking foot" volunteer teaching activity for college students from both sides of the Taiwan straits and Hong Kong and Macao regions were selected as research objects. Through the selection of 4 volunteer teachers to teach the teaching of one section of the class to analyze the individual characteristics of the classroom discourse and the overall difference of the comparative analysis, in four dimensions of analysis, draw relevant conclusions.

Keywords: *Volunteer teaching classroom discourse，PCK，The two sides of the Taiwan straits and Hong Kong, Macao region，Communication mode，Teachers' feedback type.*

Design of research tools

The tool design of this study mainly refers to the discourse research contents of foreign researchers Mortimer, Scott and Chin, as well as the relevant studies of Keping Sun and Baowei Wan in China. On the basis of their research, three basic dimensions of classroom discourse analysis of volunteer teaching have been formed, the first dimension is the the perspective of the content of teacher-student interaction discourse, differs from Keping Sun's studies, teachers' discourse is classified into categories which are more suitable for the special background of volunteer teaching, and the students' discourse content also listed as the research scope; The second dimension is the teacher-student interaction mode, which mainly refers to Mortimer and Scott's communication mode analysis method. According to the actual situation of volunteer teaching classroom, the discourse communication mode is expanded and deleted, and the "mixed" communication mode is added, while the "non-interaction-authority" is deleted. The third dimension is the perspective of teacher feedback type, which refers to the research of Christine Chin. At the same time, according to the actual situation in the classroom, the cases of "students' failure to respond" and "incomplete answers" are added, so the types of teacher feedback are also expanded. In addition to the above three dimensions of volunteer teaching classroom discourse analysis tools, this study referred to Professor Magnusson's classification of PCK components. Based on the evaluation system variables of the Public Understanding Program Science Education Program (SEPUP) of Lawrence Museum of Science, University of California, Berkeley, USA, a new dimension of " the discourse analysis from the perspective of PCK" for quantitative evaluation is established by combining "partial components of PCK" with "classroom discourse analysis".

Table 1. Th form of research records for Discourse Analysis in Volunteer Teaching Classroom from the Perspective of PCK

Number of statements	The speaker	Discourse content	Attributes of the statements	Discourse type	Types of feedback	The grading of teacher' s teaching level
1	teacher	The corresponding specific discourse content	I (Teacher's inspiring)	Q (question)		SQ (scientific concept question)（example :4.5）
2	Student 1		R (Students' response)	A (answer)	The attributes of the students' answers	
3	teacher		E (Teacher's evaluation)	R (response)	Types of teacher's feedback	AF (active participation feedback)（example :3.6）

Design of research tools

(1) from the perspective of the content of teacher-student interaction discourse, the teacher discourse of mainland undergraduate A and Taiwan undergraduate C is dominated by "teaching discourse" and "questioning discourse", while the teacher discourse of mainland graduate B and Hong Kong undergraduate D is dominated by "response discourse". (2) in terms of teacher-student interaction mode, A and C are mainly in the "interaction-authoritative" teacher-student interaction mode, while B and D are mainly in the "interaction-dialogue" teacher-student interaction mode. (3) from the perspective of teacher feedback type, 4 volunteer teachers can take appropriate behaviors to give feedback in most cases; (4) through the discourse analysis from the perspective of PCK, it is found that A and C have outstanding performance in the guidance of scientific process and the effectiveness of the construction of scientific activities. Both B and D are deficient in the effectiveness of questioning, the appropriateness of process guidance and the significance of activity construction.

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Oral Session 3	Day2 (June19th) 14：30～16：00
Room2	C2-1
【Category】	2: Science Education for Elementary School and Related Areas

=Chairperson=

Dr. YIP, Valerie W.Y.	The University of Hong Kong

=Presentation Program=

1	45-2-1-19-1（FYCO-82SV-O9021） Hasan Uştu（Turkish Ministry of Education） Tomoki Saito *A Lesson Preparation Method for Art Integrated STEAM: TA-SM-EA*
2	46-2-1-19-2（FY4W-TIFR-03021） SHIH-JUNG HUANG（Department of Science Education, National Taipei University of Education） Tian-Da Hsieh *Explore the learning of digital sensors and traditional glass tube thermometers in the fifth grade elementary school*
3	47-2-1-19-3（FY5S-QXXZ-MY021） Audchara Onpan（Srinakharinwirot University） Tepkanya Promkatkeaw *THE STUDY OF CRITICAL THINKING SKILL OF UPPER ELEMENTARY SCHOOL STUDENTS IN THAILAND*

A LESSON PREPARATION METHOD FOR ART INTEGRATED STEAM: TA-SM-EA

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2. Juntendo University, Tokyo, Japan

ABSTRACT
This is an action research study generating an art-integrated STEAM activity planning method with primary school teachers. The study was conducted in participant teachers' classes in 2018-2019 Educational Year in Osmaniye province Turkey. In the course of the study the teachers tried to generate methods based on T-SM-E (Technology-Science, Math-Engineering) in the action research process in their classrooms. At the and of the action research process the teachers generated the TA-SM-EA method and tested its functionality. It was founded that the model is practical and useful for interdisciplinary art integrated STEAM activity planning in primary level. The models can be used for planning art integrated STEAM activities by teachers teaching any class level.

Keywords: *STEAM education, Interdisciplinary art integration, Model, Action research.*

INTRODUCTION

When a teacher wants to implement STEAM (Science, Technology, Engineering, Art, and Math) activity looking the literature there is interdisciplinary integration methods (Drake 1991; Fogarty 1991; Lederman and Niess 1997) but limited methods about interdisciplinary STEM planning and art integration methods. Teachers can see numerous lesson plans at first but then realizes that they are not suitable for their students and class level. In this case, the teacher tries to do it on his own. But this is a very challenging process. The studies supporting that one of the most challenging factors and barriers for STEM education is lesson preparation for teachers (Asghar et al. 2012; Kurup et al. 2017; El-Deghaidy et al. 2017; Shernoff et al. 2017; Ozbilen 2018). In this study, we aimed to help teachers by generating an art-integrated STEAM activity planning method who wants to implement activities in their classes.

Problem: How can we generate an interdisciplinary art-integrated STEAM activity planning method that will help teachers who want to implement the activities with students?

METHOD

This is an action research study conducted with five primary school teachers generating a method that helps and guides art-integrated STEAM activity planning. To generate the method, teachers worked on how can be an art integrated STEM activity planned interdisciplinary manner based on T-SM-E method which was generated (Saito, Gunji, and Kumano 2015) and can we find a simple method for successful art integration planning. We observed implementations and made reflections with teachers about the activity planning and implementation process in their fourth-grade classes for one semester in the 2018-2019 educational year.

CONCLUSION

At the end of the planning, acting, observing, and reflection process in the action research the teachers generated a unique method called "TA-SM-EA". As can be seen in the Figure 1 the method starts first with the selection of a product to be obtained at the end of the engineering process and deciding its visual design (Technology and Art). Second, the steps and skills related to Science and Math disciplines to be used in the design process (Science and Math) are determined. Last, the knowledge and skills used to design a unique product (Engineering and Art) are defined (TA-SM-EA). While preparing the plan, the teacher first chooses a product labeled as technology that is suggested as a solution to a problem and envisions how the product design can be (TA). They then determine the knowledge and skills related to science and mathematics which are required for the students designing the products (SM) and finally organize the design process of the unique product (EA).

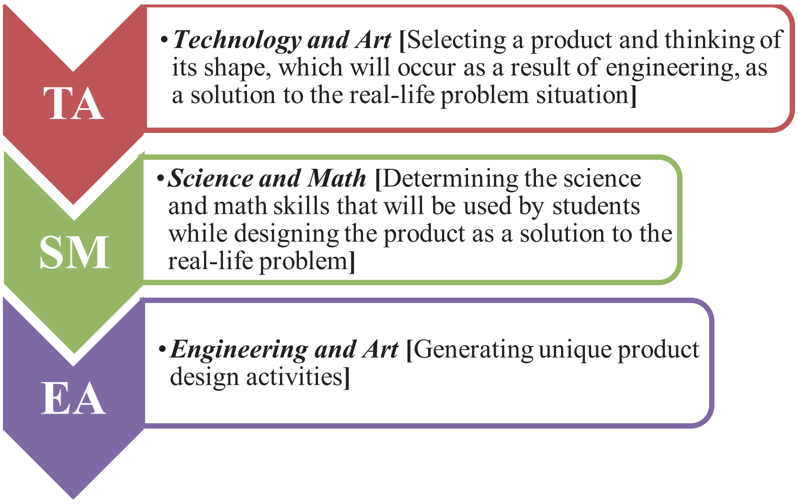

Figure 1. Schematic representation of the interdisciplinary flow of TA-SM-EA method in STEAM activity planning

The method facilitates an interdisciplinary planning process for teachers. It provides a reasonable and effective way for art integration and other related STEAM disciplines. It aligns the learning sequences in the course of an interdisciplinary STEAM activity. It allows teachers to prepare and arrange activity plans at any classroom level.

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Explore the learning of digital sensors and traditional glass tube thermometers in the fifth grade elementary school

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2. National Taipei University of Education,, Department of Science Education

ABSTRACT

In terms of natural science courses and teaching, the science tools strive to provide students with more opportunities for active exploration. In this study, a quasi-experimental study was conducted on fifth-grade students in elementary school, focusing on the effect of heat on matter. After the teaching is completed, a writing assessment is carried out, which includes the discussion of the water temperature change situation, and at the same time asks the students to write a better experimental method, and according to their own ideas, use their own experimental materials to predict the temperature change. The evaluation results were cross-compared with the statistical chi-square test and interview data, and it was found that (1) Design of the experiment by the experimental group is more suitable for the topic than control group and has reached a significant difference. (2) There was a significant difference between experimental groups tend to use short-answer in writing expressing the way of reasoning with the control group. Maybe we should think about the timing of the application of different levels of technological tools in science education. Using convenient technology tools increases the tendency of elementary students to adopt simple answers when writing.

Keywords: *digital sensor, temperature, constructivism*

INTROCUCTION

The Microcomputer Based Laboratory (MBL) strives to connect the natural sciences and the laboratory to provide students with more opportunities for active exploration. In fact, students using MBL tools can obtain significant learning benefits (David, 1992). Some scholars have also used Vygotsky's theory in their research to examine how technological tools regulate students' scientific learning through interaction, and found that the connectivity of tools to life is important in students' learning (Glenda, Susan & Cheryl, 1999). Most of the previous researches were aimed at middle school or older students.

This research is to simplify the analysis function of the computer and only use the digital display of the Digital sensor tool in the elementary school science curriculum. Finally, we analyze the impact of scientific process skills from students' writing performance.

RESEARCH METHOD

A quasi-experimental study was conducted on fifth-grade students in elementary school, focusing on the effect of heat on matter. After the teaching is completed, a writing assessment is carried out, which includes the discussion of the water temperature change situation, and at the same time asks the students to write a better experimental method, and according to their own ideas, use their own experimental materials to predict the temperature change. The evaluation results were cross-compared with the statistical chi-square test and interview data. The experimental group had a total of 49 students using digital sensors, while the control group had 56 students using glass tube thermometers for learning activities.

In terms of validity, after the first draft of the writing evaluation topics and evaluation criteria in the research is formed, five practical experts at the education site are invited to select and review topics, and after adjustments, form the formal writing topics and evaluation criteria for this study. The Krippendorff α value is 0.754.

RESULTS AND DISCUSSION

After analysis, two projects have reached a significant difference, They are the planning of the experiment (Asymptotic Significance 0.00) and the expression of reasoning (Table 2 and Table 3).

Table 1. Chi-square test of planning after the experiment

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	14.81[a]	1	.00		
Continuity Correction[b]	13.14	1	.00		
Likelihood Ratio	16.16	1	.00		
Fisher's Exact Test				.00	.00
Linear-by-Linear Association	14.67	1	.00		
N of Valid Cases	105				

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 12.60.

Table 2. The reasoning situation after the experiment

(2) Description of causality, (1) short answer, (0) unanswered or other

	2	1	0	Total
Experimental group (1)	23	25	8	56
Control group (0)	10	35	4	49
Total	33	60	12	105

Table 3. Chi-square test of reasoning after the experiment

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	7.68[a]	2	.021
Likelihood Ratio	7.82	2	.020
Linear-by-Linear Association	1.40	1	.235
N of Valid Cases	105		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 5.60.

It was found that (1) Design of the experiment by the experimental group is more suitable for the topic than control group and has reached a significant difference. (2) There was a significant difference between experimental groups tend to use short-answer in writing expressing the way of reasoning with the control group.

CONCLUSION

Therefore, although many studies have pointed out that the use of MBL tools can achieve significant learning benefits, but in the fifth grade of elementary school learning, experimental planning of the experimental group is more in line with the requirements of the topic than the control group. But about the expression of reasoning, it significantly triggered another discovery, is it because the use of convenient technology tools increases the tendency of students to adopt simple answers when writing.

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THE STUDY OF CRITICAL THINKING SKILL OF UPPER ELEMENTARY SCHOOL STUDENTS IN THAILAND

Audchara Onpan and Tepkanya Promkatkeaw

Srinakharinwirot University, Thailand

ABSTRACT

This research purposed to study critical thinking skill of upper elementary school students in primary school by using standardize test, the Cornell Critical Thinking Test Level X (CCTTX), to determine levels of students' critical thinking skill in four compositions including; induction, deduction, credibility of sources and observations, and assumption identification. The participants from purposive sampling were 400 Grade 4-6 students studying in one Chainat primary school in academic year 2020 with regular instruction according to the core curriculum. The results showed that the overall mean scores of Grade 4-6 students' critical thinking skill (30.05, S.D.=6.06) was lower than the mean scores of Grade 4-6 students who did not receive instruction in critical thinking shown in the Cornell Critical Thinking Tests Level X & Level Z manual (35.40, S.D.=5.30). The mean scores in each composition were under 50% of full scores. Thus, the critical thinking skill of upper elementary students in Chainat primary school was under the norms and needed to be improved.

Keywords: *Critical thinking skill, Cornell Critical Thinking Test Level X (CCTTX), Upper elementary school students*

INTRODUCTION

Science and technology have changed rapidly. Children need critical thinking skill for living in 21^{st} century. Efforts to develop elementary students' learning ability according to Thai core curriculum have increased attention to critical thinking skills. To enhance elementary students' critical thinking skills, the level of this skill should be identified by using reliable tool (Sukjaroen & Yoonaisil, 2016).

OBJECTIVE

This study purposed to study critical thinking skill of upper elementary school students by using standardize test to determine levels of students' critical thinking skill in four compositions including; induction, deduction, credibility of sources and observations, and assumption identification.

METHODOLOGY

This research is a survey research. The Cornell Critical Thinking Test Level X (CCTTX) (Ennis, Millman, & Tomko, 2005) was used to test 400 Grade 4-6 participant students from purposive sampling. These students were studying in one Chainat primary school in academic year 2020 with regular instruction according to the core curriculum. The quantitative data were analyzed by means, standard deviation, and percentage.

RESULTS

The results showed that the overall mean scores of Grade 4-6 students' critical thinking skill was 30.05 (S.D.=6.06). When considering each composition of critical thinking skill separately, the mean scores in each composition were under 50% of full scores. It was found that students in Grade 4-6 got highest mean scores in induction part as 9.27, 10.17, and 10.90 which were 37.08%, 40.68%, and 43.60%

of 25 full scores respectively. Students had lowest scores in deduction part as 7.95, 8.42, and 7.89 which were 33.13%, 35.08%, and 32.88% of 24 full scores respectively. Students' scores in credibility of sources and observation part were 8.28, 8.86, and 8.11 which were 34.50%, 36.92%, and 33.79% of 24 full scores respectively. Students' scores in assumptions identification part were 3.38, 3.60, and 2.51 which were 33.80%, 36.00%, and 25.10% of 10 full scores respectively. As were shown in table 1.

Table 1. Grade 4-6 Students' Mean Scores in Each Critical Thinking Skill Composition

Compositions	Full scores	Grade 4 (n=133)	Grade 5 (n=140)	Grade 6 (n=127)	
		$\bar{X}$ (S.D)	$\bar{X}$ (S.D)	$\bar{X}$ (S.D)	
Induction	25	9.27 (2.73)	10.17 (3.32)	10.90 (2.54)	
Deduction	24	7.95 (2.49)	8.42 (2.38)	7.89 (2.51)	
Credibility of sources and observation	24	8.28 (2.51)	8.86 (3.00)	8.11 (2.45)	
Assumptions identification	10	3.38 (1.60)	3.60 (1.48)	2.51 (1.44)	
Total	83	28.88 (5.58)	31.05 (6.92)	30.16 (5.23)	= 30.05 (6.06)

CONCLUSION

Critical thinking skill of upper elementary students in Chainat primary school was under the norms as the overall mean scores found in this study was lower than the mean scores of Grade 4-6 students who did not receive instruction in critical thinking shown in the Cornell Critical Thinking Tests Level X & Level Z manual (35.40, S.D.=5.30) (Ennis, Millman, & Tomko, 2005, p.10). When considering in each composition, similar to the findings of several researches in Thailand, it was found that Thai students tended to have high scores in induction part (Chantarawong & Pruekpramool, 2019) and low scores in deduction part (Jaruariyanon, 2018; Thitumanowong, Jansawang & Santiboon, 2019). However, the mean scores in each composition were lower than half of full scores. Thus, students' critical thinking skill needed to be improved.

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Oral Session 3	Day2 (June 19th) 14：30～16：00
Room3	C3-7
【Category】	3: Science Education for Middle or Secondary School and Related Areas

=Chairperson=

Dr. Pramudya Dwi Aristya Putra	Universitas Negeri Jember

=Presentation Program=

1	48-3-7-19-1（FY4J-LMDT-3J021） SRI WAHYUNI（University of Jember） Supeno, Iwan Wicaksono, Zainur Rasyid Ridlo Critical Thinking Blended Learning (CTBL) as a Teaching Model of Students Critical Thinking Skills
2	49-3-7-19-2（FY4K-0JRL-EW021） Hui-Shan Lin（National Changhua University of Education） Meichun Lydia Wen *A design-based learning program for gifted learners developed by an interdisciplinary community of practice: A case study*
3	50-3-7-19-3（FY4Q-NULL-I2021） Chen-Chen Yeh（Sanxia Junior High School, New Taipei City, Taiwan, R.O.C.） Wen-Hua Chang *A Biology Teacher’s Reflection about Applying Slowmation Learning Tasks on Students’ Representations of System and Scale*

Critical Thinking Blended Learning (CTBL) as a Teaching Model of Students Critical Thinking Skills

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ABSTRACT

This study aims to develop Critical Thinking Blended Learning (CTBL) model that valid, practical, and effective to improve students' critical thinking skills in science learning for junior high school students. This development research used a research and development design adapted from Borg and Gall (2003). consisting of three stages: 1) preliminary and development model, 2) trial in limited and extensive population, and 3) test od model. The research instrument consisted of a validation sheet, an observation sheet, an interview guide, a critical thinking skill test, and a questionnaire. The results showed that: 1) the CTBL model was valid, both in terms of content and constructs, 2) the CTBL model had met the practical criteria in terms of learning implementation in an excellent category, and 3) the CTBL model has met the effective criteria in terms of the average value of n-gain critical thinking skills.

Keywords: *Critical Thinking Blended Learning (CTBL), Blended Learning, Critical Thinking Skills*.

INTRODUCTION

Critical thinking skill is one of the essential skills in learning science. Teachers need to design appropriate learning strategies from models to learning strategies that will be applied to improve critical thinking skills. The learning model designed to meet the needs and challenges of the 21st century and the Indonesian National curriculum is named the Critical Thinking Blended Learning (CTBL) model. This learning model resulted from an analysis from the guided inquiry model and blended learning model with several modifications to be applied to all students from various backgrounds, academic ability, type of school, and culture. This model is also following the demands in the world of education, which are influenced by the industrial revolution 4.0 or what is often referred to as education 4.0. Education 4.0 is an education characterized by the use of digital technology in the learning process or known as a cyber system (Li, 2017).

METHODOLOGY

This development research used a research and development design that it adapted from Borg and Gall (2003). The development model consisted of three stages 1) preliminary and development model, 2) trial in limited and extensive population, and 3) test of the model. The research instruments consisted of a validation sheet, an observation sheet, an interview guide, a critical thinking skill test, and a questionnaire.

RESULT

The CTBL model had several phases such as (1) Identify problems covering face-to-face and online; (2) In-person and online investigations; (3) Face-to-face and online problem-solving discussions; (4) Presentation of arguments by face-to-face and online; and (5) Drawing Conclusions with implications by face-to-face and online. In phase 1, students are given phenomena/simulations that could be downloaded online related to the concept being studied by identifying unstructured problems (ill-structured) face-to-face with teacher guidance. The critical thinking skill component in phase 1 was that students could analyze facts because this process was carried out to help students recognize problems based on facts and phenomena in everyday life (Fu, 2013). In phase 2, students conducted face-to-face and online investigations, organized students in groups, and facilitated students to find or discuss draft problem formulations by referring to ill-structured problems on the student's worksheets. After that, each group submitted the problem formulations online. The critical thinking skill component that emerged in phase 2 was that students could convey reasons by guiding students to gather information and trying to find explanations and solutions to ill-structured problems in students' worksheets (Delialioglu, 2012). In phase 3, the teacher provided opportunities for students to solve problems face-to-face and online, and in phase 4, students present their argumentation face-to-face and online. The components of critical thinking skills raised in phases 3 and 4 were students could convey the arguments by providing opportunities. Students' answers that have been compiled respond to questions that provide evidence against their ideas, evaluate the benefits of exchanging ideas, and share views or ideas—alternative both face-to-face and online. In phase 5, in this stage, the teacher guided students to reconstruct ideas until a conclusion occurs with face-to-face and online implications. In this activity, students with teacher guidance identify information that was prioritized related to the conclusions made and made generalizations by induction and deduction to the implications. In addition, at this stage, the teacher evaluated the answers to the practice questions sent by students online. The five phases are designed to provide opportunities to improve critical thinking skills.

CONCLUSION

The development of the CTBL model was carried out by fulfilling the valid, practical, and affective aspects. The validity of the CTBL model was in terms of content and construct validity. The practicality of the CTBL model referred to the implementation of the CTBL model and the obstacles that occur during learning using the CTBL model. The effectiveness of the CTBL model have been increasingly critical thinking skills and student responses. Therefore, the CTBL model has been expected to be a valid, practical, and effective model to improve critical thinking skills.

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A DESIGN-BASED LEARNING PROGRAM FOR GIFTED LEARNERS DEVELOPED BY AN INTERDISCIPLINARY COMMUNITY OF PRACTICE: A CASE STUDY

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ABSTRACT

To solve problems in the real world, students need to use interdisciplinary knowledge and skills they learned in school. A "Community of Practice (CoP)" can promote teachers' professional development on curriculum design by providing opportunities for teachers to interact and share knowledge with others.

Based on a case-study method, this program was held in the summer of 2020 and lasted for 44 hours. A total of 42 gifted and high-ability junior-high students participated in this research. The community members were five colleagues of the same school with different backgrounds.

The topic "Detective Conan's challenges" was emphasized in the program. And students were required to utilize what they had learned in this program to design a "real escape room" for their peers to challenge as the summative assessment of this program.

The result revealed that the "real escape room" was students' favorite part. And the students considered that their logical thinking skills had improved. The teachers in the CoP agreed they had learned lots of knowledge from other teachers. They also gave some suggests on the assessment criteria, and the operation of the community.

This research showed that a design-based learning program can make learning more joyful and meaningful. It also shows that CoP is a good approach for professional development, and can facilitate teachers in developing new curriculums.

Keywords: *interdisciplinary curriculum, community of practice, design-based learning*

INTRODUCTION

The Natural Sciences Curriculum Guidelines of 12-Year Basic Education in Taiwan emphasize interdisciplinary learning, so that students can not only use the knowledge and skills they learned from each subject, but also apply the cross-domain knowledge to solve the problem in the real world. The Guidelines also lay stress on the role of teachers' community of practice (CoP), to encourage teachers improving professional development, and designing innovative lessons; therefore, this research focuses on a design-based learning program developed by an interdisciplinary CoP for the gifted program.

A CoP relies on situated learning theories. In a CoP, teachers can access professional development by interacting and sharing knowledge with others, and have more ability to develop new curriculums (Wang, W.-K., 2007). Additionally, design-based learning, based on creative problem solving, encourages students using system thinking, knowledge management, creativity and teamwork ability to design products (Yang, C.-Y., et al, 2018). A design-based learning program may help gifted students to utilize higher-order thinking ability to gain better sense of accomplishment.

RESEARCH METHOD

This research adopted the case study method, focusing on a group of 42 gifted and high-ability students in a junior-high school in central Taiwan. The CoP was organized by the first author and four colleagues of the same school with different backgrounds, including biology, physical science, mathematics, Chinese literature, and English. The CoP members met once a month before the program, to discuss the goal, learning experience and assessment of the program.

This program was held in the summer of 2020, and lasted for 44 hours. The program's core emphasis was "Detective Conan's challenges", covering various topics such as learning to take forensic examinations, to set up mechanisms, to design and solve puzzles, and to write a detective story. As the summative assessment, students needed to utilize what they had learned in this program, to design a "real escape room", including a reasoning story and several puzzles, for their peers to challenge.

After the program, a questionnaire was used to collect the students' feedbacks and opinions of the program, and the CoP discussed and revised the curriculum design again.

RESULTS AND DISCUSSION

The result revealed that 18 students liked the "real escape room" part the most because they could design their own room with various aspects and experience the diverse creations designed by their peers. Apart from the integrated lessons, the students liked the physical science lessons more than any other lessons, because there are many interesting activities and hands-on experiments in this topic.

About half of the students agreed that this program improved their logical thinking skills. Some mentioned that their vision was expanded by the interdisciplinary lessons, and some mentioned that their reading and writing skills, problem-solving ability were also increased.

Teachers within the CoP said they had learned a lot from others, including interdisciplinary knowledge, and teaching activity planning. They also mentioned that assessment criteria should focus on interdisciplinary knowledge and could be provided to the students at the beginning of the program so that students could aim at it when designing their escape rooms. In order to make a closer connection with each subject, the teachers also suggested that the community could discuss more detail about the activities they designed for the lessons in the meetings.

CONCLUSION

This study shows that a design-based learning program developed by an interdisciplinary CoP could help teachers' professional development and students' higher-order thinking ability, because this type of program embodied challenging and ill-structured problems (Ke, F., 2014). Future studies can put more emphasis on the role of teachers' CoP on students' learning.

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A Biology Teacher's Reflection about Applying Slowmation Learning Tasks on Students' Representations of System and Scale

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ABSTRACT
Literature reveals that design learning activities for students to develop animations is effective to promote students' understanding of science content. Analyzing students' multimodal representations in their artefacts has potential to afford teachers' reflection-on-action, and lead to teachers' improving and re-enacting the lessons. This study focused on cross-disciplinary topic System and Scale to develop the unit for thirty-one ninth graders in an urban lower secondary school. Followed by generating themes in terms of to what extent the students forming the slowmation, the teacher researcher reflected on her design and enactment of the unit. We suggest that guiding lower secondary students to build slowmation, students can progressively refine their understandings of science content and cross-disciplinary concept. Moreover, teacher researcher can further deliberate the facilitating strategies during groupwork.

Keywords: *Socio-scientific issues, Cross-disciplinary topic, Slowmation*

INTRODUCTION

Literatures indicate when students develop animations to present contents from textbooks, news, the Internet, or scientific videos, in the form of media, they not only learn scientific contents, but also further represent their own explanation digitally (Unsworth, 2020). Students' interest and understanding about scientific contents thus become necessary, and their ability to evaluate accuracy and adequacy of diverse information can also be developed (Mills, Tomas, Whiteford, & Lewthwaite, 2020; White, Nielsen, & Tytler, 2020). In the aspect of learning performances, this research focused on whether students can understand the connections and interactions within a specific system, and choose appropriate scales and ways of presentation.

RESEARCH METHOD

Thirty-one 9th graders (F=16, M=15) involved in the trial. Data sources included student artifacts, slowmation scripts, and teaching videos. The design of instructional activities was shown in Table 1.

Table 1. Procedures of The Instruction

Topic	Duration	Students' Actions
Introduction to the socio-scientific issue	20mins	To watch videos of oyster farming along the coast To discuss the ecological impact of microplastic sea
How to make slowmation	25mins	To watch slowmation examples How to utilize PowerPoint to make slowmation
Work collaboratively to make slowmation	90mins	To choose appropriate topics To search information, drawing, taking photos, or give each other feedbacks

RESULTS AND DISCUSSIONS

The participating students were engaged in the activities in groups. The learning performances they showed are as follows:

1. **Students are able to fluently present the occurrence of events, and adequately explain scientific concepts.**

   Probably because that the teacher-researcher chose the slowmation videos which described life history or cycles of nature for demonstration, all students' works could present processes related to the topic, along with scientific explanations. However, most of them presented scientific knowledge fragmentally.
2. **Students are able to identify and represent the comparative scale of the things in the same system, but the things are out of proportion to the reality.**

   No accurate scale was labeled in their works, neither in macroscopic nor microscopic pictures. When analyzing the contents of their productions, it was found that students were able to identify comparative scales of things in the same system, but the scale they represented did not match the reality.
3. **"Perspective of one single system" is shown in most of the minor topics.**

   Students showed their primary understanding about Systems in their works, and they could clearly identify the boundaries of a system. Nevertheless, most of the students' works showed the interactions and changes within "one single system". For example, on the formation and changes of Earth, they focused on the changes on the surface of Earth from primordial time to now, without paying attention on the relation between Earth and the solar system, and the interactions that happen among the subsystems inside Earth.

CONCLUSIONS

1. **The choice of topics should focus on students' choices and judgement on information.**

   In selecting topics for future instruction activities, students may have more chances to practice the abilities of evaluation, judgement, and choosing adequate information, if a more controversial topic with information from both pros and cons, or a new theory in development, is chosen.
2. **Facilitate students' connections among all contents and adequate conclusion is crucial.**

   In presenting their works, students only described scientific phenomena without going deeper into evidence, inferences, and explanations of science. The teacher must delicately consider how to help students notice related scientific evidence before composing the scripts, making inferences, come up with their own explanations, and make conclusions adequately.

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Oral Session 3	Day2 (June 19th) 14：30～16：00
Room4	C3-8
【Category】	3: Science Education for Middle or Secondary School and Related Areas

=Chairperson=

Dr. Irma Rahma Suwarma	Universitas Pendidikan Indonesia

=Presentation Program=

1	51-3-8-19-1（FY4R-38YG-HX021） Chaninan Pruekpramool（Srinakharinwirot University） Chanyah Dahsah, Theerapong Sangpradit, Pinit Khumwong *EXPLORING THE MULTIPLE PERSPECTIVES ABOUT THAI SECONDARY STUDENTS' SCIENTIFIC SENSEMAKING*
2	52-3-8-19-2（FY62-6AW6-T0021） Ippei MINETA（University of Tsukuba） *Changes in the Processes of Inquiry and the Scientific Methods in the Transition of the Courses of Study:The Case of Junior High School Science*
3	53-3-8-19-3（FXIM-JDF4-EV021） Santy Nurmalasari（Science Education, Indonesia University of Education, Indonesia） Irma Rahma Suwarna, Gregory Shaw, Asep Supriatna, Yuyu Rahayu and Eneng Rahmayanti *KELING MITBAN: LEARNING MEDIA FOR FLOOD MITIGATION AND CRITICAL THINKING FOR DISASTER PREVENTION FOR INDONESIAN JUNIOR HIGH SCHOOL STUDENTS*
4	54-3-8-19-4（FY63-DSW7-IQ021） Hisashi OTSUJI（Toyo University） *THE PHILOSOPHICAL BACKGROUND OF ART IN STEAM EDUCATION: A PRACTICAL TRIAL FOR PROSPECTIVE SCIENCE TEACHERS IN JAPAN*

EXPLORING THE MULTIPLE PERSPECTIVES ABOUT THAI SECONDARY STUDENTS' SCIENTIFIC SENSEMAKING

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ABSTRACT

Science is an important subject for students to understand the nature. Learning science focuses on students to be able to explain the natural phenomena as well as the daily life situations. Scientific sensemaking involves with cognitive process and serves as basis of learning science. For Thai students, communication in the classroom is a common obstacle. Therefore, it seems difficult to know exactly how students' scientific sensemaking is constructed. This research aimed to explore the multiple perspectives about Thai secondary students' scientific sensemaking from 3 groups of participants which were 284 grade 7-12 students, 48 science teachers and 55 parents. The participants were voluntarily participating in this research by responding to the 5 Likert scale and written questionnaires. The results indicated that students, science teachers and parents tended to agree with all items related to students' scientific sensemaking in the high and highest levels. The item that all students (M = 4.53, S.D. = 0.65), science teachers (M = 4.72, S.D. = 0.45), and parents (M = 4.64, S.D. = 0.52) agreed at the highest level was "Science is an important subject". For science teachers, they additionally agreed on the item "Science can explain the phenomena around us" (M = 4.65, S.D. = 0.48). For parents, the item "Students' scientific sensemaking arises from hands-on activities in science classroom" was ranked in the highest level of agreement (M = 4.58, S.D. = 0.50). The qualitative data reflected the factors affecting the students' scientific sensemaking which were 1) students 2) teachers and teaching methods and 3) class atmosphere. In their opinions, allowing students to learn through hands-on and various activities and related to their lives could enhance students' scientific sensemaking. In addition, students' scientific sensemaking could be seen when they speak or write the scientific explanations in the classroom, summarize what they have learned, give examples, select the proper sources to search information and create inventions based on accurate scientific concepts.

Keywords: *Scientific Sense Making, Multiple Perspectives, Secondary Students*

INTRODUCTION

Science focusses on studying to understand nature. Students learn science to explain the natural phenomena and situations that take place in the world including their daily life situations leading to the understanding of nature of science. Fostering students to understand nature, scientific knowledge is certainly important. How do we know that students understand science? Scientific sensemaking plays an important role and is the process that can be expressed through communication in science classrooms (Audet, Hickman, & Dobrynina, 1996). Scientific sensemaking requires the communication skills which is one of the essential skills in the 21st century. Students can express their knowledge, thoughts, and understanding in various forms of communication which is a part of students' explanation construction (Zangori, Forbes, & Biggers, 2013). However, for Thai students, communication is a common obstacle in science classrooms and other subjects as well. Students mostly do not respond to the questions and lack of interaction with their teachers and classmates which is considered as one-way communication. Although, Thai science teachers presently have changed their teaching methods to be more active and provided more hands-on activities, this problem still exists and can be easily seen in the normal Thai science classrooms. It seems difficult to know exactly how students' scientific sensemaking is constructed. Therefore, this research aimed to explore the multiple perspectives about Thai secondary school students' scientific sensemaking from 3 groups of participants which were secondary school students, science teachers, and parents. These people have involved in students learning science. The results from this research have reflected the multiple perspectives of students' scientific sensemaking. More importantly, it also reflects the Thai students' behaviors in learning science and leads to the understanding about how students learn which is very informative and useful for science leaning management.

Research methodology

The research instrument used in this survey research was the 5 Likert scale and written questionnaires and divided into 3 parts; 1) participants' information 2) perspective about Thai secondary school students' scientific sensemaking 3) Additional questions related to factors affecting the students' scientific sensemaking teaching and learning methods and students' behaviors. The questionnaires content validity was verified by 4 experts in the field of science education. The participants were voluntarily participating in this research composed of 284 grade 7-12 students, 48 science teachers and 55 parents.

Findings

The perspectives about Thai secondary school students' scientific sensemaking from 3 groups of participants can be seen in Table 1.

Table 1. perspectives about Thai secondary school students' scientific sensemaking

Items	Students (n = 284)			Science teachers (n = 48)			Parents (n = 55)		
	M	S.D.	Levels of agreement	M	S.D.	Levels of agreement	M	S.D.	Levels of agreement
1	4.53	0.65	Strongly agree	4.72	0.45	Strongly agree	4.64	0.52	Strongly agree
2	4.45	0.65	Agree	4.65	0.48	Strongly agree	4.49	0.60	Agree
3	4.32	0.67	Agree	4.48	0.62	Agree	4.36	0.65	Agree
4	4.32	0.72	Agree	4.42	0.58	Agree	4.62	0.53	Agree
5	4.30	0.73	Agree	4.45	0.54	Agree	4.27	0.73	Agree
6	4.27	0.76	Agree	4.46	0.54	Agree	4.58	0.50	Strongly agree
7	4.19	0.79	Agree	4.23	0.70	Agree	4.31	0.77	Agree
8	4.27	0.74	Agree	4.48	0.55	Agree	4.47	0.60	Agree
9	4.11	0.78	Agree	3.94	0.67	Agree	4.27	0.80	Agree

The factors affecting the students' scientific sensemaking, teaching and learning methods and students' behaviors can be seen in Table 2.

Table 2. Factors, teaching and learning methods and students' behaviors related to scientific sensemaking

Factors	Teaching and learning methods	Students' behaviors
▪ Students ▪ Teachers and teaching methods ▪ class atmosphere	▪ Hands-on activities ▪ Science experiments ▪ Simulations ▪ Asking questions and discussion	▪ Speak or write the scientific explanations ▪ Summarize what they have learned ▪ Give examples ▪ Select the proper sources ▪ Create inventions

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Changes in the Processes of Inquiry and the Scientific Methods in the Transition of the Courses of Study: The Case of Junior High School Science

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ABSTRACT

The purpose of this study is to identify the characteristics required in the handling of "Data" from the changes resulting from the revision of the Courses of Study for Junior High School. Data is one of the components of scientific evidence in scientific inquiry, and in many countries, it is an important component of the science curriculum. In the Processes of Inquiry and the Scientific Methods, the processing, analysis, and interpretation of data is positioned as a scientific process. Since descriptions of the handling of "Data" can be found in the Courses of Study for Junior High Schools, this study summarized the transition of the descriptions, analyzed the Processes of Inquiry and the Scientific Methods, and discussed the results. As a result, it was clarified once again that the changes caused by the 1989 revision had the greatest impact, and that thinking, judgment, and expression skills are recognized as important in inquiry activities.

Keywords: *Processes of Inquiry, Scientific Methods, Data*

INTRODUCTION

Influenced by the U.S. science education curriculum, Japanese science education has introduced the Processes of Inquiry and the Scientific Methods in the Courses of Study since the 1969 revision. The policies of science education in Japan during this period were 1) development of basic scientific concepts, 2) mastery of Scientific Methods, and 3) careful selection of content (Suzuki, 1982), and the process of acquiring knowledge was emphasized rather than the previous emphasis on knowledge. In Japan, the Courses of Study are revised about once every ten years, and there have been six curricula five times in total since 1969; in the 1977 revision, "Data processing" was newly added, and it has been incorporated in different forms up to the present.

Data is one of the evidences used to support claims in scientific inquiry, and has been incorporated as an important component of the science curriculum in many countries. Regarding science education in Japan, Otaka (2010) evaluated that observation and experiments have been consistently emphasized, and the importance of collecting data has been well understood by students. Indeed, in the Courses of Study, descriptions of observation and experiments for collecting data, data processing, analysis, and interpretation can be viewed as components of the Processes of Inquiry and the Scientific Methods. However, the revision of the Courses of Study infer that the way of viewing data is changing because there are differences in the Processes of Inquiry and the Scientific Methods.

In other words, clarifying the characteristics required for the handling of "Data" in this scientific inquiry is an essential component for the development of qualities and abilities appropriate to the times. In addition, tracing the transition of the curriculum will lead to new knowledge by examining the policies and ways of the context of science education in Japan. Therefore, this research analyzed the descriptions in the Commentary on the Courses of Study for Junior High School from 1969 to 2017, and from the changes due to the revision, the characteristics required for handling "Data" were identified and discussed.

RESEARCH METHOD

This research categorized 1) "Collecting information" in the Processes of Inquiry, and 2) "Experiment", "Measurement", "Recording", and "Data" in the Scientific Methods, based on the changes caused by the revision of the Courses of Study, and discussed them based on the characteristics identified.

RESULTS AND DISCUSSION

As a result, we found that 1) the Processes of Inquiry emphasized gathering information through observation and experiment until 1977, but after 1989, it changed to discovering regularities from the information gathered. 2) In the Scientific Methods, the description of "Experiments," which appeared in 1969, changed to "Experiments (Planning and conducting, correct operation of equipment, etc.)" in 1989 and "Experiments (Planning, operation of equipment, etc.)" in 2017. In addition, "Recording", which appeared in 1969, was changed to "Recording (Appropriate recording)" in 1989, and returned to the original description of "Recording" in 2008, is described to this day. Furthermore, "Data processing," which appeared in 1977, became "Data processing and interpretation" in 1989, and changed to "Data processing, analysis, and interpretation" in 1998. On the other hand, "Measurements," which appeared in 1969, was removed from the description in the 1989 revision.

Table 1. The Scientific Methods in the Transition of the Courses of Study

Year	The Scientific Methods												
1969	Finding Problem	Prediction	Observations	Experiments	Measurements	Recording	Classification	Graphing	Inference	Model formation	Hypothesis formulation	Verification	Other
1977		Expectation					–	–			Hypothesis		Data processing
1989		–		(Planning and conducting, correct operation of equipment, etc.)	–	(Appropriate recording)	–	–	–		Hypothesis formulation	–	Data processing and interpretation
1998		–			–		–	–	–			–	Data processing, analysis, and interpretation
2008		–			–		–	–	–		–	–	
2017	Discovering question	–		(Planning, operation of equipment, etc.)	–		–	–	–		–	–	

The 1989 revision had a major impact on the Processes of Inquiry and the Scientific Methods, as it called for a new view of scholastic ability that emphasized the ability to think, judge, and express oneself. The new view of scholastic ability emphasizes students' ability to think and solve problems, and in science, the development of scientific inquiry skills through observation and experiments was required. Although there was an emphasis on observation and experiments, the process of obtaining results tended to be neglected and ended up confirming the results (Kittaka, 1993). It is thought that the focus on the process of obtaining results has changed the ways in which data is viewed. Therefore, the new view of scholastic ability has brought about great changes in the science curriculum.

CONCLUSION

This research summarized the transition of descriptions in the Commentary on the Courses of Study for Junior High School, analyzed and discussed the Processes of Inquiry and the Scientific Methods, in order to identify the characteristics required for the handling of "Data" from the changes caused by the revision. As a result, it was clarified once again that the changes caused by the 1989 revision had the greatest impact, and that thinking, judgment, and expression skills are recognized as important in scientific inquiry.

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KELING MITBAN: LEARNING MEDIA FOR FLOOD MITIGATION AND CRITICAL THINKING FOR DISASTER PREVENTION FOR INDONESIAN JUNIOR HIGH SCHOOL STUDENTS

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ABSTRACT

*This research examines the effectiveness of learning media (*Keling Mitban*) through demonstration to explain flood mitigation and strengthen student understanding and stimulate critical thinking of Indonesian junior high school students. Teacher and student questionnaires and teacher interviews are analysed within a mixed research methodology using a Research and Development focus. The results indicate that this learning media explains environmental damage and flood mitigation and improves grade VII students' critical thinking skills. Students found the learning media helpful for their understanding, it was engaging, and it helped their thinking about how to reduce the impact of a disaster. Most students asked critical thinking questions. The pedagogical approach and the model design provide direction to learning in other science topics in secondary schools. This research supports the essential role of simulations and demonstration in Science Education and the opportunities of using digital recording of simulations and demonstration for learning using the Internet.*

Keywords: *Learning media, simulations, demonstrations, critical thinking skills*

INTRODUCTION

To recognize climate disaster risks in Indonesia, it is essential to understand the causes of disasters and disaster risk mitigation. These actions include proactive approaches to identifying disaster-prone areas, and techniques for prevention and reducing disasters. Disaster mitigation involves helping people understand the causes and nature of disasters. Schools and teachers have a significant role in helping students understand disaster mitigation (Shiwaku, 2011). While there is some attention to disaster mitigation in the Indonesian curriculum, students in this study reported that they lacked deep understanding of the concept.

Learning media presents information, assists students in constructing understanding and motivates student learning (Sahronih, 2019). Demonstration of concepts and phenomena via a simulation, which encourages critical thinking, can strengthen understanding (Putranta & Kuswanto, 2018). This research examines the effectiveness of learning media (Keling Mitban) for Indonesian junior high school students. Keling Mitban is a model (and a digital video) to demonstrate flood mitigation.

METHODS

Keling Mitban replicates two land conditions; 1) a forest plot and 2) a deforested plot, placed in parallel and connected to a flood detection device. An upstream water source replicates rain, irrigating the two different plots simultaneously. A video allows for multiple viewings of the effect and Internet distribution. The learning media requires a student to observe, think and answer questions on their experience. Data is collected and analysed using a mixed research methodology - Teacher and student questionnaires and teacher interviews were undertaken.

FINDINGS AND DISCUSSION

Based on input from media-expert lecturers (Prof. Dr. H. J. Anna Permanasari and Dr. Muslim) and classmates of the 2020 UPI postgraduate science students, the Keling Mitban development occurred over six months . This research uses a Research and Development (R&D) approach with three stages: (1) Define,

(2) Develop solutions, (3) Optimize:

Define: An analysis of the junior high school level curriculum from the 7th, 8th and 9th grade levels.

Develop Solution: The instructional media was designed and presented to expert lecturers and classmates for feedback. The model replicates two land conditions and their response to flood conditions; 1) a forest plot and 2) a deforested plot. These two plots are connected to a flood detection device. Teacher and student questionnaires and teacher interviews were analysed within a mixed research methodology.

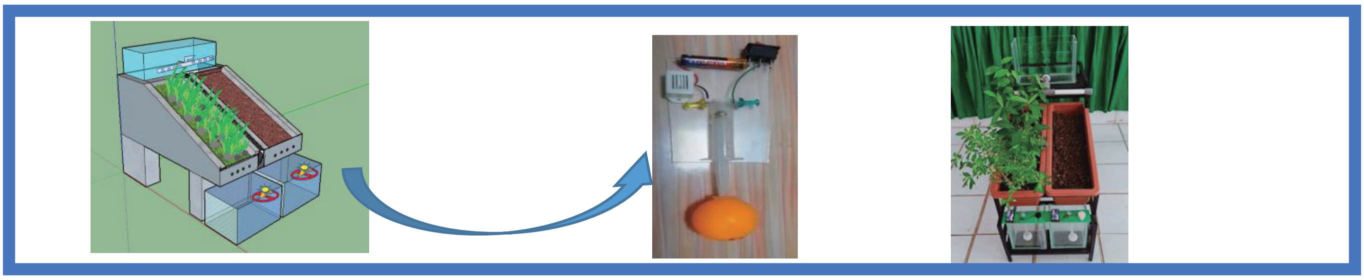

Figure 1. Keling Mitban

Optimize: The Keling Mitban model was constructed according to the final design, taking into account the feedback from science teachers and students. The model was presented in lessons and student and teacher evaluations and feedback obtained.

The results show that this learning media is appropriate to explain the concept of environmental damage and flood mitigation and improves grade VII students' critical thinking skills. Following are details of the teacher surveys' results and their views of the media: it suitably explains concepts of environmental damage from flooding and flood mitigation (91.1%); was interesting for students (100%); was interactive (95.6%); improved students' critical thinking skills (93.3%); addressed student experience limitations and overcame classroom boundaries (88.9%); allowed direct interaction between students and their environment, contiguous and virtual (91.1%). Students indicated that they found Keling Mitban helpful for their understanding: it was engaging (91.4%); the simulation made it easy to understand the causes of flooding (88.4%); it helped thinking about how to reduce the impact of a disaster (91.6%). Seventy-five per cent (75%) of students asked critical thinking questions.

CONCLUSION

The results show that the Keling Mitban model, the video and associated pedagogy are effective for learning, replicating an external environmental phenomenon in the classroom (or online) through a simulation. The media successfully facilitates junior high school students' learning and critical thinking of flood mitigation and disaster management. The pedagogical approach of Keling Mitban confirms the beneficial effect of simulation and demonstration on learning for understanding. Additionally, powerful learning can be achieved even when students cannot attend classes face-to-face (such as under COVID-19) using digital media of simulations-demonstrations on the Internet.

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THE PHILOSOPHICAL BACKGROUND OF ART IN STEAM EDUCATION: A PRACTICAL TRIAL FOR PROSPECTIVE SCIENCE TEACHERS IN JAPAN

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ABSTRACT

In the first part of this paper, the background of Art in STEAM education is examined, based on the four main underlying philosophies in the history of educational curricula (idealism, realism, pragmatism, and existentialism). From ancient times, discussions of knowledge or education have been conducted in relation to the existence of the supernatural (idealism and realism). After the 19th century and the appearance of the theory of evolution and the theory of relativity, such discussions moved from the pursuit of universality to questions of utility or effectiveness (pragmatism). In modern society, in which the dignity of the individual has been recognized, there is a belief in the potential and creativity of each person. Existentialism developed in such an era. In education, individualism and "choice" are emphasized, and Art has received significant attention. In the second part of this paper, the results of a trial of STEAM education for prospective science teachers in three universities (N = 167) are reported. The class explored the mystery of a haiku, using the moon's shape to arrive at a new interpretation of the scene. T-test, analysis of variance, and chi-square test were performed, using factors such as gender, university, students' major and ordinary science score, and the degree of their interpretation of the haiku. Some significant differences were observed, but participants generally accepted this trial of STEAM education. Reflecting the philosophical background above, it was more valuable to emphasize students' own ideas and thoughts in the discussion process than to incorporate haiku.

Keywords: *STEAM education, Existentialism, Inquiry-based learning, Haiku, Buson, Nirvana.*

THE ART OF STEAM EDUCATION AND THE FOUR UNDERLYING PHILOSOPHIES IN THE HISTORY OF EDUCATIONAL CURRICULUM

From ancient times, discussions of knowledge or education have been conducted in relation to the existence of the supernatural (e.g., God) in the Western world (idealism and realism). After the 19th and 20th centuries and in the wake of the theory of evolution and the theory of relativity, such discussions shifted drastically from the pursuit of universality to questions of utility or effectiveness (pragmatism). In modern society, in which the dignity of the individual has been recognized, there is a belief in the potential and creativity of each person. Existentialism developed in such an era. In education, individualism and "choice" are emphasized, and Art has received significant attention (Otsuji, 2019). The nature of the Art in STEAM education should be re-defined in light of philosophical discussion (Table 1). Moreover, Art itself tends to blend with STEM activities to produce integrated learning (Silverstein & Layne, 2010).

A PRACTICAL TRIAL OF STEAM EDUCATION

At the end of the lunar study unit in Grade 9 science, Yosa Buson's haiku: "On the yellow field, the moon in the east and the sun in the west" is often taken up in our country to inquire about the season, shape of the moon, and approximate time. I innovatively introduced the nirvana painting (Nehan-zu) and the fact that Buson composed the haiku after visiting the Maya temple in Kobe (Otsuji, 2020; 2021). More than 200 university students guessed the moon's shape in the nirvana painting, which was initially hidden, and the approximate time. They were expected to notice that Buson not only described the beautiful scenery but also alluded to the world's impermanence based on the setting of moon and sun, and the birth and death of

Buddha. On the way back to his birthplace, full of mustard flowers, Buddha may also have dreamed of a yellow field.

Table 1. Overview of Major Philosophies (Orstein, A.C. & Hunkins, 2012, p.33)

Philosophy	Reality	Knowledge	Values	Teacher's Role	Emphasis on Learning	Emphasis on Curriculum
Idealism	Spiritual, moral, or mental; unchanging	Rethinking latent ideas	Absolute and eternal	To bring latent knowledge and ideas to consciousness; to be a moral and spiritual leader	Recalling knowledge and ideas; abstract thinking is the highest form	Knowledge based; subject based; classics or liberal arts; hierarchy of subjects: philosophy, theology, and mathematics are most important
Realism	Based on natural laws; objective and composed of matter	Consists of sensation and abstraction	Absolute and eternal; based on nature's laws	To cultivate rational thought; to be a moral and spiritual leader; to be an authority	Exercising the mind; logical and abstract thinking are highest form	Knowledge based; subject based; arts and sciences; hierarchy of subjects: humanistic and scientific subjects
Pragmatism	Interaction of individual with environment; always changing	Based on experience; use of scientific method	Situational and relative; subject to change and verification	To cultivate critical thinking and scientific process	Methods for dealing with changing environment and scientific explanations	No permanent knowledge or subjects; appropriate experiences that transmit culture and prepare individual for change; problem-solving activities
Existentialism	Subjective	Knowledge for personal choice	Freely chosen; based on individuals' perception	To cultivate personal choice and individual self-definition	Knowledge and principles of the human condition; acts of choosing	Choices in subject matter, electives; emotional, aesthetic, and philosophical subjects

The lesson, which synthesized science and Japanese literary art and approached a mystery like a detective novel, was widely accepted by students as a trial of STEAM education. An analysis of complete data for 167 students revealed a significant difference between the daily science achievement of those students who correctly identified Buddha's last sight and those who did not (t (138) = 3.01, p =.003). The degree of interpretation and appreciation of the haiku differed significantly from students' grades (χ^2 (16, N = 167) = 30.0, p =.018), as did the identification of Buddha's last sight (χ^2 (8, N = 141) = 13.36, p = 0.10).

Reflecting the philosophical background discussed earlier, it was more valuable to emphasize the students' own ideas and thoughts in the discussion phase of the lesson than to incorporate haiku.

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Oral Session 3	Day2 (June19th) 14：30～16：00
Room5	C4-3

【Category】 4: Science Education for High School and Related Areas

=Chairperson=

Prof. Zhang, Bao-Hui	Shaanxi Normal University

=Presentation Program=

1	55-4-3-19-1（FXY0-PE03-6R021） Younkyeong Nam（Pusan National University） Jinmong Shin *High School Girl's System Thinking Skills about the Carbon Cycle*
2	56-4-3-19-2（FY3B-A6HV-YW021） Idris Solola（Ehime University） *The Impact Of Integrating Entrepreneurship Management In Teaching Chemistry Among Academics Of Selected Institutions*
3	57-4-3-19-3（FY3J-SW29-CU021） Go Tanaka（Shizuoka University） Takanori Kakutani, Yoshiyuki Gunji *Blended Learning Practise of Basic Biology “Immunity” Using Video Materials in High School*
4	58-4-3-19-4（FY3U-DW0H-4L021） Apiradee Pansing（Srinakharinwirot University） Chanyah Dahsah *A Study of Critical Thinking of Upper Secondary School Student on Fossil Fuels Using Thinking Aloud Technique*

High School Girl's System Thinking Skills about the Carbon Cycle

Younkyeong Nam[1], Jinmong Shin [2]

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2. Busan Science High School, Korea

ABSTRACT
This study is for investigating high school girls' system thinking skills about the carbon cycle and its impact on global temperature increase. One hundred and fifty-seven female freshman students participated in a program that offers opportunities for analyzing data and predicting the future carbon dioxide ratio using an Excel program and actual data of carbon cycle in the atmosphere and global temperature. Students' system thinking was measured by three sources of data; 1) the number of carbon cycles and feedback loops drawn in the causal maps before and after class, 2) future carbon dioxide prediction graphs students make using Excel program, and 3) students' answers in the open-ended questions during the class. The result shows that the students' system thinking level was improved overall after the program. Although some students' system thinking levels changed hierarchically from one level to another, changes within a certain level (strengthened, maintained, or weakened system thinking skills) were also identified. In addition, the graph analysis of changes in the future atmospheric carbon dioxide concentration predicted by the students reveals that about half of the student groups showed the ability to generalize the phenomenon and understand the periodic characteristics of the system. Although the program and the analysis framework developed in the study did not reflect all elements of system thinking, it is meaningful in terms of improving students' system thinking skills. We expect the program content and system thinking analysis framework could be easily used in the high school science context.

Keywords: *the carbon cycle, system thinking skills*

HIGH SCHOOL GRILS' SYSTEMS THINKING SKILLS ABOUT THE CARBON CYCLE AFTER THE EXCEL BASED EARTH TEMPERATURE SIMULATION LESSONS

One hundred and fifty-seven female freshman students participated in a program that offers opportunities for analyzing data and predicting the future carbon dioxide ratio using an Excel program and actual data of carbon cycle in the atmosphere and global temperature. Students' system thinking was measured by three sources of data; 1) the number of carbon cycles and feedback loops drawn in the causal maps before and after class, 2) future carbon dioxide prediction graphs students make using Excel program, and 3) students' answers in the open-ended questions during the class.

1. Students' Drawing about the Carbon Cycle and Feedback Loops

Students' drawing about the carbon cycle and feedback loops were analyzed by counting all the propositions and categorizing the propositions by earth system interactions. The difference between pre and post drawings was measured by the frequency of propositions by the analysis categories of earth system interactions. The result shows that the students' system thinking level was improved overall after the program. Although some students' system thinking levels changed hierarchically from one level to another, changes within a certain level (strengthened, maintained, or weakened system thinking skills) were also identified (see Figure 1).

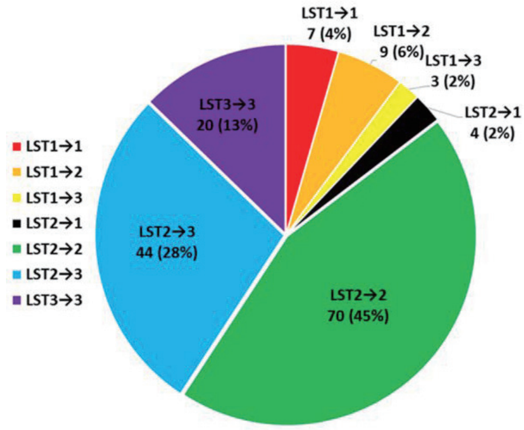

Figure 1. Systems thinking level change after the program

2. **Students' Prediction about Future Earth Temperature Change**

In addition, the graph analysis of changes in the future atmospheric carbon dioxide concentration predicted by the students reveals that about half of the student groups showed the ability to generalize the phenomenon and understand the periodic characteristics of the system.

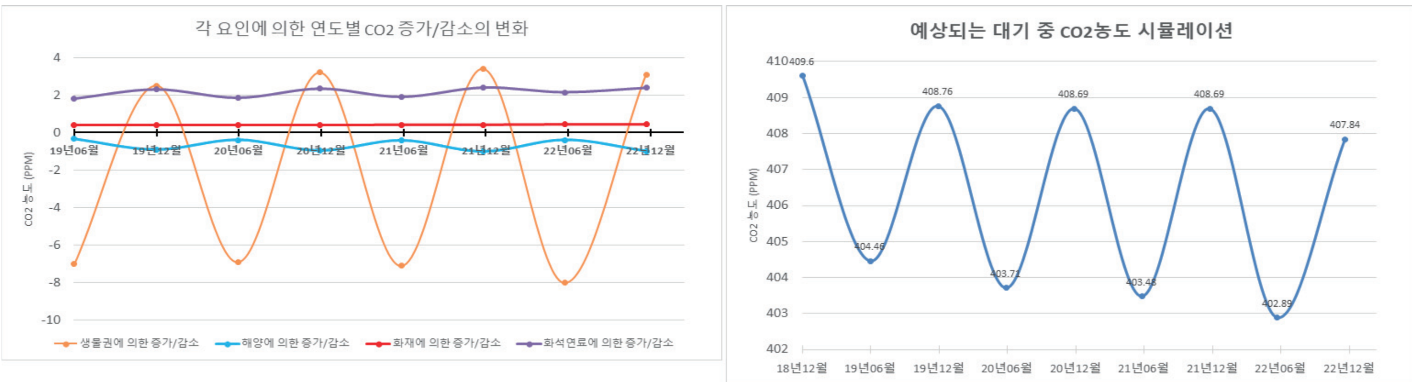

Figure 2. Student's earth temperature prediction example

Although the program and the analysis framework developed in the study did not reflect all elements of system thinking, it is meaningful in terms of improving students' system thinking skills. We expect the program content and system thinking analysis framework could be easily used in the high school science context.

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THE IMPACT OF INTEGRATING ENTREPRENEURSHIP MANAGEMENT IN TEACHING CHEMISTRY AMONG ACADEMICS OF SELECTED INSTITUTIONS

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ABSTRACT

Chemistry cuts across almost all areas of human endeavor. The acquisition of the vast knowledge provided by chemistry can be converted into entrepreneurial skill, which is an important survival skill. When teachers possess these entrepreneurial skills it makes them more efficient and effective in the knowledge delivery. The purpose of this study therefore was to investigate how effective the integration of entrepreneurial skills in teaching chemistry can be in developing the interest of students in the acquisition of the process skills and as well improving their performance. The research method adopted was the descriptive survey method using questionnaire. The sample chosen for the research comprises of eighty (80) chemistry teachers from fifteen (15) selected public high schools in Abeokuta, Nigeria; which is made to be a representative of the population. The result showed that Nigerian chemistry teachers believe that incorporating entrepreneurial skills in teaching will boost their efficiency in knowledge delivery.

[Keywords] *Entrepreneurship management, chemistry education, teaching*

INTRODUCTION

The formal teaching of science in Nigeria is dated back to the introduction of western education in Nigeria by the Christian missionaries. Elementary science was also introduced in the school curricular. The introduction of the Higher School Certificate (HSC) in 1951 gave schools the opportunity to offer subjects like chemistry, biology and physics at senior school level. The West African Examination Council (WAEC) is the board involved in testing the school curriculum subjects including the sciences.

Chemistry education has a crucial role to play in helping to find answers to various human and socio-economic problems as well as making the society more scientifically literate (Gladys and Dimas, 2015). When entrepreneurship education is embedded into the formal education it has the potential of offering functional education for the youth to be self-reliant, creative and innovative in identifying novel business opportunities. It can also serve as a catalyst for economic growth and development (Paul, 2005). From the angle of the inherent entrepreneurship opportunities, chemistry teachers can engage students in the production of polishes for shoes etc. The purpose of this study was to investigate how effective the integration of entrepreneurial skills in teaching chemistry can be in developing the interest of students in the acquisition of the process skills and as well improving their performance in assessments.

METHODOLOGY

The research method adopted was the descriptive survey method. The sample chosen for the research comprises of eighty (80) chemistry teachers from fifteen (15) selected public high schools in Abeokuta, Nigeria. Forty-nine (49) of the teachers were male while thirty-one (31) were female. 3.8% of the respondents have 1- 4 years teaching experience, 11.3% have 5 - 9 years, 45% have 10 – 14 years while 40% of the respondents have 20 years and above.

The research instrument was the questionnaire which was drawn on Likert scale point format. The first part of the questionnaire (comprising ten items) obtained information about the possession of entrepreneurial skills and the likely in-service entrepreneurship training. The second part (with ten items) sought their various opinion on the infusion of entrepreneurship skills in chemistry and the effect it will have in the teaching-learning process. The level of agreement was indicated as Strongly Agree (SA), Agree (A), Disagree (D) and Strongly Disagree (SD). The collected questionnaires were analyzed using frequency and percentages.

RESULT AND DISCUSSION

Majority of the respondents believed that ’teachers with more educational qualification are likely to integrate entrepreneurship management in teaching process in chemistry more effectively’. This was attested to by the distribution as 62.5% strongly agreed. It was also revealed that the majority of the respondents believed in the statement ’teachers that have access to entrepreneurship management facilities are likely to integrate these in teaching and learning process’. This was attested to by the distribution as 50% strongly agreed. 44 (55%) of the total respondents strongly agreed with the statement, 25 (31.3%) of the respondents agreed with the statement – “teachers' efficiency in entrepreneurship skills have greater effect in the teaching and learning process”. 27 (33.8%) of the respondents disagreed with the statement, 25 (31.3%) of the respondents strongly disagreed with the statement – “school teachers are not interested in integrating entrepreneurship management in chemistry curriculum’’.

The result showed that Nigerian chemistry teachers believe that incorporating entrepreneurial skills will boost their efficiency in knowledge delivery. The study reveals that teachers’ efficiency in entrepreneurial skills has a greater effect in the teaching--learning process. Recommendations were therefore made for the in-service training of high school chemistry teachers in entrepreneurial skills in such a way as to effect an evolvement in the teaching methods to that which will emphasize more in creating experiential knowledge for students.

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BLENDED LEARNING PRACTICE OF BASIC BIOLOGY "IMMUNITY" USING VIDEO MATERIALS IN HIGH SCHOOL

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ABSTRACT

This practice is intended for students to understand the contents of the basic biology unit "Immunity" and for them to be able to think, judge, and express themselves based on scientific knowledge about infectious diseases and their prevention. In this practice, we devised an original educational program in the unit "Immunity" of basic biology, and conducted the practice for first-year high school students. The program used a blended learning approach. The effectiveness of this practice was verified through the "Reflection Sheet" filled out by the students for every lesson and the questionnaire survey after the practice. As a result, We observed that students had acquired an attitude toward applying the learning contents to their lives. In addition, many students answered that they were able to apply the knowledge they learned from the video materials in the face-to-face classes.

Finally, we found that the students become "more motivated to learn" and "opportunities to use the knowledge they had gained".

Keywords: *Blended learning, Basic biology, Immunity, Video materials*

INTRODUCTION

This practice is intended for students to understand the content of the basic biology unit "Immunity" and for them to be able to think, judge, and express themselves based on scientific knowledge about infectious diseases and their prevention. In order to achieve these goals, we thought that a blended learning approach would be appropriate. Blended learning is a form of learning that combines online materials and face-to-face classes. Students use the online materials to acquire knowledge outside of class time, and work on developmental content and performance tasks in the face-to-face class. The use of videos as online materials makes students to acquire knowledge efficiently in a short period of time. In addition, supplementary explanations of the video materials in the face-to-face class can promote their understanding, and students can be given time to think.

Therefore, we devised an educational program called "Basic Biology Movie Program" in this practice. This program used familiar topics in the introduction, and students would be able to understand the mechanism of vaccines scientifically at the end of the program.

METHOD

About the class outline

We tested it on 93 first-year high-school students in three classes.
Before each class, the students were given a check sheet to check the contents of the "Study Movie".

Outline of the materials

In this practice, the video materials were shared with students using an educational platform called Classi. Students watch these movies before class every lesson and take them to class.

Survey method

Reflection sheet

Students were asked to fill in their own understanding of the lesson, the content of the lesson, and the questions asked in the video/lesson. Students were asked to fill out the reflection sheet after each class.

Questionnaire

All the items had a free space for the respondents to write their reasons.The survey was conducted after the completion of the program.

RESULT

Reflection sheet

Four things were found from the descriptions on the reflection sheet. (1) Increased motivation to learn, (2) Understanding of learning methods, (3) Attitude to deepen learning contents by students themselves, and (4) Attitude to apply learning contents to real life.

Questionnaire survey

Q1: ”Did you use the knowledge you gained from the video materials in the class?”

61 students answered “Yes”, 29 students answered “No”, 3 students answered “Don't know”.

Q2: “Do you think scientific knowledge is useful in your daily life?”

10 students answered “Strongly agree”, 68 students answered “Agree”, 14 students answered “Disagree”, 1 students answered “Completely disagree”.

Q3: “Did your study time outside of class hours change?”

22 students answered “Increased”, 2 students answered “Decreased”, 68 students answered “No change”.

DISCUSSION

Through this practice, many students were able to become more motivated to learn and use the knowledge they gained from the video learning in the face-to-face class. It was suggested that the viewing of video materials was perceived as an increase in learning time by the students.

Reasons given for answers other than "Yes" in Q1 were “I did not remember the contents of the video” and “I do not know the situation to use the knowledge”. This supposes that the teachers were not able to provide sufficient support. It is also possible that the students were unconsciously using their knowledge. In Q3, there were many students who felt that watching videos increased their study time, while there were many students answered that it did not change. This may mean that they did not consider the time spent watching videos as learning time, or that they answered their learning time did not change because they changed their preparation time to watching videos.

CONCLUSION

In this practice, in the actual situation of the students, it was possible to "utilize the knowledge gained through video learning in face-to-face classes" and "substantially increase the students' learning time. In addition, this program used in this practice is connected to the SDGs “3. Good health and well-being” and “4. Quality education”. In SDG "3", the recommended topics are infectious diseases and vaccines. In SDG "4", the recommended topic is quality education through the use of ICT. The effects of this program will continue to be tracked through practice based on the results and challenges of this study.

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A Study of Critical Thinking of Upper Secondary School Student on Fossil Fuels Using Thinking Aloud Technique

Apiradee Pansing[1], Chanyah Dahsah[1]

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ABSTRACT

Critical thinking is an important skill for 21st century learners. Understanding students' critical thinking abilities and processes would help teachers develop effective teaching strategies to promote students' critical thinking. This study aims to measure critical thinking and study critical thinking processes of upper secondary school students using Thinking Aloud technique. The research instrument was a Critical Thinking Test developed by the researcher, according to Ennis Cornell Critical Thinking Test Level X (1985) using scenarios of fossil fuels. The participants were 13 Grade 12 students in a science-mathematics stream from a school in Bangkok. Each student was asked to say out loud what they were thinking about during taking the test. The video of each student was recorded and transcribed. The results indicated that the sample's average score was 13.23 (out of 24). A dimension with the highest average score was judging source reliability (mean = 4.31 out of 6) while the lowest average score was deduction (mean = 2.46 out of 6). When classifying students into three levels, only one student (7.69) was at a high level, and 12 students (92.31 percent) were at medium level. In terms of critical thinking processes, the qualitative data showed that the samples considered the reliability of data from reference sources that were consistent with individuals or agencies expertise. They chose an answer based on the relevance and consistency of the text in the problems, judged the message or drew conclusions from situations using knowledge learned or information in situations provided.

Keywords: *Critical thinking, Upper Secondary School students, Fossil Fuel, Thinking Aloud technique*

INTRODUCTION

Critical thinking is one of the most important skills in education in the 21st century (Bellanca & Brendt, 2010). Many educators and researchers are interested in exploring and developing students' critical thinking. Ennis and Millmans Cornell Critical Thinking Test Level X (1985) is one of the most powerful research tools in science education research (Ennis & Millman, 1985). However, multiple choice tests might be able to indicate learners degree of critical thinking, but it cannot reflect learners critical thinking process. Moreover, this type of test cannot determine whether learners answered correctly due to guessing or having a real understanding. Therefore, thinking aloud is a research technique that can help researchers understand unseen thoughts while learners take the Critical Thinking Test and their critical thinking processes (Chantarawong, 2019; Sawetrattanasatian, 2013). Therefore, this research was designed to use a thinking aloud technique to get better understanding of students critical thinking and the process while students took the Critical Thinking Test based on Ennis and Millmans Cornell Critical Thinking Test Level X (1985).

OBJECTIVE

1. To measure the level of critical thinking of upper secondary school students on fossil fuels.
2. To study the critical thinking processes of upper secondary school students on fossil fuels.

METHODOLOGY

This is a survey research with both quantitative and qualitative methods. The first research objective is a quantitative research to assess learners degree of critical thinking using the Critical Thinking Test developed by the researcher, according to Ennis Cornell Critical Thinking Test Level X (1985) . The second research objective is phenomenological research to study upper secondary school students critical thinking processes using a thinking aloud technique. The data was collected from 13 Grade 12 students in a science-mathematics stream from a school in Bangkok. The quantitative data was analyzed based on the test scores and classified students into three levels (high, medium, unsatisfied). The qualitative data was analyzed from video recording and verbatim transcribed. These aimed to get information on critical thinking processes while students were taking the test.

RESULT

1. The critical thinking average score overall was 13.23 (out of 24). The average score of four components were between 2.46 – 4.31 (out of 6) as shown in Table 1.

Table 1. Critical Thinking Average Score

Components of critical thinking ability	n	Min	Max	$\bar{x}$	Std.
Determine credibility of sources and observation	13	3.00	6.00	4.31	.85
Induction	13	2.00	4.00	2.62	.77
Deduction	13	1.00	5.00	2.46	1.45
Identifying assumptions	13	2.00	5.00	3.85	1.14

2. Only one student was at a high level (7.69), 12 students (92.31 percent) were at medium level, no student was at an unsatisfied level.

Critical Thinking Process

- The ability to determine the reliability of information and observations was found that to identify evidence, students determine the reliability of information from sources that was consistent with the situation in the story and people who have expertise in that matter.
- Inductive reasoning was found that students choose the answer and supportive answer based on the relevance and consistency of the text in the situation.
- Deductive reasoning was found that students' processes could be divided into three groups. In group 1, students could judge the text or make a reasonable conclusion from given situations, and they could explain the reasons for the answers. In group 2, students should not judge the text or make a reasonable conclusion from given situations. In group 3, students chose the answer by guessing.
- The ability to specify basic agreements was found that students who were able to judge a message or make a conclusion from given situations usually rely on knowledge they have.

Conclusion

The results of the study on learners critical thinking were found that most students in the study group (12 out of 13) had a medium level of critical thinking. There was only one student who had a high level of critical thinking. When considering the average score in each aspect, it was found that the ability to determine the reliability of the information and observations, there was the highest average score. The aspect with the lowest average score includes deductive reasoning since learners had misunderstandings in the content of the study. Therefore, they cannot use knowledge to judge the text or make a reasonable conclusion correctly, so they relied only on guessing the answer.

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Oral Session 3	Day2　(June19th)　14：30～16：00
Room6	C4-4
【Category】	4: Science Education for High School and Related Areas

=Chairperson=

Prof. Yao, Jian-Xin	Beijing Normal University

=Presentation Program=

1	59-4-4-19-1（FXIX-YQ4L-FM021） Cheng-Chueh Liu（Graduate Institute of Science Education, National Taiwan Normal University） Ying-Shao Hsu *TEACHERS' REFLECTIONS ON HOW SSI CURRCULUM PROMOTES STUDENT SCIENTIFIC LITERACYS*
2	60-4-4-19-2（FY4D-WLBO-2R021） Waralee Sinthuwa（Faculty of education, Kasetsart university） Chatree Faikhamta, Pattamaporn Pimthong, Sasithep Pitiporntapin *Environmental Conservation: Indigenous Science in Thai Urban Society*
3	61-4-4-19-3（FY6P-DMIC-D2021） Yi Liu（Central China Normal University） Guofeng Zhang, Wenhua Zhang, Peixing Li, Yuejiong Su *Research on PCK Integration Mechanism of Preservice Chemistry Teachers*
4	62-4-4-19-4（FY7K-OOQG-L6021） Pingping Wang（Northwest Normal University） *Research on Teaching Design of Electrochemistry Core Concepts in Senior High School Based on Learning Progression Theory*

TEACHERS'REFLECTIONS ON HOW SSI CURRCULUM PROMOTES STUDENT SCIENTIFIC LITERACYS

Cheng-Chueh Liu [1] and Ying-Shao Hsu [1]

1. Graduate Institute of Science Education, National Taiwan Normal University

ABSTRACT
The major purpose of this study was to explore the practical experiences of carrying out a well-designed SSI curriculum based on a framework of STEPWISE (Science and Technology Education Promoting Wellbeing for Individuals, Bencze, 2017) pedagogy which we expected that students would develop abilities of argumentation and scientific literacy through this. Data collection included pre- and post- test conducted to explore students' development of scientific literacy before and after the enactment of the SSI curriculum. Also, semi-structured interviews were used to collect teachers' reflections on developing and enacting the SSI curriculum. Teachers perceived the difficulties and challenges which would be used to revise the SSI curriculum for better teaching practices. The preliminary result indicated that teachers found that students had difficulties to select topics with "dilemma" which is a feature of SSI, and students also need to take time to clarify the connection between science/technology and social issue. And teachers all mentioned about the necessity for the instructors to contact SSI issues as much as possible and keep themselves open-minded that benefits the instructions they give to the students.

Keywords: *Socioscientific issues, Scientific literacy, Teacher professional development, Teaching practices, Reflection.*

INTRODUCTION

Facilitating students' scientific literacy is one of the most important goals of science education in many countries. " Literacy " can be expressed with other words such as "competence"," ability", " capacity", " skill", and" proficiency " which appear in contemporary educational reform. In Taiwan, the new curriculum guidelines for the twelve-year national compulsory education has been published, and the core idea of this guideline is that school curriculum should provide opportunities for students to cultivate "core literacy". "Core literacy" refers to knowledge, ability and attitude possessed by citizens to adapt the current life and overcome future challenges. Base on the guideline, social scientific issues (SSI) is a good way to provide contexts for students to apply knowledge and competence they've learned in solving real-world problems and to develop their scientific literacy.

This study proposed a well-designed SSI curriculum based on a framework of STEPWISE (Science and Technology Education Promoting Wellbeing for Individuals, Bencze, 2017) pedagogy which encourages teachers to provide students reflection opportunities on the issue of science and technology through introducing the harm caused by science and technology and guiding students to discuss the different viewpoints from various stakeholders. Such discussions help students develop their arguments and multiple perspectives about SSIs. Also, teachers lead students to search first-hand and second-hand data to design and carry out their plans of "action"; then, communicate their findings via posters, videos, and public talks to influence others and try to persuade the key stakeholders about the possible solutions. The model of STEPWISE pedagogy could be depicted as figure 1.

The SSI curriculum was designed and enacted by a group of teachers in a senior high school in Taiwan for a year (2 semesters). In the first semester, the teachers facilitated students to think and reflect about the SSI, producing and buying cotton products. Then, several daily-life examples would be introduced for students to recognize the possible harm of producing and buying cotton products. Also, teachers guided students to learn the competence of searching information and developing action plans for solving this issue. Teachers also provide different type of action for students to choose (educate others, develop better inventions, boycott offenders, lobby power-brokers, improve personal actions and provide service), then they could design a suitable action for their own group. Pre- and post- test were conducted to explore students' development of scientific literacy before and after the enactment of the SSI curriculum.

METHOD

The participants of the study contained 6 classes of senior high school student(K11), each class are 26-27 people and all females, there were 3 teachers involved to carry out this curriculum, each teacher hold 2 classes. In the beginning of the curriculum, teachers made students to form a group of 3-4 people, and after the first 6 weeks, students could choose their partner to form a group. Every week teacher had 1 hour to instruct students, but there were following 2 more hours for students to carry out their self-directed learning, students could decide if they want to do something else of keep on doing their research about SSI .

We collected the data from the teaching material designed by the teachers, work sheet from students, students' report documents and oral presentation. And we conducted pre- and post- test by a series of questions about nuclear energy. Semi-structured interviews were used to collect teachers' reflections on developing and enacting the SSI curriculum.

We would use the result of the practice of the curriculum this time and try to adjust the curriculum and carry out it again.

RESULTS

This curriculum is still ongoing and the pre-test is done. In the semi-structured interviews, teachers perceived the difficulties and challenges which would be used to revise the SSI curriculum for better teaching practices. The preliminary result indicated that teachers found that students had difficulties to select topics with "dilemma" which is a feature of SSI, and students also need to take time to clarify the connection between science/technology and social issue. And teachers all mentioned about the necessity for the instructors to contact SSI issues as much as possible and keep themselves open-minded that benefits the instructions they give to the students.In the preliminary result of analyzing the report of students, we also explored that it is a challenge for these students to come up with a suitable action for their issue, and most of them choose "educate others".

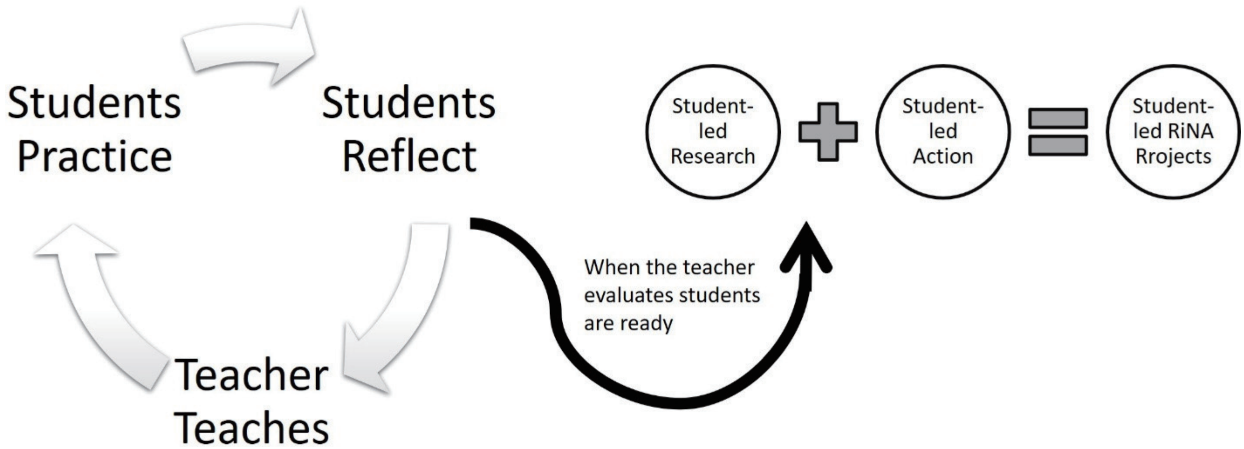

Figure 1. Framework of STEPWISE. [adapted from https://wordpress.oise.utoronto.ca/jlbencze/stepwise/].

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ENVIRONMENTAL CONSERVATION: INDIGENOUS SCIENCE IN THAI URBAN SOCIETY

Waralee Sinthuwa[1,2], Chatree Faikhamta[1], Pattamaporn Pimthong[1], and Sasithep Pitiporntapin [1]

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2. Wachirathamsatit school

ABSTRACT

Indigenous knowledge is the link between scientific knowledge and local students' prior knowledge. It supports students' scientific literacy, motivation, and identity and creates a bond with the local communities. There are extensive research applying indigenous knowledge to support scientific learning regarding the environment; however, most studies focus on rural areas. A knowledge gap exists with regard to lessons that relate to Thai urban students' life styles, with regard to the cultural economic, and societal context and the influence on science learning. Therefore, this study aims to examine the indigenous knowledge in urban society that relates to environmental conservation and to analyze the science behind indigenous knowledge. Semi-structured interviews were employed for five knowledge keepers, who were selected through the snow ball sampling method to gather data. A narrative analysis was applied to identify indigenous knowledge in the following dimensions: ontology, epistemology, and axiology. Scientific knowledge is extracted from stories. The themes were emerged into the learning guideline dimensions. The results shed light on the possibility of scientific learning regarding the environment for urban students. Scientific content and meaningful context from indigenous knowledge are provided. Indigenous knowledge acts as the bridge that connects the science classroom, society, and sustainable development. This study will contribute to the development of science curricula and pedagogy based on urban culture, specific to the constantly evolving urban context.

Keywords: *Indigenous knowledge, environment conservation, urban, science learning*

INTRODUCTION

The indigenous knowledges that related to agriculture and natural environment have fuse in the way of living for long time. They supported STEM learning in various way such as enhancing the meaningful context, bringing the culture to construct knowledge and providing participant in the issues of local community (Miller & Roehrig, 2018). According to the literature about science integrated indigenous knowledge learning, there are only few studies on neo-indigenous ways of knowing nature, and most of them convey the cultures of Islam, and Japan. The way of knowing of Thai indigenous knowledge, that concerns on the grounded philosophy, is still be the gap. In addition, Aikenhead and Ogawa (2007) also point out this gap and suggest that neo-indigenous culture should be studied increasingly. Therefore, this study provided Thai neo-indigenous knowledge in urban society that includes culture diversity for supporting science learning.

RESEARCH QUESTION

1. How does philosophy of indigenous knowledges relate to environment conservation in urban society?
2. How are science in philosophy of indigenous knowledges in urban society?

METHODOLOGY

The methodology of this study based on constructivism pragmatism. The case study design and qualitative method that provide the depth data of phenomena are used to answer the both research questions.

The researcher roles are a part of urban community who collect and analyst data. Six indigenous knowledge keepers (K) that match with the criteria: staying in the urban area, having indigenous knowledge related to environment and spreading knowledge to other people in society were interviewed. Narrative analysis was adopted. The voice of interview was transcribed to be text and interpreted the dimensions as following: ontology, epistemology and axiology based on the knowledge system lens (Aikenhead and Ogawa, 2007). The themes were emerged from the interview data. The member checking and researcher triangulation (the degree of agreement more than 90%) were used for credibility and confirmability.

Results & Discussion

Ontology

There are science knowledges that fuse in indigenous knowledge. All knowledge keepers mention on the nature as the part of life. The mind is integrated in every activity. The emulating ecosystem in nature are utilized in urban agriculture. For example, soil cooking or soil preparation, they mixed parent materials sand, soil, cow dung and food waste together. They apply the traditional idea to design the artifacts. For instance, the composed fertilizer box catalyzes the production of fertilizer quickly. The vegetable garden system in the limited area, natural package and the safety and sustainable food for the family and society. These ideas relate to STEM disciplines and scientific explanation even knowledge keepers do not concern on the linking or thinking only some part of it. Therefore, indigenous knowledge should be in the same position with science knowledge as indigenous science. However, there are the difference points from the ontology of science and indigenous science such as the harmony of ontology epistemology and axiology of indigenous science. The indigenous science can fill the gap of science in the dimension of well-being.

Epistemology

The starting point of learning the indigenous science is distinguished to be the concerning of food safety and sustainable, and knowhow of family. The knowledges are emerged by culture, the way of living, interaction in the society and transmit by telling. Some part of knowledge construct relates to STEM practice that can be apply in science classroom.

Axiology

The value groups are as following groups. First, proud of oneself, the knowledge keepers reveal the happiness through the voice while they told us about the change of lifestyle to participate and persuade others in natural conservation. Second, the ethic fuse in every activity such as basis for success and responsibility. On the other hand, STEM learning does not focus on this point. Therefore, integration of indigenous science may support students' affective domain.

Conclusion

Indigenous science in the urban society is influenced by healthy and environment conservation trend. It shed light on the value of STEM learning for well-being that is not clarify in only STEM discipline. Therefore, what is the key characteristics of learning approach that integrated indigenous science in philosophical root and how students learning through this approach are needed to find out.

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Research on PCK Integration Mechanism of Preservice Chemistry Teachers

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3. Taiyuan No. 61 Middle School, Shanxi Province,China

ABSTRACT
Based on Park's PCK Pentagon model, the PCK evaluation scale is adapted to analyze the PCK integration mechanism of three chemistry pre-service teachers in microtraining on the theme of "methane". The research shows that: (1) there are great individual differences in the integration of PCK among the three pre-service teachers in microtraining. The degree of PCK integration of pre-service teachers is not necessarily related to their academic scores during their college years. (2) pre-service teachers' Orientations toward Teaching Science (OTS) has a significant effect on Knowledge of Instructional Strategies and Representations (KISR), but sometimes leads to the loss of connection between KSIR and other components. (3) pre-service teachers lack the integration of Knowledge of Science Curriculum (KSC) and Knowledge of Assessment of Science Learning (KAs). (4) pre-service teachers have rich teaching strategies in this topic, but sometimes the integration of KISR and other components is poor, especially the misrepresentation concepts and learning difficulties in Knowledge of Students' Understanding in Science (KSU).

Keywords: *Pre-service teacher PCK The pentagon model*

Introduction

Shulman defined PCK as the knowledge organically integrated through the interaction between pedagogical knowledge and content knowledge, which is an important symbol to measure the level of teachers' professional development (1986). Therefore, it can be seen that the professional development of pre-service teachers can be promoted by studying how pre-service teachers integrate PCK and finding out their shortcomings and influencing factors. Based on this, this study puts forward two research questions: How do three pre-service teachers integrate PCK in microteaching training? What are the main factors that affect the PCK integration mechanism of pre-service teachers? Case study method was used in this study, and research data were collected by means of classroom observation and interview.

Methods

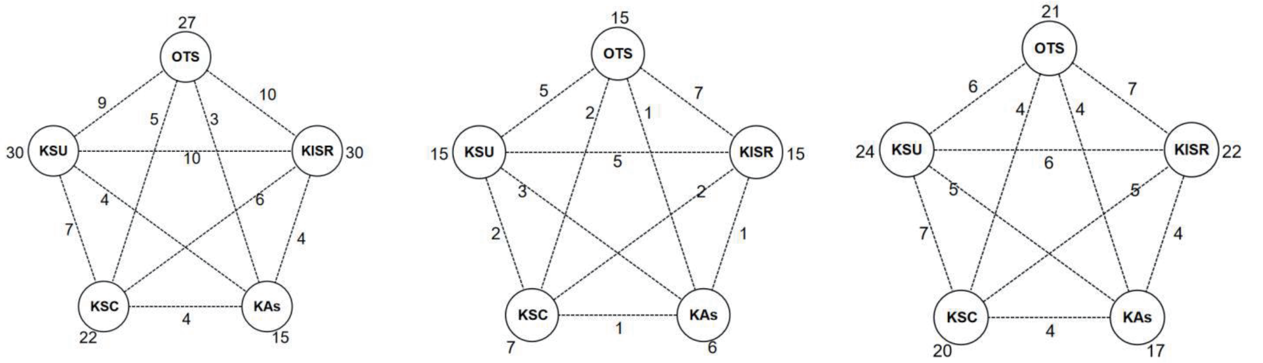
This study adopts Park's Pentagon model and holds that PCK is an integration of five components represented in the pentagon model: (a) Orientations toward Teaching Science (OTS), (b) Knowledge of Students' Understanding in Science (KSU), (c) Knowledge of Science Curriculum (KSC), (d) Knowledge of Instructional Strategies and Representations (KISR), and (e) Knowledge of Assessment of Science Learning (KAs). The quality of PCK depends on the integration of PCK, that is, the consistency among various components and the strength of each component (Park 2005, 2010). Based on Park's Pentagon model and further adaptation, PCK evaluation scale suitable for this study was developed. The interview outline of this study draws lessons from the content representation tool of Loughran (2014).

The participants in this study were three pre-service teachers in microteaching training, whose teaching topic was the PEP edition of "Methane". This study draws lessons from the analysis method of Park to analyze the data, we constantly compared and analyzed the data and data, data and results, results and literature, so as to draw the conclusion of this study.

Results and Discussion

The results are presented in five points: (1) From the PCK map, we can see that the three pre-service teachers have great individual differences in the integration degree of PCK in micro-training.

According to their grades, it is not necessarily that the higher the grades of pre-service teachers are, the higher their PCK integration degree is. (2) Three pre-service teachers' OTS significantly regulated KISR and sometimes prevented the connection of KISR with other components, especially with KSU. (3) The integration of KAs and KSC of pre-service teachers was relatively lacking. (4)The teaching strategies and representation methods of pre-service teachers in this topic are abundant, however, Some KISR is not highly integrated with other knowledge. The three pre-service teachers seldom adopt effective teaching strategies for students' learning difficulties and misconceptions. (5) According to the results of interviews and analysis, the main factors influencing the integration mechanism of teachers' PCK are summarized as follows： including teaching reflection of pre-service teachers, intervention of expert teachers, and micro-training assignments and so on. These factors infiltrate each other and act on pre-service teachers' PCK together.



Teacher A　　Teacher B　　Teacher C

Figure 1. three pre-service teachers' PCK map

Table 1. Frequency of connections of PCK components

	OTS-KAs	KSC-KAs	KAs-KISR	OTS-KSC	KAs-KSU	KSC-KISR	KSC-KSU	OTS-KSU	KSU-KISR	OTS-KISR
A	3	4	4	5	4	6	7	9	10	10
B	1	1	1	2	3	2	2	5	5	7
C	4	4	4	4	5	5	7	6	6	7
Total	8	9	9	11	12	13	16	20	21	24

Based on the above analysis, this study puts forward the following suggestions: (1) Pre-service teachers should fully consider and integrate various relevant knowledge to optimize their own PCK structure. (2) Pre-service teachers should attach importance to micro-teaching and training, correct the attitude of practice and reflection. (3) Normal universities should perfect the structure and content of training courses for normal university students.

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Oral Session 3	Day2 (June19th) 14：30～16：00
Room7	C5-3
【Category】	5: Science Education for Undergraduate or Graduate School Students

=Chairperson=

Prof. Mei-Chun Lydia Wen	National Changhua University of Education

=Presentation Program=

1	63-5-3-19-1（FY63-WTML-XA021） Siriporn Kruatong（Kasetsart University, Kamphaeng Saen Campus） Tussatrin Wannagatesiri *ENHANCING SCIENCE STUDENTS TEACHERS' SCIENTIFIC LITERACY AND TEACHING PREPARATIONS THROUGH ONLINE LEARNING CONTEXT*
2	64-5-3-19-2（FY6N-JGBS-6Y021） Wenhua Zhang（Central China Normal University） Zuhao Wang, Guo-feng Zhang, Zhu-yan Song, Liu Yi *Research on the Development of Pre-service Chemistry Teachers' Pedagogical Content Knowledge*
3	65-5-3-19-3（FY6T-S442-UK021） Zhu-yan Song（No. 6 Middle School of Harbin） Wenhua Zhang；Zuhao Wang *A Study on the Standards of Excellence for Chemistry Teachers and PCK Level Survey*
4	66-5-3-19-4（FY4K-8G59-RP021） R. Ahmad Zaky El Islami（Kasetsart University） Chatree Faikhamta, Samia Khan, Nguyen Van Bien, Indah Juwita Sari, Song Xue, Le Hai My Ngan, Vipavadee Khwaengmake, Nguyen Thi To Khuyen, Thauresean Prasoplarba, Anupong Praisri *DEVELOPING PRE-SERVICE SCIENCE TEACHERS' ABILITY TO TEACH THE MII-STEM APPROACH THROUGH MICROTEACHING*

ENHANCING SCIENCE STUDENTS TEACHERS' SCIENTIFIC LITERACY AND TEACHING PREPARATIONS THROUGH ONLINE LEARNING CONTEXT

Siriporn Kruatong[1] and Tussatrin Wannagatesiri[1]

1. *Kasetsart University, Kamphaeng Saen Campus, Thailand*

ABSTRACT

The COVID-19 crisis has forced education systems worldwide to find alternatives to face-to-face instruction. As a result, online teaching and learning have been used by teachers and students on an unprecedented scale. In this study, the online learning activities were designed for enhancing science student teachers' scientific literacy and their teaching preparation for engaging students' scientific literacy. Research participants were 60 science student teachers (SSTs) who are the third-year undergraduate students in the Teacher Education program. The research instruments consisted of 1) the PISA-like scientific literacy assessment test and 2) lesson plan analyses. The SSTs were guided to PISA scientific literacy and assigned to create the learning activities that require students to identify scientifically oriented issues, explain phenomena scientifically, and use scientific evidence. They also had chances to present their learning activities and reflected on others' presentations. The scores from the PISA-like scientific literacy assessment test revealed that they could not do the test as well as they should in the beginning, however after the online learning, their post-test was higher than pre- at significant level .01. The data from lesson plan analyses revealed that 52 SSTs had learned how to enhance students' scientific literacy through the PISA framework. Their learning activities have provided student's everyday problems or situations that require the student to grasp knowledge about science themselves through the relevant investigation activities or any science experiments. However. The development of knowing how to formatively assess students' PISA scientific literacy is needed.

Keywords: *Scientific literacy, science student teachers, online learning*

INTRODUCTION

The Covid-19 crisis, not only in Thailand (Parichat, 2021) has had a lot of effect on the education system but worldwide also has this problem (Dailinews, 2021). This situation needs to find alternatives to face-to-face instruction. The Programme for International Student Assessment (PISA), which is performed by the Organization for Economic Co-operation and Development (OECD), has emphasis on measuring the scientific literacy competency that investigates how students can apply their scientific knowledge and skills. The assessment focused on the thinking process, the ability to understand a given situation, understanding of science content and the use of knowledge effectively in various situations (PISA Thailand, 2020). In this study, the online learning activities were designed for enhancing SSTs' science literacy and their teaching preparation for engaging students' scientific literacy in the Covid-19 crisis. This research established three sub-objectives which are: 1) To develop online courses to enhance SSTs' science literacy and their teaching preparation for engaging students' scientific literacy and 2) To study the results of the use online course to enhance SSTs' science literacy and their teaching preparation for engaging students' scientific literacy.

RESEARCH METHODOLOGY

The methodology of this research is action research. The research participants were 60 SSTs who are the third year undergraduate students in the Teacher Education program in Thailand. The four weeks in Learning Management online course were provided for enhancing SSTs' science literacy and their teaching preparation for engaging students' scientific literacy. The topic of this 1-semester is consists of: 1) Introduce science literacy, 2) Discuss about science literacy analysis in science standard and indicator, 3) Discuss about science literacy analysis in science lesson plan, 4) Assign group working to design science activities concerning science literacy, 5) Assign individual students to design their own lesson plan that require students to identify scientifically oriented issues, explain phenomena scientifically, and use scientific evidence and 6) Provide for reflection and revision of lesson plan. The PISA-like scientific literacy assessment test were used before and after learning. The SSTs' lesson plans were analyzed.

RESULTS

SSTs' scientific literacy

The data in Table 1 has shown the scores from the PISA-like scientific literacy assessment test revealed that SSTs could not do the test as well as they should in the beginning, however after the online learning, their post-test was higher than pre- at significant level .01.

Table 1 Comparison of SSTs' average scores of PISA-like scientific literacy between pre-test and post-test (full scores=17)

	Mean	Std. Deviation	t	p
Post-test	11.6667	2.97	9.280	.000*
Pre-test	7.6000	2.77		

* significant level 0.01

Lesson plan analysis

The lesson plan analysis revealed that 52 SSTs had learned how to enhance students' scientific literacy through the PISA framework. The data showed that 60 percent of SSTs were able to design the lesson plan for enhancing scientific literacy at an exemplary level in developing PISA competencies as identified for learning purposes 60 percent. They were able to provide the lesson which 1) using everyday life situations (68%), 2) planning activities for students to investigate or experiment (100%), 3) planning activities for students to learn about conclusion and utilization of scientific evidences (68%), 4) planning activities about explaining everyday life situations related to the content being studied (77%), and 5) defining media, teaching materials, learning resources to search for information that promotes activities along the PISA guidelines (54%). However 96 percent were not able to integrate formatively assessing in their lesson student' PISA scientific literacy.

CONCLUSION

The online learning activities were designed for enhancing SSTs' science literacy and their teaching preparation for engaging students' scientific literacy. The PISA-like scientific literacy assessment test revealed that SSTs could not do the test as well as they should in the beginning, however after the online learning, their post-test was higher than pre- at significant level .01. The lesson plan analysis revealed that 52 SSTs had learned how to enhance students' scientific literacy through the PISA framework.

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Research on the Development of Pre-service Chemistry Teachers' Pedagogical Content Knowledge

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ABSTRACT
This research adopts Questionnaire survey, classroom observation, semi-structured interview, text analysis method and other methods. This paper firstly defines the relevant core concepts, and then formulates the PCK non-situational cognition questionnaire and PCK context cognition questionnaire for pre-service chemistry teachers from five dimensions based on the Professional standards for Middle school teachers in China (trial) and the PCK five-element model of Park. This study investigated the status of situational cognition and non- situational cognition of PCK among undergraduates majoring in chemistry education in Wuhan, The survey found that the two kinds of PCK cognitive status quo of the research object and the existing problems, discusses the causes of the current situation, put forward the development strategy to improve the level of PCK. And then the author to carry out the development of PCK pre-service chemistry teachers of chemistry teacher education curriculum practice, the course uses reflection task mode of action, the PCK of situation cognitive assessment questionnaire and PCK of classroom teaching evaluation scale and characterization PCK content questionnaire assessment tools, such as collection of pre-service chemistry teachers in chemistry teacher education curriculum based on one year chemistry special subject development of PCK evidence, explore PCK development level of the research object under the different chemical subject and the PCK cognitive development characteristics by evaluating the PCK development level before and after course learning.
Keywords: *Pre-service teachers, Chemistry teacher education course, PCK development*

PCK knowledge is a kind of practical knowledge. As the main source of teachers' professional knowledge, reflective practice has always been the key path to improve teachers' professional development after service. If this strategy is applied to improve the training mode of pre-service teacher professional development, it is of great significance and value to improve the curriculum of teacher education for the influence and effectiveness of pre-service teacher PCK development. Therefore, it is an arduous and urgent task to study the learning and evaluation of pre-service teachers' PCK and explore the rules of pre-service teachers' professional learning and development.

1 Design of research on the development of PCK for pre-service chemistry teachers

Based on Shulman's seven kinds of teacher teaching knowledge and New York State teacher professional standards, this paper designed situational cognition and non-situational cognition PCK cognitive questionnaires for pre-service chemistry teachers. Through two kinds of questionnaire surveys, the problems existing in the current cognitive status of chemistry teachers' PCK were found. Then, according to Park's PCK pentagon model, the PCK development evaluation scales for two courses of pre-service chemistry teacher education theory were constructed, namely Chemistry Teaching Theory and Analysis of Middle School Chemistry Curriculum Standards and Textbooks. Based on the framework of PCK content representation tool developed by Loughran (2004), the development level and transformation evaluation tool of PCK in practice simulation course "Middle School Chemistry Teaching Skilled Training" were optimized and designed. The three courses solve the real chemistry teaching learning tasks and reflect on the design, use the corresponding tools to evaluate and analyze the development characteristics of the research object PCK, and finally explore the influencing factors of the development of PCK through the questionnaire survey of the sources of chemistry teaching knowledge.

There are four types of subjects selected in this study, all of which are from a normal university in

Wuhan. Among them, the subjects surveyed are pre-service teachers of the class of 2013. The subjects of non-situational cognition were students of Grade 2015 and 2016. The practice target of PCK development course is two pre-service chemistry teachers of Grade 2017 (junior year) (including free normal university students and non-free normal university students); The sources of chemistry teaching knowledge were studied from 18 undergraduates of 2016, 50 undergraduates of 2017 and 25 graduate students of 2019 in chemistry education.

2 Data collection

The 50 subjects of this study are 2017 undergraduates. The first teacher education theory course is scheduled to start in the autumn of 2019 and end on January 10, 2020. The course Analysis of Curriculum and Textbooks will start in the spring of 2020 and end on April 12, 2020. According to the course practice design in Chapter 3, this study explores how the subject's teaching knowledge of chemistry (PCK) changes during the course learning of teacher education theory in one academic year by using multiple case studies with 50 students in one class. According to the reflective task and evaluation tool design in the course teaching practice of Chapter 3 and Chapter 4, the evidence of PCK progress trajectory was collected, and the evaluation standard tool was used to explain the changes of the five components of PCK of the research object. These data are collected by the PCK capture method for the homework and homework data assigned to each pre-service teacher in this semester. For each homework, there is a structured reflection written assignment to solve the difficult problems in oral interview. These assignments are all designed to solve the problems that a pre-service teacher needs to solve in the future teaching, that is, how to design an effective one-hour chemistry teaching design scheme and classroom teaching tasks according to the new curriculum standards of high school chemistry, and there is a relationship between teaching logic, knowledge logic and cognitive logic. These logical relations are the essence of the interaction of different elements in the PCK pentagon model.

3 The research conclusion

The conclusions of this study are as follows:

(1) Preservice chemistry teachers' cognitive level of each important component of PCK situational cognition is not high, but the lowest cognitive level is teaching evaluation knowledge.

(2) Pre-service chemistry teachers can construct a PCK thinking model by learning the theoretical courses of chemistry teacher education, and effectively promote the PCK development of pre-service chemistry teachers by reflecting on the PCK components.

(3) The PCK development of theoretical courses are as follows: ①"Science teaching orientation" (OTS) level of development overall performance level is low, but the speed of improvement is relatively fast.②"Science curriculum knowledge" (KSC) level development difference is still very big.③ "Students' understanding of scientific knowledge" (KSU) varies greatly. ④The level of "subject teaching strategy knowledge" (KISR) is above average, and its performance level in consistency analysis and design tasks of chemistry teaching objectives and activities is low. ⑤Most of the "science teaching evaluation knowledge" (KAc) performance level is medium.

(4) The development characteristics of PCK 5 dimensions in pre-service teachers' learning of chemistry teacher education practice course are unbalanced.

(5) Through the research, it is found that the source of subject teaching knowledge of pre-service teachers is mainly influenced by 4 factors, which are composed of 13 variables.

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A Study on the Standards of Excellence for Chemistry Teachers and PCK Level Survey

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ABSTRACT

Since the 20th century, as an important measure of teacher education personnel training reform, "excellent teacher" plan has been widely valued by domestic and foreign experts and scholars.2018 issued by the ministry of education "about 2.0 outstanding teacher training scheme", which has been clear about the new era in our country outstanding teacher training objectives and tasks, namely to do good a batch of high level, there are characteristics of teachers and teachers' professional education colleges, by 2035, the comprehensive quality of students, professional level and innovation ability significantly increased, and lay a solid foundation for training outstanding teachers.However, after consulting a large number of literatures, it is not difficult to find that China's professional standards for teachers are not mature, theoretical , and do not have observable behavioral indicators, so the identification of excellent teachers is particularly vague.Secondly, the domestic research on the standards of excellent chemistry teachers mostly stays in the stage of theoretical analysis, narrative research and other stages, with relatively single methods and lack of empirical research based on data analysis.

Therefore, this study is based on the standard framework of excellent chemical teachers based on our national conditions, and then using the different classification standards of the more mature different dimensions in the international system to continuously refine and refine the framework, and develop a more complete, well-measured and effective standard of chemistry teachers. Then, according to the standard, a self-assessment questionnaire was distributed to the 2015 and 2016 class of chemical teachers in central China normal university, and the analysis and comparison of the various dimensions of the various dimensions were analyzed by using spss20.0 software. Based on the data processing results, the evaluation of the performance of the three levels of the evaluation and the self-evaluation of the research subjects were compared and analyzed in the third level certification, and the Suggestions and the improvement strategy of the two grade chemical majors were proposed and improved.

In the end, the results and conclusions of the following results and conclusions: (1) the establishment of excellent chemistry teachers and their self-assessment questionnaires; (2) the results of the study of the subjects were higher than the results of the experts' assessment; (3) the level of the standard self-evaluation of the two aspects of the knowledge or skill of the chemistry subject and the level of knowledge of the students' knowledge will be lower. (4) there were significant differences in the degree of achievement of excellent chemistry teachers in different grades.

The innovation point of the institute is :1) designed the standard of excellent teachers for the chemistry subject; (2) to make the standards of excellent chemistry teachers observable and operable, with executive

effect.And the three levels of normal university students certification standards to improve the behavior indicators.

Keywords: *pre-service teacher , standards for excellence in chemistry teachers , PCK non-situational cognition level survey*

Design and optimization of research tools

This study refers to Wang Yinghua's conclusion in "International Comparison of Professional Standards for Excellent Teachers and Its Enlightenment" : "The United States has established the most perfect professional standards system for excellent teachers based on the five basic principles". Therefore the design standard of excellence chemistry teacher evaluation mainly refer to teacher's professional standards of one state in the United States, the standard of "highly effective" observable index to a certain extent, carding and integration, in the process of combing the author of American teachers' professional standard framework construction, after the reading of vast amount of literature, through the comparison, And reference level 3 certification standard system framework, the author finally agree and choose shulman seven teachers knowledge as a remarkable chemical standard evaluation framework, the framework is the most close to the author refined level 3 certification standard system framework, comprehensive and theoretical generalization of an outstanding chemistry teachers should have in education career and achieve all aspects of the quality and requirements.

Evaluation framework and observable (behavior) indicators of excellence chemistry teacher standards(Show Part of the Content)

表 3.3 卓越化学教师标准评价框架

框架	一级指标	二级指标	三级（可观测）指标
学科内容知识	实体知识	教师展示他们所教授内容的知识，包括中心概念、原理、探究工具、结构和学科内当前发展之间的关系。	通过使用多种表示和解释，在教学过程中融入关键概念。
	句法知识	教师设计相关的教学，将学生先前的理解和经验与新知识联系起来。	通过提问技巧、讨论和其他方法，确定学生对内容理解和知识的当前水平。
		教师展示当前基于研究的学习和语言习得理论和过程的知识。	设计教学计划并调整教学内容，使之包含各种支持每个学生学习需求的策略。

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DEVELOPING PRE-SERVICE SCIENCE TEACHERS' ABILITY TO TEACH THE MII-STEM APPROACH THROUGH MICROTEACHING

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ABSTRACT

This study aims to examine the effectiveness of model-based integrated inquiry in science, technology, engineering, and mathematics (MII-STEM) approach implementation to pre-service science teachers' ability to teach the MII-STEM approach through microteaching. The key features of the MII-STEM approach consist of real-world problems, constructing a STEM model, predicting, collecting data, testing solutions, and formulating hypothesis-proposal solutions. The method used in this study was a one-shot case study. Data were collected through a teaching-practice assessment form covering eight aspects, including teaching purpose, science and engineering practices, modelling, inquiry, the integration between S-T-E-M, overview and sequence of learning management, learning management steps according to MII-STEM and methods of measurement, assessment, and evaluation. The participants consisted of 25 pre-service science teachers that be divided in five groups. We analyzed the data using rubric scores to obtain a mean score for each pre-service science teacher. The results indicate that all five pre-service science teachers are in the acceptable category for practicing the MII-STEM approach based on the results of the microteaching assessment. These findings conclude that pre-service science teachers' ability to teach the MII-STEM approach is acceptable, showing that the MII-STEM approach impementation is effective towards pre-service science teachers' ability to teach the MII-STEM approach. Future studies need to be conducted to develop and evaluate the online MII-STEM approach as a response to the COVID-19 outbreak.

Keywords: *Pre-service science teachers' ability to teach, MII-STEM, Microteaching*

INTRODUCTION

Model and modelling is the basis of cognition to stimulate scientific inquiry (Wang et al, 2016). Modeling is the process to establish a scientific theory or solve problems and for the students, modelling to develop the scientific comprehensive understanding (Wang et al, 2016). A science teacher needs modeling in the learning process to explain the scientific concepts and phenomena. Models and modelling are considered integral parts of scientific concepts and reflecting science teachers' efforts to introduce and engage students in authentic scientific inquiry (Louca & Zacharia, 2012). STEM Education refers to Science, Technology, Engineering, and Mathematics Education that should improve students' skills and creativity that have an impact to economic condition in the society (Bybee, 2010). In this study we combined model and modeling and integrated STEM approach to model-based integrated inquiry in science, teachnology, engineering, and mathematics (MII-STEM). This study aimed to examine the effectiveness of model-based integrated inquiry in science, technology, engineering, and mathematics (MII-STEM) approach implementation to pre-service science teachers' ability to teach the MII-STEM approach through microteaching.

CONCEPTUAL FRAMEWORK

MII-STEM stands for 'Model-based Integrated Inquiry in Science, Technology, Engineering and Mathematics' (University of British Columbia, 2019). The key features of the MII-STEM approach consist of real-world problems, constructing a STEM model, predicting, collecting data, testing solutions, and formulating hypothesis-proposal solutions

METHOD

Weak experiment method is used in this study using the design of the one shot case study in Table 1 (Fraenkel et al, 2012). This reseach conducted in one state university in Indonesia. The instrument used in this study is an microteaching assessment using rubric score. The participant in this study is consisted 25 pre-service science teachers that divided to five groups. One pre-service science teacher in each group practiced MII-STEM approach through microteaching in 30 minutes. Data were collected through a teaching-practice assessment form covering eight aspects, including teaching purpose, science and engineering practices, modelling, inquiry, the integration between S-T-E-M, overview and sequence of learning management, learning management steps according to MII-STEM and methods of measurement, assessment, and evaluation. The criteria of this teaching assessment is consisted three categories; need improvement ($\overline{X} = 1$), acceptable ($1 < \overline{X} < 3$), and complete ($\overline{X} = 3$).

Table 1. The one shot case study design

X	O
MII-STEM Approach	Ability to Teach MII-STEM Approach

RESULTS AND DISCUSSION

Table 2. Microteaching Result Assessment

Pre-service science teachers	Mean	Category
A	2.775	Acceptable
B	2.6	Acceptable
C	2.525	Acceptable
D	2.525	Acceptable
E	2.8	Acceptable

Based on Table 2, the results indicate that all five pre-service science teachers are in acceptable category for practicing MII-STEM with mean score in each pre-service science teachers at more than 2.0 from 3.0. These findings concluded that the pre-service science teachers' ability to teach MII-STEM approach is acceptable, showing that the MII-STEM approach implementation is effective towards pre-service science teachers' ability to teach the MII-STEM approach. These findings is supported by the learning process in the MII-STEM curriculum that consisted of six lessons; the nature of science and modelling; Science and Engineering Practices (SEPs); Integrated STEM; teaching approach for mii-STEM; assessment of student modelling competencies, and practice that thought using MISTEM approach. These six lessons that thought in 14 meetings that consisted; creating bubble wands; seed sort and growth; black box as a metaphor for nature of science; moon phase; learn SEP through Scientist and Engineer Views (period I and II); right the light LED to integrated STEM; teaching approach in MII-STEM for pre-service or in-service teachers (period I-III); assessment of student's competencies at modelling (period I and II); microteaching for practicing mii-STEM (period I and II). Future studies need to be conducted to develop and evaluate the online MII-STEM approach as a response to the COVID-19 outbreak.

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Oral Session 3	Day2 (June19th) 14：30～16：00
Room8	C6-1
【Category】	6: Science Education for Informal Setting or Life-Long Learning or In-Service Teacher training

=Chairperson=

Prof. myeong-kyeong shin	Gyeongin National Univ. of Ed

=Presentation Program=

1	67-6-1-19-1（FXD4-0T91-2I021） Takekuni YAMAOKA（Tokai Gakuen University） Tetsuya YAMADA *A Research-Based Instructional Model for Promoting Scientific Thinking in STEM-Practicing Schools in Japan*
2	68-6-1-19-2（FXNT-K4AB-0A021） Nurul F. Sulaeman（Mulawarman University） Pramudya D. A. Putra, Yuki Yasuma, Ippei Mineta, Hiroki Hakamada, Yoshisuke Kumano *EXPLORING STUDENTS' ENGAGEMENT IN AFTER-SCHOOL STEM PROGRAM FROM GENDER PERSPECTIVES*
3	69-6-1-19-3（FY4C-DHO5-SY021） Nina Rosliana（Universitas Pendidikan Indonesia） Anna Permanasari, Nahadi *LOW CARBON BEHAVIOR OF WASTE MANAGEMENT PROSPECTIVE INSTRUCTORS: A CASE STUDY IN ONE VILLAGE OF WEST JAVA-INDONESIA*
4	70-6-1-19-4（FY4X-DG02-SM021） Phattraporn Thongkesorn（Srinakharinwirot University） Chanyah Dahsah *THE CAUSAL RELATIONSHIP MODEL OF FACTORS AFFECTING THE DECISION TO PARTICIPATE IN THE EDUCATION PROGRAMS IN THE SCIENCE MUSEUM OF UPPER ELEMENTARY STUDENTS*

A Research-Based Instructional Model for Promoting Scientific Thinking in STEM-Practicing Schools in Japan

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ABSTRACT
This study aimed to examine the characteristics of classes in schools that practice advanced science, technology, engineering, and mathematics (STEM) education. Furthermore, this study aimed to propose more appropriate STEM education for the educational situation in Japan. From 2019 to the present, 25 teachers practicing STEM education were surveyed through an interview or a questionnaire. It was found that teacher had better did the class is based on a firm understanding of the students' situation. Often, student-centered activities are required in learning. Hence, it is important to have a teacher who can make this happen, for example, by understanding the situation of the students. And, it can be seen from this study that the quality question was designed to encourage student to think. In fact, when students do think, they provoke new questions. And student ask the new question. There needs to be the good cycle that is from the teacher's quality question to the student's asking question in the classroom.

Keywords: *STEM education, high-quality questioning, higher-order thinking, Instructional model.*

Introduction

The context of inquiry learning in science, technology, engineering, and mathematics (STEM) education is related to the independent, interactive, and deep learning described in Japan's new Courses of Study. In science and technology education in Japan, many studies have been conducted on inquiry-based learning that arouses interest and promotes knowledge understanding through experience. However, to the best of our knowledge, there is no research on educational programs that promote scientific higher-order thinking triggered by questions from the teacher in classes. Conversely, the K-12 Science Education Standards, a proven theoretical pillar of STEM education in the United States and Europe, states that questioning promotes scientific thinking. Additionally, according to the National Research Council (NRC), special attention to STEM education is best seen in curricula that deepen STEM learning over time, as well as STEM instructional time, materials, and teachers. In addition to the development of science teaching materials and the devising of observations and experiments, teachers' questions aiming to promote scientific thinking among learners must be considered, such as devising questions based on activities that generate cognitive conflicts. To explore the effective and high-quality questions used by STEM teachers in their regular classes, this study focused on teachers who are well prepared to teach in STEM fields, and to explore how to teach students to connect their questions to their next learning contents.

Research Objectives

This study aimed to examine the characteristics of classes at schools that practice advanced STEM education. Further, based on the results of the survey, it strived to propose a research-based instructional model for promoting scientific thinking in accordance with the educational situation in Japan.

Research Method

This study conducted the survey in 2019, interviewing 10 domestic STEM education practitioners (Yamaoka and Yamada, 2020), and in 2020, surveying 15 domestic STEM education practitioners using a web-based questionnaire form (https://sites.google.com/view/a-theoretical-and-practical-st/top). The 25 teachers included in the study were domestic STEM education practitioners (13 science teachers, 5 technology and home economics teachers, 3 industrial science teachers, and 4 mathematics teachers). The following three questions were asked regarding teaching methods to promote scientific thinking. Question 1: Under which teaching strategies can effective and high-quality questioning be established? How does it affect students' thinking activities? Question 2: Which teaching strategies used in best practices generate cognitive conflicts and promote higher-order thinking? Question3: Which teaching strategies are used to connect high-quality questioning by students to the next learning stage? The text document of the content of these responses was used as elementary data and analyzed using Bell Curve’s software, Trend Search 2015 that can text mining.

Results and Discussion

This study conducted an interview or a questionnaire survey with 25 domestic STEM education practitioners. Question 1 tended to indicate that it is important to “think” about such questions, whether the teacher’s “questioning” is such that it is based on “experience” or whether it seeks “essence.” In question 2, there was a tendency to think that it is important to hold “group” activities and to intentionally create situations in which cognitive “conflicts” occur, which can then be “discussed.” In question 3, there was a tendency to think that it is important to “reflect” on learners’ “questions” and “doubts.” Typical examples of comments were as follows. (1) Does the objective lie in the climax of the class? I consider the class plan so that the climax of the class can be the essence of the question. Therefore, an unplanned class will not produce high-quality questions. (2) I think this is the activity of having students write down new questions that arise in class. I think that having students write is a critical aspect of educational instruction because it helps them organize themselves. (3) One is to have them reflect on their portfolio. First, I think it is significant that when you check the students’ reflections in the formative assessment, you can also reflect on your own teaching.

The results of text mining are shown in the figure 1. Among the words that were common to all questions, the more frequent words were “think”, "Ask", and so on. A quality question is designed to encourage people to think. When students do think, they ask new questions, and then ask them. There needs to be a good cycle in the classroom.

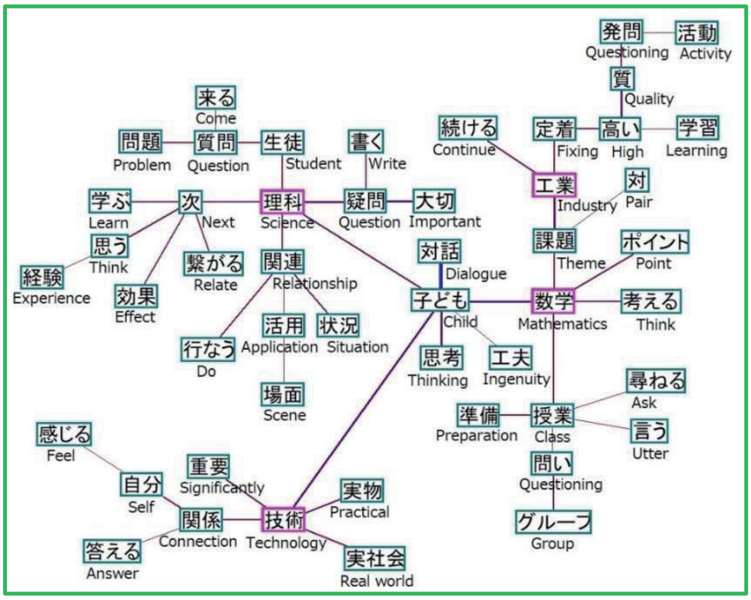

Figure 1. The results of text mining.

Summary

In this study, we found the following. A quality question is designed to encourage people to think. When students do think, they ask new questions, and then ask them. There needs to be a good cycle in the classroom. The results of the interviews indicate that in order to achieve this cycle, teachers are aware of the following. STEM education practitioners have a firm grasp of the current situation of their students. Thus, they devise ways to generate cognitive conflicts. Moreover, the key to connecting to the next stage of learning is to use student-centered activities as the basis. However, timely teacher advice is also important.

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EXPLORING STUDENTS' ENGAGEMENT IN AFTER-SCHOOL STEM PROGRAM FROM GENDER PERSPECTIVES

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ABSTRACT

While STEM education is growing, gender disparity is an essential issue in many countries, including Japan. This phenomenon is also observed in an after-school STEM program organized by National University in Japan. While the participants' participation is open for students from 5th to 9th graders, female participants are always lower than males for three years in a row. Therefore, exploring gender perspectives in students' engagement in after-school STEM programs is essential. Our study aimed to explore students' engagement in after-school STEM programs from the gender perspective. Forty-six students (33 male and 13 female) completed three STEM sessions. After the activities, participants filled a self-reflection toward their engagement. Qualitative analysis was conducted to discover the critical ideas of students' engagement. Co-occurrence network analysis was completed by qualitative software to find the central words used in participants' reflections. While most of the participants highly participate in the project, their central idea is related to design and share with their team. While male participants strongly relate their engagement with making and designing activities, females share opinions with friends. From their reflection, group activity in the after-school STEM program became central to participants' engagement. Therefore, dynamic group activity is essential. Female students need to be encouraged to translate their opinion in the discussion to the designing activity. Both genders acknowledge STEM activities that facilitate more teamwork support more engagement.

Keywords: *Student's Engagement, After-school, STEM Program, Gender*

INTRODUCTION

Although the science learning process mainly conducts in the formal education setting, previous research showed that after-school STEM programs bring positive impact (Cohen, 2018; Dabney et al., 2012). The impact found to student engagement (Sakata & Kumano, 2018) and perception to career (Sulaeman et al., 2020) While the after-school science programs are commonly found in Japan that supported by the Japan Science and Technology Agency (JST), the after-school science program that addressed the integration of STEM is rarely found. Moreover, the essential issue in STEM education is the problem of gender equality. This issue globally faced by the education system became one of the Sustainable Development Goals by United Nations (United Nations, 2015) and issue in science education in Japan (Isa & Chinen, 2016). Gender, with all the complexity around this factor, influence the process in the small group interaction in STEM activity (Wieselmann et al., 2019). Therefore, it is essential to support after-school STEM programs with a deeper understanding of student engagement from gender perspectives.

METHOD

This study utilized a case study to explore the student's engagement in an after-school STEM program from gender perspectives. Forty-six students (33 male and 13 female) completed three STEM sessions: balloon rocket, wind power location, and blade design for the wind power project. After the activities, participants filled a self-reflection toward their engagement. Qualitative analysis was conducted to discover the critical ideas of students' engagement. Co-occurrence network analysis was completed by qualitative software to find the central words used in participants' reflections.

RESULT AND DISCUSSION

Although males and females showed high engagement in STEM programs, how they explain their engagement might be different. To clarify whether or not male and female students show the same engagement. The result of frequency word in participation point by gender could be observed. In general, both genders show words that are related to cognitive and social engagement. However, the male students express their perceptions with more different words. Compared to the female students, the male students show that the words "make" are repeated as the most frequent words. This result shows that the male students more actively involve.

Moreover, the co-occurrence network clarified the finding from frequency word analysis. The words with high centrality for male students are "friends" and "make" while for female students are "opinion" and "friends." Both genders agreed that "friends" or the relationships with peers play a central role in their engagement. In specifics, the male students have broader concepts to explain their engagement. The words related to science concepts were found in male students and not in the female result, such as "experiments" and "time.” Female students tend to have more simple perceptions. Interestingly, while male students reflect that "make" related to "design", female students, reflect that "make" is closely related to "think". The engagement showed the cognitive and social engagement from the students.

CONCLUSION

While male participants strongly relate their engagement with making and designing activities, females share opinions with friends. From their reflection, group activity in the after-school STEM program became central to participants' engagement. Therefore, dynamic group activity is essential. Female students need to be encouraged to translate their opinion in the discussion to the designing activity. Both genders acknowledge STEM activities that facilitate more teamwork support more engagement.

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LOW CARBON BEHAVIOR OF WASTE MANAGEMENT PROSPECTIVE INSTRUCTORS: A CASE STUDY IN ONE VILLAGE OF WEST JAVA-INDONESIA

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ABSTRACT

In line with the Sustainability Development Goals (SDGs) number 3, ensuring a healthy life and promoting the welfare of all people at all ages, STIKes Dharma Husada Bandung has and is conducting the crash program with the target some villages around Bandung City, West Java-Indonesia. One of the villages that has become the focus of the development is the Desa Mekarmanik, one of the villages in the Bandung area, West Java. Cadreization was carried out for 30 volunteer housewives in the village who would later provide counseling to the community. The research also browsed how they act and behave toward low carbon behaviour. The data were collected using a questionnaire covering the knowledge, attitudes and behavior of cadres regarding low carbon-based waste management which were filled in directly by the respondents. The results of the research show that the respondents' knowledge regarding low carbon-based waste management is fairly good with an average achievement of 82.0%. However, the attitudes and behaviors that were verbalized in the answering the questionnaire from the prospective instructors still need to be improved. Only 68% of them answered correctly on the questions posed, while for the behavioral aspect, on average only 67.7% answered correctly. These results indicate the need for more comprehensive education/training activities so that they become eligible to become instructors who can educate the public/society regarding low-carbon-based waste management behavior.

Keywords: *volunteer instructors, low carbon behavior, waste management*

I. PRELIMINARY

The world is facing huge problems, global warming is just one of them. UN outlined into 17 objectives of sustainable development goals (SDGs) (Ministry of Planning/Bappenas, 2020) are ways to overcome the difficulties. One of the objectives of SDGs, namely the third; live healthy and prosperous, relates to the management of waste. A well-functioning waste management that did not give rise to an increase in CO2 and CH4 in the air will contribute to meet the third objectives of SDGs. Countries in the world do various efforts for lowering the concentration of CO2 in the air with a variety of programs, one of them is through education of low carbon (Low Carbon Education = LCE). Low carbon-based waste management means to minimize and even prevent the release of carbon as waste into the environment, it can contribute in fulfilling the purpose of the third SDGs. Fatin Aliah Phang, et al (2019) paid attention to LCE by researching efforts to implement low carbon education.

Based on the data of waste in Bandung Regency, West Java, the highest percentage of waste generation comes from household at 66.0%. In the Mekarmanik Village of Bandung Regency, there are habits of waste burning and littering that can cause health risks, polluting the environment, blocking water channels, and potentially nests germs causing numerous diseases. It can also cause the growth of pathogens such as bacteria, parasites, and fungi. Fungi found in a pile of garbage when accidentally consumed by humans can cause various diseases such as diarrhea, typhoid, and parasitic worm infection. In addition to that, the waste can be a thriving habitat for vectors of disease such as rats, cockroaches, and flies.

To deal with this problem, volunteers' help is needed to educate the public so that information can be delivered as widely and quickly as possible. For the success of the program, before cadres plunge into the community to do education on the management of waste, it's a good idea to do a measurement of the cadre's competence, to assess their readiness to carry out education to the community.

II. RESEARCH METHOD

The research design that is used is quantitative and the type of research is descriptive analysis. The research population is the whole cadre in the village of Mekarmanik, while the sample are volunteers who are willing to fill the questionnaire, altogether totaling 30 people. Variables in this research are knowledge, attitudes, and behavior of cadres regarding the management of waste in the village of Mekarmanik. The instrument used was a questionnaire about knowledge, attitudes, and cadres' behavior regarding the low carbon-based management of waste. The instrument validation was carried out content-based with discussions with experts. Data collected through filling a questionnaire by the cadres, which then processed by using a computer. The results were analyzed visually to be interpreted then concluded, it is expected that the research objectives can be achieved.

III. RESULT AND DISCUSSION

Table 3.1. Cadre's competencies

No.	Competency	Score %	Category
1	Knowledge	82	Good
2	Attitude	68	Passable
3	Behavior	67,7	Passable
	Competency (Average %)	**72,6**	**Passable**

Research result shows that the knowledge of the respondents can be categorized as good (82.0%), while their attitude categorized as passable (68.0%), also similar for the behavior of cadres which is categorized as passable (67.7%). Then from the results recap shows that the competence of women cadres to provide counseling regarding the low carbon-based waste management just reached the category of passable, scoring 72.6% only. The results have shown that these women cadres still need to be educated more about the attitude and behavior of the management of waste until their understanding increase to 'good' category.

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THE CAUSAL RELATIONSHIP MODEL OF FACTORS AFFECTING THE DECISION TO PARTICIPATE IN THE EDUCATION PROGRAMS IN THE SCIENCE MUSEUM OF UPPER ELEMENTARY STUDENTS

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ABSTRACT

The education programs in museums aim to offer enjoyable and positive experiences for children in all ages based on the needs of the visitors. Thus, the objective of this study was to analyze the factors affecting the decision of upper elementary students to participate in the education programs in the science museum. The samples consisted of 200 upper elementary students who visited the National Science Museum (NSM), Thailand in December 2020. The research instrument was a questionnaire including three parts; personal information, causal factors affecting decision making, and activity participation. Cronbach's alpha coefficient for reliability of each questionnaire was between 0.72 - 0.93. Data was analyzed in two factors which were personal and family factors by structural equation modeling technique. The result showed that the proposed model fitted with the empirical data (χ^2 = 9.106, df = 9, p = 0.428, χ^2/df =1.012, CFI = 1.000, TLI = 0.999, RMSEA = 0.008, RMR = 0.014). That means personal and family factors played a role in the decision to participate in the education programs in the science museum. However, the results of variable influence analysis showed that the personal factors (0.24) [science career interest (0.80), attitude towards science (0.58), study habits (0.71)] and the family factors (0.52) [family relationship (0.46), science academic support (0.76), economic status (0.65)] did not directly affect decision to participate in the education programs in the science museum.

Keywords: *Causal Factor, Education Programs, Science Museum, Informal Learning, Upper Elementary Student, Structural Equation Model*

INTRODUCTION

Museums are an important setting for informal learning that have been identified as learning opportunities to enhance students' knowledge and motivation in various ways. The education programs in museums aim to offer enjoyable and positive experiences for children in all ages based on the needs of the visitors. In the current situation, it was found that various activities have a relatively small number of participants and most of the participants were early childhood. Thus, the objective of this study was to study the factors affecting the decision of upper elementary students to participate in the education programs in the science museum. These data could be used as a guideline for the development of learning promotion activities to meet the needs of the target audience.

Theory of motivation (Maslow, 1970), theory of decision making and social action (Reader, 1971) state that a person's decisions are influenced by several factors that support them and motivation is a major motivator for behavior. Motivation comes from the needs within the individual who are constantly interacting with the environment around them. Therefore, we define the causal relationship model of factors affecting the decision to participate in the education programs in the science museum of upper elementary students by using a model depicting major influences and decision-making factors leading to lifelong involvement in science of Simson and Oliver (1990). The hypothesis model consisted of two factors which were personal (science career interest, attitude towards science, study habits) and family factors (family relationship, science academic support, economic status).

MATERIAL AND METHODS

This research was a survey research. The data was collected through requesting permission of persons in research from 200 upper elementary students who visited the National Science Museum (NSM), Thailand in December 2020 according to the sample size criterion of Hair and others (2010) by convenience sampling. The participants were asked to completed a questionnaire included three parts; personal information, causal factors affecting decision making, and activity participation. The Cronbach's alpha coefficient for reliability of each part of the questionnaire was between 0.72 - 0.93. After that, data was analyzed by descriptive statistics and structural equation modeling technique.

RESULTS

The results of general data analysis of the sample showed that students were 42% male and 58% female, 48%, 29.5% and 22.5% studying in grades 4, 5 and 6, respectively, 32.5% located in Bangkok and surrounding areas and 67.5% other provinces, 70.5% visited the museum as a group and 29.5% individual, with 20.50% visited the museum before and 79.5% never.

The results of verification of the model consistency showed that the proposed model fitted with the empirical. However, the results of variable influence analysis showed that the personal factors (INT) (science career interest (CIN), attitude towards science (ATS), study habits (SHA)) and the family factors (FAM) (family relationship (FRE), science academic support (ASU), economic status (ECO)) did not directly affect decision-making as shown in Figure 1.

The results of activity participation analysis 106 students decided to participate in the education programs in the science museum using rank order scale questionnaire from 1 to 4 showed that 33 students ranked survey in the first order, and 50 students ranked workshop in the second order as shown in Table 1.

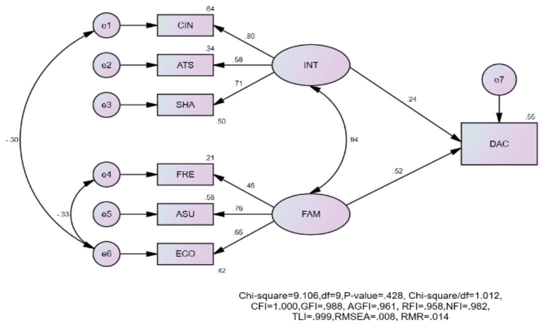

Figure 1. The causal relationship model of factors affecting the decision to participate in the education programs in the science museum of upper elementary students.

Table 1. Number of students interested in participating each activity when ranking in order.

Rank Order	Survey	Workshop	Show	Hands-on
1	33	29	24	20
2	21	50	19	16
3	14	23	47	21
4	38	4	16	49

CONCLUSION

Martin (2016) suggested that education programs might incorporating multiple modes of instruction to appropriately pitch content to participants in the target age range with regard to behavioral and emotional engagement participation. The hypothesis model is consistent with the empirical data. However, personal and family factors did not directly influence decision-making. May be due to the Science Museum located in area near Bangkok. Therefore, most of the sample visited the museum as a group, and have never visited before. Most of them decided to take a walk through the exhibitions inside the museum rather than participate in the education programs. This was consistent with activity participation analysis showed that students were most interested in survey activities, which are self-learning activities through a path that connects various stories in the museum such as walk rally, museum trail, etc. Thus, education programs in the science museum for upper elementary students should be an activity that located in the exhibition area.

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Oral Session 4

Day2 (June 19th) 16：30～18：00

Room1	C1-2	Science Education for Young Children and Related Areas
Room2	C2-2	Science Education for Elementary School and Related Areas
Room3	C3-9	Science Education for Middle or Secondary School and Related Areas
Room4	C3-10	Science Education for Middle or Secondary School and Related Areas
Room5	C4-5	Science Education for High School and Related Areas
Room6	C7-1	Science Education for Policies and Others

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Oral Session 4	Day2 (June19th) 16：30～18：00
Room1	C1-2
【Category】	1: Science Education for Young Children and Related Areas

=Chairperson=

Assist. Prof. Witat Fakchareonphol	Kasetsart University (Kamphaeng saen campus)

=Presentation Program=

1	71-1-2-19-1（FXG5-3QC8-4F021） Jing-Wen Lin（Department of Science Education, National Taipei University of Education） Yi-Yen Lee *A systematic review of phases and cycles of model(ing)-based inquiry*
2	72-1-2-19-2（FY4N-LU6T-DG021） Vipavadee Khwaengmek（Kasetsart FY4N-LU6T-DG021 University (Bangkhen Campus) Chatree Faikumta *Pre-service Science Teacher Reflective thinking involving STEM teaching*
3	73-1-2-19-3（FY4T-27LH-WJ021） Titisan Rumchatsakul（Srinakharinwirot University） Navara Seetee *THE TREND OF MIDDLE SCHOOL STUDENTS' SCIENTIFIC REASONING ABILITIES IN THAILAND*

A systematic review of phases and cycles of model(ing)-based inquiry

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ABSTRACT

Model-based or modeling-based inquiry (MBI) has played an increasingly significant role in education reforms in various countries. MBI is often organized into several phases that together form a cycle. However, different variations and factors on what constitutes MBI in the literature may confuse educators. The current study (a) focuses on identifying and summarizing the core features of MBI utilizing a systematic literature review and (b) develops a synthesized cycle that combines the strengths of existing MBI frameworks. In this framework, MBI begins with Orientation and flows through Model Generation, Investigation, to Model Evaluation, and ends with the Model Modification, where several cycles are possible. Besides, when considering the scopes and limitations, the Model Reconstruction may become active. The Discussion phase potentially connects to all the other phases and could be present at any phase during MBI. In addition, this MBI framework is based on various modelling environment, so it can be extensively used in mock/computer and reality/classroom environment, to assist teachers or curricula designers to design appropriate MBI tasks, textbooks, teaching, curricula, or guidance to classroom observation. Finally, a comprehensive framework is proposed to describe the MBI cycle in which all phases and sub-phases are represented. Implications for guiding science educators to focus inquiry learning that values models and modeling and recognizes the core cognitive elements are provided.

Keywords: *Cycle of model(ing)-based inquiry; Framework of model(ing)-based inquiry; Phases of model(ing)-based inquiry; Model-based inquiry, Modeling-based inquiry*

INTRODUCTION

Using models or modeling as cognitive elements to supplement the simple inquiry method as model-based and modeling-based inquiry (MBI) that overcomes problems inherent in a simple inquiry method. Model(ing)-based inquiry (MBI) is a type of inquiry that engages students deeply with content and epistemic characteristics of scientific knowledge to change their mental models. Problems that inquiry-based teaching and learning are faced with are also present in MBI. Pedaste et al. (2015) considered a need to build a comprehensive and general framework of inquiry. Therefore, it is necessary to determine the essential and common elements and their sequence when developing a primary and clear MBI framework to guide teachers during instructional design. Accordingly, this study aims to provide a MBI framework from the learners' perspectives to guide designers of instructional activities and science teachers to focus inquiry learning such that students could emphasize the value of models and modeling and recognize the core cognitive elements.

METHODOLOGY

The literature search was set up used four criteria: (1) specific terms, (2) full-text search, (3) published since 2000 (the earliest year available), and (4) academic journals. We entered the following keywords into EBSCOhost and Scopus : (1) model-based inquiry, (2) modeling-based inquiry , and (3) modelling-based inquiry. The second step was searching the full texts by using specific terms, "phase", "stage", "cycle", "models", and "learning process". The topics, keywords, contents, and detailed procedures of related journals and chapters should correspond to “model(ing)-based inquiry.” As a result, there were 26 studies meeting the prescribed requirements. We manually searched related studies and works of authors from the relevant research fields. Finally, 31 studies were included and analyzed. Two authors coded all articles with 100% consistency and then counted, and descriptive statistics were determined.

RESULT AND DISCUSSIONS

The analysis of the descriptions and the definitions of MBI phases revealed in this systematic review led to a new MBI cycle (Figure 1). This comprehensive framework includes six general model-based inquiry phases (Orientation, Model Generation, Investigation, Model Evaluation, Model Modification, and Discussion) with a specific phase for modeling-based inquiry (Model Reconstruction).

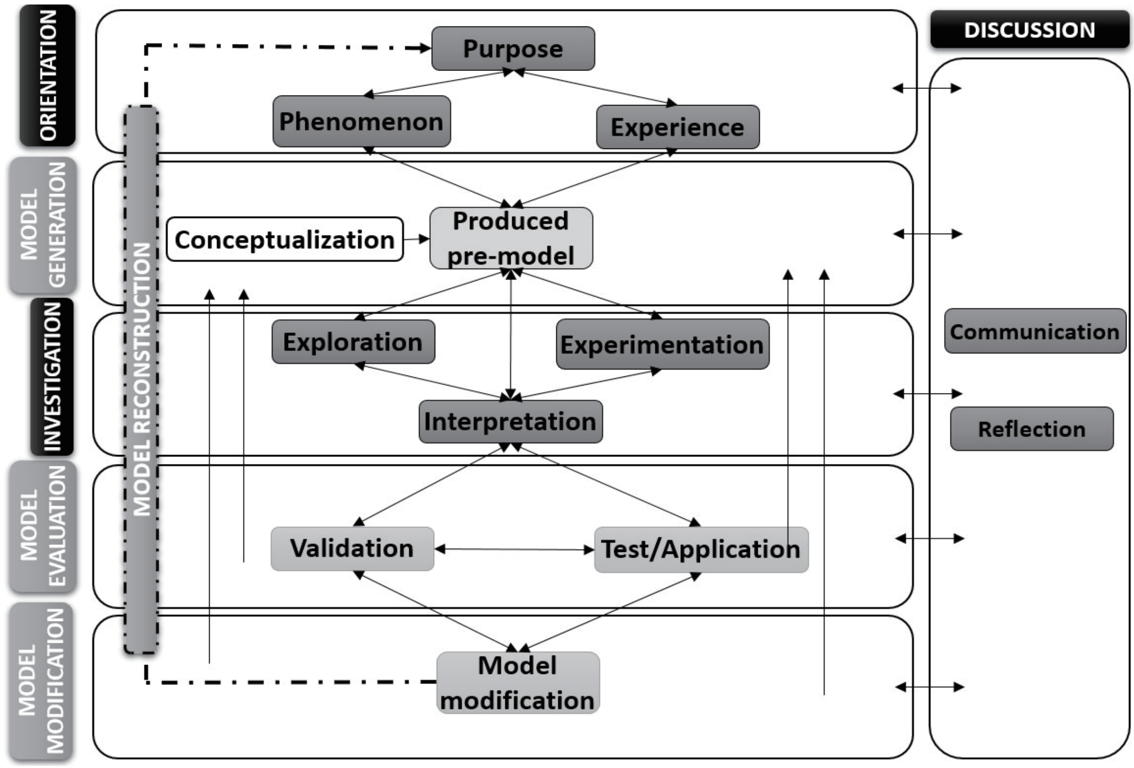

Figure 1. A comprehensive framework of MBI cycle

The inquiry process part of the new framework (Figure 1) was compatible with the phases of the inquiry-based learning reported elsewhere (Pedaste et al, 2015) that identified the general phases as Orientation, Conceptualization, Investigation, Conclusion and Discussion. The Conceptualization phase had sub-phases of Questioning and Hypothesis generation, while the Investigation phase had sub-phases of Exploration and Experimentation leading to Data interpretation; and the Discussion phase was divided into Reflection and Communication sub-phases. It can be expected that our new cycle might therefore be compatible with the current understanding of inquiry-based learning, and could help teachers to structure their teaching according to this framework of learners’ processes.

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Pre-service Science Teacher Reflective Thinking involving STEM Teaching

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ABSTRACT

This study was aimed at investigating pre-service science teachers' self-reflection on learning in STEM teaching. Participants were 12 pre-service science teachers who were encouraged to reflect on learning of STEM by writing structured journals. They were given a video STEM teaching model which they wrote their reflection after they finished watching video. Data analysis through qualitative content analysis. Four levels of reflective writing suggested by Hatton & Smith (1995) were used in the analysis result following: descriptive writing; descriptive reflection; dialogic reflection; and critical reflection. This study examined the processes of reflection of pre-service teachers from questions about the STEM content and STEM knowledge. In the reflection, they reflected on the dialogues, content, method and equipment in the STEM teaching video. They also reflected on the scientific STEM concepts that presented in the STEM lesson in video and reflected on how to achievement of the lesson goals, and their personal feelings regarding what was watch in the lesson STEM teaching in video. For the discussion of the findings focuses on: the pattern of level of reflection of STEM content and STEM knowledge from the pre-service science teachers. The finding from the four levels of reflective writing shows, the typical pattern of reflection used by the teachers was descriptive (descriptive writing and descriptive reflection level) and the frequency of the categories dialogic reflection level and 'critical reflection level was low, in some cases almost non-existent. These results will be useful information for the teacher's professional improvement by practicing pre-service teacher to have more ability of self-reflection in level of dialogic reflection and critical reflection for understand and can improve in the STEM teaching more.

Keywords: *reflective thinking, STEM, pre-service science teacher, journal writing, self-reflection*

INTRODUCTION

For the research work on reflection and reflective practice that shown pre-service teachers can get a benefit from reflective practice and the result also shows the pre-service teacher can have conversations that more expressed and increasing of desiring idea. Beside that reflective practice also can helping pre-service teachers for developing and extend understanding of their experiences. (Fox et al.,2011) Rodman's work use of reflection for preparing, encouraging and improving pedagogical knowledge for pre-service teachers and found that, the reflection helping in development of teaching performance and professional development by use the way that teachers engage in reflection, levels of reflective and pedagogical ability through reflection. (Rodman, 2010). So, this study interested to present a framework for understanding of reflective writings which use the framework of Hatton & Smith's work (1994) by defined into 4 types of reflective writing for explain how the pre-service science teacher reflection of their idea about STEM teaching through reflective writing.

Reflection of journal writing, writing in reflection

The reflection in the way of journal writing form is the one way to help teachers of understanding to engage them in reflection of their learning as well. (LaBoskey,1993) The journal writing activity had many benefits, it provides the opportunity about the reflect including the level of understanding, the feelings, the dialogue or even can reflect on metacognitive process that show the students thinking. Nickerson (1985) mention about the power of writing is as a means for thinking in the process of reflection and the way that can help to explore or represent our thoughts to ourselves, to others, is the writing, that can help in many part as a generating or integrating including of evaluating ideas (Langer,1986). Daloglu (2001) also mention and support an idea about the written reflections, such as journal writing, that it can serve as a teaching tool for teacher educators for developing critical thinking to pre-service teacher development.

Reflective writing framework

In this paper will present in level of reflective writing from pre-service science teacher by using Hatton and Smith's reflective writing framework. This framework will help the author and educator understanding and evaluate the levels of refection that express through in the writing journal of learner as well. According from this framework that compose with four types level of writing reflections - descriptive writing, descriptive reflection, dialogic reflection, and critical reflection. (Hatton&Smith,1994)

Participants

There were 12 participants of pre-service science teachers from enrolled in the last year undergraduate bachelor degree in Science education program.

Research Findings

<u>Characteristic Patterns of Reflection</u>

The analysis of the answer of reflection from four questions about STEM and result is distribute according to the categories defined into four type levels (Hatton&Smith,1994) (descriptive writing, descriptive reflection, dialogic reflection, critical reflection) that presented in Figure 1.

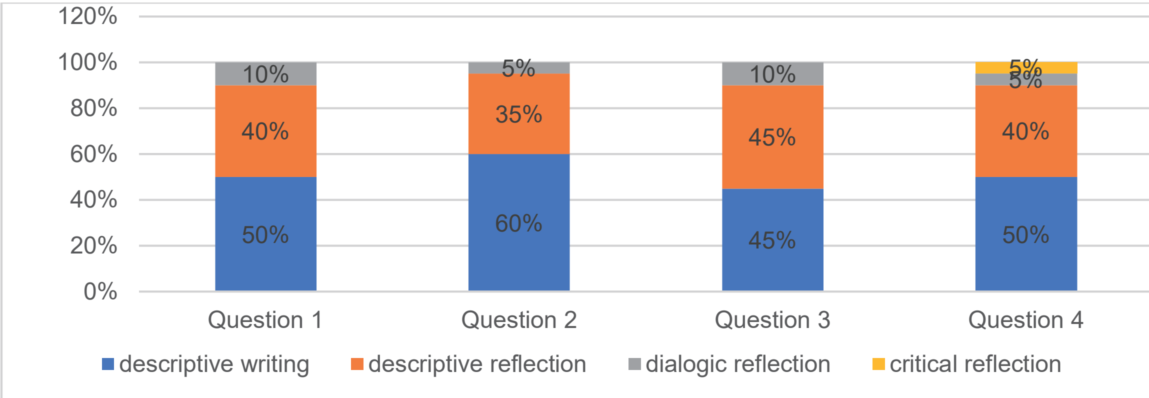

Figure 1. Distribution of characteristic patterns of level of refection.

The finding from the four levels of reflective writing shows, the typical pattern of reflection used by the teachers was descriptive (descriptive writing and descriptive reflection level) and the frequency of the categories dialogic reflection level and 'critical reflection level was low, in some cases almost non-existent. These results will be useful information for the teacher's professional improvement by practicing pre-service teacher to have more ability of self-reflection in level of dialogic reflection and critical reflection for understand and can improve in the STEM teaching more.

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THE TREND OF MIDDLE SCHOOL STUDENTS' SCIENTIFIC REASONING ABILITIES IN THAILAND

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ABSTRACT

Scientific reasoning is one of the goals in science teaching and learning. Previous researches in Thailand have studied scientific reasoning abilities of grade 7, grade 8, and grade 9 students separately. However, there is a lack of research studying scientific reasoning abilities development in middle school. Therefore, this research aimed to study the trend of students' scientific reasoning abilities in middle school. A cross-sectional study was used in this study. Scientific reasoning abilities test was developed by a researcher. The test was five situations selecting multiple choices in the first section and reasoning in the second section (full scores = 20). Cronbach's alpha coefficient was .87 and inter-rater reliability was 87%. The test was administered to grade 7 (n=130), grade 8 (n=130), and grade 9 (n=130) students at the end of the first semester of the 2020 academic year, totaling 390 students, from a school in Saraburi province by cluster random sampling. Data was analyzed using means, standard deviation, one-way ANOVA. It was found that scientific reasoning abilities of grade 7 students were at a fair level, grade 8 and grade 9 students were at a good level. There was a statistically significant difference at .05 level between grades as a whole. However there were no differences between grade 7 and grade 8 students. The trend showed that there is linear development from grade 7 to grade 9. The explanation of the results were discussed based on the curriculum and intellectual development theory.

Keywords: *Cross-sectional study, Lower secondary school students, Scientific reasoning*

INTRODUCTION

Scientific reasoning is the ability to express ideas in searching evidence, finding relationships between evidence and conclusions to reasonably support or reject a hypothesis (Lawson, 1985). Scientific reasoning abilities are one of the important goals of science education. (OECD, 2018). Previous research study in Thailand was conducted to explore the scientific reasoning of grade 7 (Surachai, 2015), grade 8 (Jindawong, 2012), and grade 9 students (Nangsrikun, 2014). However, there is a lack of research studying the trend of scientific reasoning abilities from grade 7 to grade 9 students. Students in this ages (13-15 years old) have developed intellectually and are able to think for reasons, as well as able to think like a scientist (Goot, 1986). The developmental study of students' scientific reasoning abilities will be useful. If there is a problem or defect in any part, teachers or educators can help to promote them immediately and effectively.

OBJECTIVES

1. To study the scientific reasoning abilities of grade 7, grade 8, and grade 9 students
2. To compare the mean score difference between three grades
3. To study developmental trends in scientific reasoning abilities at different ages.

METHODOLOGY

A cross sectional study was used in the study. The samples were 390 students from grade 7, grade 8 and grade 9 students selected by cluster sampling method from a population of 15,301 middle school students in Saraburi province. Scientific reasoning abilities test (Cronbach's alpha coefficient of the test = .87, inter-rater reliability = 87%) was administered to the samples at the end of the first semester of 2020 academic year. Data were analyzed by means and standard deviation. The mean scores were classified into the four levels of abilities (0–5 = need improvement, 6-10 = fair, 11-15 = good, and 16-20 = very good).

One-way ANOVA was used to test the difference between grade levels. Graph was constructed to see the developmental trend of the abilities across three grades.

RESULTS

The students' scientific reasoning abilities of grade 7 were at a fair level (M= 10.65, S.D= 3.65). Grade 8 (M = 11.54, S.D = 4.09) and grade 9 (M= 13.62, S.D = 4.08) students were at a good level. There was a statistically significant difference between grades ($F(2,387) = 25.80$, $p = .000$. Grade 9 was statistically significantly higher than grade 8 (19.43, $p = .000$) and grade 7 (19.43, $p = .000$). There were no statistically significant differences between grade 7 and grade 8 students. The developmental trend of middle school students' scientific reasoning abilities were shown in Figure 1.

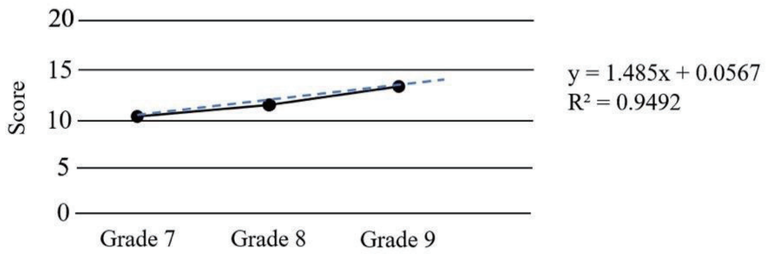

Figure 1. Trend of middle school students scientific reasoning abilities

DISCUSSION AND CONCLUSIONS

Grade 7 and grade 8 students have learned using the new science curriculum (B.E. 2560), but grade 9 students have studied using the old one (B.E. 2551). The new science curriculum focuses on promoting the ability of scientific reasoning. However, the scientific reasoning abilities of grade 7 students were at a fair level and the abilities of grade 7 and grade 8 were no different. There was a statistically significant difference between grades as a whole, as well as the graph revealed that the trend is linear development according to Piaget's cognitive development theory. The students' scientific reasoning abilities are result of their development by age. Therefore, teachers should help them to improve their level by adjusting ways of teaching and learning appropriately. The first grade of middle school is especially a good beginning.

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Oral Session 4	Day2 (June19th) 16：30～18：00
Room2	C2-2
【Category】	2: Science Education for Elementary School and Related Areas

=Chairperson=

Dr. LI, Wai Chin	The Education University of Hong Kong

=Presentation Program=

1	74-2-2-19-1（FY5O-MDJE-5G021） Winnie Wing Mui SO（Department of Science and Environmental Studies, The Education University of Hong Kong, Hong Kong Special Administrative Region, the People’s Republic of China / Centre for Education in Environmental Sustainability, The Education University of Hong Kong, Hong Kong Special Administrative Region, the People’s Republic of China） Qianwen HE *ENGAGING STUDENTS WITH INTELLECTUAL DISABILITY IN STEM LEARNING*
2	76-2-2-19-3（FY5Z-8T3W-G0021） Tawinan Saengkhattiya（Brunel University London） Mike Watts, Sarmin Hossain *Framework for developing STEM activities for teaching sustainable development and 21st century skills in Gifted science pupils at primary school level in Thailand*

ENGAGING STUDENTS WITH INTELLECTUAL DISABILITY IN STEM LEARNING

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ABSTRACT
Involving students with different disabilities (ID) with STEM learning is of particular importance and usefulness in order not to deprive of their learning opportunities for the future. But how to expose students with ID to STEM learning has not been well explored. There are suggestions of using inquiry, engineering and technology to their advantages to support students with disabilities. In the design of STEM learning for students who have ID, teachers from a special school constructed a 4E model, which emphasizes inquiry and at the same time leverages technology and engineering to integrate learning content in a purposeful and informed way to better student engagement in lessons.
Lesson observations were conducted to study students' cognitive, affective and behavioural engagement in lessons. The lesson plans from teachers were analysed to supplement the observation data to better understand the effect of lesson design with a focus on student engagement.
Results showed that Students with mild ID in the classes responded and worked actively while students of moderate ID asked for more assistance. However, it is found that students were more engaged in engaging, exploring, and engineering, but less to be involved in explaining. This research provides the practical model and evidence to engage student engagement in STEM learning with a focus on inquiry, engineering and technology. This gives more insights for strategies in designing STEM learning for students with ID for better student engagement.

Keywords: *Students with intellectual disability, Student engagement, STEM learning, Special education need*

INTRODUCTION

Preparing today's students for STEM fields seems logical and functional (Miller, Krockover & Doughty, 2013). For students with intellectual disability (ID), barriers exist in providing access and evidence-based practices for success in the STEM related fields.

In Hong Kong, in the advocate of "One Curriculum for All" approach since its release in 2011, the special schools are generally implementing a school-based curriculum adapted from the mainstream school curriculum to entertain the learning capabilities of students with ID. Hence, involving students with different disabilities with STEM learning is also a priority of special schools in Hong Kong in order not to deprive students' learning opportunities for the future.

Among the four disciplines of STEM, two of them, Science and Mathematics, have always been a part of the school curriculum. It would be more informed to base on their existing work of inquiry in science education, with a leverage of technology and engineering, which are originally not in the school curriculum, to integrate learning content in a purposeful way.

METHODS

Lesson design

The topic for STEM learning design was about the design of an "Alarm" under the topic "The Opium War". The lesson design emphasizes inquiry and at the same time leverages technology and engineering, consisting of Engaging in inquiry; Exploring through technology; Engineering for innovation and Explaining for understanding, which can be concluded as a 4E model. The learning activities were arranged into two lessons, with each lesson lasted for 60 minutes. Different tasks were assigned to students with varied abilities to explore and experience the design of the "Alarm System".

Participants

A class of 10 students aged between 10-12 years who had been identified with intellectual disabilities and was enrolled in a special school participated in this study. 5 of them were regarded as mild ID than the remaining five ID students in the same class.

Data collection and analysis

A qualitative research methodology was used with observations of students during the lessons. Students' engagement in verbal and non-verbal forms including students' questions, responses and answers, facial expressions, and actions were recorded to identify the relevance and quality of students' engagement, as well as categorizing into cognitive, affective and behavioural engagement for further detailed analysis after the lessons.

FINDINGS

Based on the observation of students throughout the two lessons, students' engagement was analysed and was counted as frequency by indicators of their cognitive, affective and behavioural engagement and the 4E model: Explaining for understanding. Both students with mild and moderate ID were observed to have a certain extent of engagement in the lesson, but mild ID students performed more diversely with a higher level of engagement.

Students with mild ID in the classes responded and worked actively while students of moderate ID asked for more assistance. Moderate ID students can also perform well if they had assistance timely. However, it is found that students were more engaged in Engaging in inquiry, Exploring through technology and Engineering for innovation, but less to be involved in Explaining for understanding, which students were required to conclude, communicate and justify their thoughts, and then they also tried to suggest how to apply the design in school life by transferring concepts to more complex problems.

DISCUSSION AND CONCLUSION

This study echoed well with Palincsar et al., (2000) that, students with ID who lacked knowledge and skills of STEM, teacher-guided approach may be effective for STEM teaching and learning in classroom setting and also coding task. And with the leverage of engineering and technology, students with ID not only acquired problem-solving skills and linkage of real-life, but also context and active engagement in STEM learning.

Positive results of active cognitive engagement, positive affective engagement and reactive behavioural engagement were found in this study. To conclude, we suggested that (1) the leverage of technology and engineering in the inquiry facilitated students' active cognitive engagement; (2) creating more versions and various of STEM learning activities for ID students with incorporate student interactions and guidelines for teachers as facilitator in STEM learning; and (3) balancing the teacher-guided approach and student-centred STEM learning environment to boost students' proactive engagement.

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FRAMEWORK FOR DEVELOPING STEM ACTIVITIES FOR TEACHING SUSTAINABLE DEVELOPMENT AND 21ST CENTURY SKILLS IN GIFTED SCIENCE PUPILS AT PRIMARY SCHOOL LEVEL IN THAILAND

Tawinan Saengkhattiya[1], Mike Watts[1] and Sarmin Hossain[1],

1. *Brunel University London, United Kingdom*

ABSTRACT

Empowering youth for sustainable development can trigger society's transformation by changing these youth attitudes to create sustainability-minded citizens and ultimately shape their collective future. Gifted science student can be part of this change by learning about sustainable development and help to solve environmental issues. Science education could be integrated with Education for Sustainable Development (ESD) to create cross-curricular practices for teaching ESD while gifted students are nurtured with science knowledge and skills. According to Thailand's science standards at the primary school level, knowledge regarding environmental issues are embedded in the learning standard, and this can be the basis for gifted science students to have awareness for the environment, other people and society (Ledwith et al., 2017; Littledyke, 2008; Schroth & Helfer, 2017). Moreover, learning to solve problems is just one part of an approach for learning ESD (Thomas, 2009). So, the STEM problem-solving approach adopted in this study provides students with learning opportunities to solve environmental sustainability issues. Before constructing the educational interventions, a framework was created to ensure that students will learn about sustainable development and develop their problem-solving skills and collaborative skills to reach the study's objectives. This conceptual framework will be implemented to create an education intervention for further exploring the integration of ESD through science education by targeting gifted science students and their teachers in Thailand.

Keywords: *STEM intervention, gifted development, Education for Sustainable development*

INTRODUCTION

This paper describes a framework constructed to shape enrichment interventions for teaching gifted science students at the primary school level in Thailand. Called Young Engineers for a Sustainable Future, the aim of the framework is to integrate Education for Sustainable Development (ESD) with science education in a way that fits with the Thai context. This framework aims to enhance awareness for sustainable development, develop problem-solving skills and collaborative skills, and promote gifted science characteristics in target students.

BACKGROUND

In 2020, the UNESCO roadmap for achieving global sustainability by 2030 stated that sustainable development goals (SDGs) must be embedded in Education, and promoting to youth is one of the key priorities to achieve sustainable development (UNESCO, 2020). To promote ESD in Thailand, SDGs are introduced in the educational strategies targeting education management that promotes quality of life and environment-friendly life (Office of the Education Council, 2017). However, there is no current ESD curriculum in Thailand at the primary school level. According to the 20-year Thailand National strategic plan, promoting talented students in Science and Mathematics is one of the pathways for preparing human resources (Office of the National Economic and Social Development, 2018). Scientific and mathematics talented classrooms were established in many primary schools due to the government's strategy to improve students' scientific and mathematics abilities. STEM education was used to promote their learning ability.

Indeed, that enrichment programme focuses on nurturing their scientific knowledge and related skills. This programme has now been adapted to create new interventions to be used in schools to teach gifted science students at the primary school level about ESD and learning science. The conceptual framework was created as a guideline for constructing the teaching and learning interventions for the gifted student in Thailand, which will allow research data to be acquired from participating students and teachers, to evaluate the interventions in terms of alternative approaches for teaching ESD with science education as an integral part of Thailand's educational context.

PURPOSE OF STUDY

To construct a conceptual framework for integrating the ESD through science education that can raise awareness of sustainable development of gifted science student in Thailand and promote problem-solving and collaborative skills.

METHODOLOGY

The literature survey undertaken here has covered sustainable development education, STEM education, practices for delivering ESD, gifted science characteristics, and various teaching and learning programmes. Additionally, the Thailand science standard at the primary school level and SDGs were analysed. This survey explores the knowledge for creating education interventions suitable for the target students in the Thai context. Besides, a prior 90-minute STEM intervention using landslides has already been implemented with 160 students in Thailand, as a case study to inform the shaping of the framework.

RESULT

The framework was constructed below as the integration of ESD with science education. This framework is adopted for constructing pedagogical intervention that will experiment in the future.

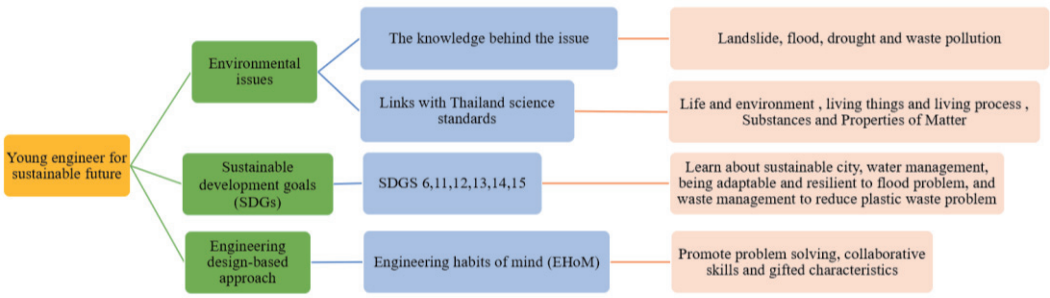

Table 1. a conceptual framework for creating young engineer for sustainable future intervention

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Oral Session 4	Day2 (June 19th) 16：30～18：00
Room3	C3-9
【Category】	3: Science Education for Middle or Secondary School and Related Areas

=Chairperson=

Dr. Pramudya Dwi Aristya Putra	Universitas Negeri Jember

=Presentation Program=

1	77-3-9-19-1（FY4Y-3MDN-UG021） Hung Ming CHEN（Taichung Municipal Shi-Yuan Senior High School） *Seventh Graders' Multimodal Modeling of Ecosphere*
2	78-3-9-19-2（FY4H-16Z3-YQ021） Pramudya Dwi Aristya Putra（The University of Jember） Nur Ahmad, Idrawati, Sutarto, I Ketut Mahardika *The Enhancement of Students' Critical Thinking Skills Using Engineering Design Process Approach in The Science Classroom*
3	79-3-9-19-3（FY50-CDLV-1H021） NIKMATIL HASANAH（University of Jember） SUTARTO, NURIMAN *IMPROVING CREATIVE THINKING SKILLS OF STUDENTS THROUGH STEM ACTIVITY IN COLLOID TOPIC (SOAP-MAKING EXPERIMENTS)*
4	80-3-9-19-4（FY52-W1KQ-L6021） THANAWAT NGAODA（Faculty of Education, Kasetsart University (Bangkhen Campus)） Assoc. Prof. Sasithep Pitiporntapin *Promoting Students' Achievement and Argumentation skills Using Online Socio Scientific Issue-based Teaching in the Topic of Genetics Engineering*

Seventh Graders' Multimodal Modeling of Ecosphere

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ABSTRACT

Equip students with abstract concepts such as ecological cycle and balance is challenging. In this study we tried to combine planning, multimodal writing, building an Eco-Ball, and self-assessment, for (78 students) seventh graders (from3classes) to represent their ideas in a sequence of learning tasks. By creating mini biosphere in a glass-bottle, each group of students retrieved their background ecological concepts, developed a design plan and decide ecological components. The analyzing results by applying constant comparative method on the student weekly artefacts and the follow-up modifications, indicate that students were making progress in terms of developing investigation objectives, improving observation timetable plan, and interpreting results more and more sophisticated.

Keywords: *Ecology, Modeling, Multimodality, Secondary science*

RESEARCH PURPOSES

The purposes of my study are to afford seventh graders to combine abstract concepts such as ecological cycle and balance with abilities to solve environmental problems and take sustainability actions. In this study we tried to combine planning, multimodal writing (Tytler & Hubber, 2016), building an Eco-Ball, and self-assessment as learning tasks.

INSTRUCTIONAL OBJECTIVES AND METHODS

The instructional objects and teaching approaches are as following:

1. To understand the ways ecosystem operate (biological roles and environmental factors).
2. By creating a mini biosphere in an enclosed glass-bottle, each group of students retrieved their background ecological concepts, developed a design plan and decide ecological components, as well as quantities of organisms in the bottle.
3. Students collaborate to build their investigation objectives.
4. Students can solve environmental problems and take sustainability actions.
5. Students made a working model of food web, and negotiated within group to reach an observation timetable for their mini system.
6. Each group claimed their investigation successfully working or failure, based on their investigation objectives, understandings of related theory.

Methodology

Seventy-eight seventh graders from 3classes of the teacher researcher represented their ideas in a sequence of learning tasks. Data came from students' worksheets, oral presentation and dialogue between teacher and groups. This study continues for 3 weeks, one class per week. During the learning tasks, the students made a working model of food web, and negotiated within group to reach an observation timetable for their mini system in the following duration of 3 weeks.

Content of Teaching

Related science factual, conceptual and procedural knowledge includes:

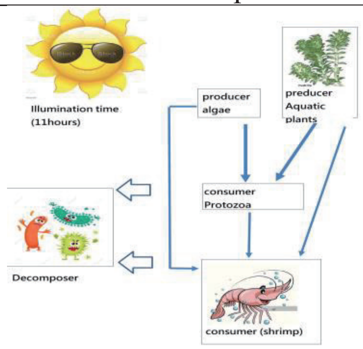
1. Students learn the main eco-concepts first, such as the roles of a eco-system. They read a story about the food-chain and food-web. The story is from their daily school life.
2. The students investigate photosynthesis and respiration inside an eco-system.

3. Students learn which roles can’t be removed in a eco-system.
4. Their design plans must consider carbon and nitrogen cycle and energy flow in the eco-ball.
5. Each group must claim their investigation successfully working or failure based on evidence, as well as their suggestions, as conclusions.

Teaching Process

In this study, the process of scientific method described in textbook was applied. The learning steps of scientific method are observation, raise a question, state a hypothesis, design an experiment, analyze data, discuss and make conclusions. Including the following:

1. The eco-ball that I see…
2. My question…
3. My hypothesis…
4. My design of an eco-ball...
5. Set up self-assessment criteria for making a working model of food web.
6. Within-group negotiation to reach an observation timetable for their mini system.
7. Write down more questions that I want to study further.



Students’ design of the eco-ball food web

Date	Plant & animal survival situation	Illumination time	Environment factors
Week1			
Week2			
Week3			

Students’ observation & recording table.

Figure 1. Examples of Student Artefacts

Learning Journey and Results

1. Each group of students retrieved their background ecological concepts, developed a design plan and decided ecological components, as well as quantities of organisms in the bottle.
2. Tasks included planning, multimodal writing, building an Eco-Ball, and self-assessment
3. Each group self-assessed their objectives, plan, observation records, and results to claim the influential factors before group presentation.
4. Each group shared their record to another group weekly, followed by modifying observing plan.
5. For students who showed interest in doing science fair project, the teacher guided them to inquiry into various aspects.

We conclude that the participating seventh graders demonstrate their enhanced understandings about scientific inquiry process to design and execute experiments, moreover, the students learn ways to solve self-generated questions.

Content of Teaching

The purposes of my study are to afford seventh graders to combine abstract concepts such as ecological cycle and balance with abilities to solve environmental problems and take sustainability actions. In this study we tried to combine planning, multimodal writing (Tytler & Hubber, 2016), building an Eco-Ball, and self-assessment as learning tasks.

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The Enhancement of Students' Critical Thinking Skills Using Engineering Design Process Approach in The Science Classroom

Pramudya Dwi Aristya Putra[1], Nur Ahmad[1], Indrawati[2], Sutarto[2], and I Ketut Mahardika[2]

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2. Post Graduate Program Science Education, Faculty of Teacher and Education, University of Jember, Indonesia.

ABSTRACT

Critical thinking skills are one of the skills from 21st skills, which is needed recently by students. This skill should be improved in the science class to analyze the scientific phenomenon properly to make a decision. This study aims to enhance students' critical thinking skills using STEM activities that focus on the physics classroom's engineering design process. The participants involved were 12 students (6 male and six female). The study was a single case-study design that student gave the Problem in Worksheet and students several solutions to solve the given problem. The data collected based on the students' perspective about the steps on the make solution includes individual and group collaboration. Qualitative analysis was conducted to make the patterns of students' critical thinking skills follow the Engineering Design Process stage (define, learn, plan, try, test, dan decide). While the students use critical use skills EDP, students explore their ability that matched with the critical thinking skills' Indicator, such as Focus, Reason, Inference, Situation, Clarity, and Overview.

Keywords: *critical thinking skill; Engineering Design Process, and the Science Classroom.*

INTRODUCTION

Critical thinking's skill is one of the skills' demand in the 21 century for students in-class activities (Kavenuke et al., 2020). Critical thinking skills support for students to make a decision in a specific way. For example, students create a solution using their argumentation to solve a problem (Ennis, 1993). However, the research on the exploration of students' critical thinking skills lacks on the performance ability. Critical thinking skills need to be investigated in the actual context and profound understanding in revealing the statement scientifically with communication (Farmer & Wilkinson, 2018). This study was in qualitative design that focuses on exploring the students' critical thinking skills using Engineering Design Process (EDP) in the science classroom.

METHODOLOGY

This study was a single case study approach. This study examined the one case intensively, in detail, and comprehensively (Creswell & Poth, 2016). The context of the study was in the twelve highs school students; in particular, ten grade was joining in the STEM activities club. The physics worksheet focused on the Engineering Design Process (EDP) was developed and implemented for students to see the link between EDP steps and student critical thinking skills. The step of EDP was to start defining a problem, learn, plan, try, test, and decide. At the same time, the critical thinking skills was including focus, reason, inferences, situation, clarity, and overview.

The data collected was from several methods such as document observation, activities observation, and interviews. The text analysis was utilized in this study that the all the data source was transcribed and coded based on the critical thinking skills indicator in the step of EDP. The code developed including focus, reason, inference, situation, clarity, and overview.

RESULTS

This study showed the step of EDP and the activities that described the students' critical thinking skills. Table 1 showed the student's activities in EDP and students' activities that showed critical thinking skills.

Table 1. the coding of critical thinking skills in the EDP step

EDP Step	Explanation	Coding activities in critical thinking activates
Define (individually)	Definition of a problem given	"Focus to the context." "Show the basic needs."
Learn (Individually)	Using a science concept to solve a problem	"Give a reason." "inference" "Making a connection between science concepts." "evaluation"
Plan (group)	Connecting a problem with the solution, student design a solution using science and mathematics concepts	"variable"; "staying on the topics"; "open-minded"
Try (group)	Implement a design and connected it with the solution to the problem.	"Staying in the context"; "testing variable"; "Filed"; "Self-assessment"; "Clarity"
Decide (group)	Make a decision and evaluation of the product to give a solution in with the context.	"Result"; "overview"; "match on the solution"

Define a problem:

Students make a connection and analysis the cause of a problem risen. The students still focus on the context, for example, S1: "*I tried to explain the cause of the problem given, the farmer difficult to find the water so that they need a special method for watering his filed."*

Make a solution:

Students highlighted the constraints to make and design solution with their argumentation, for example S1: "*the way to keep farmers from pumping water again is by making a dam. The client wants the dam to last for a long time for IDR 30,000,000. The importance of this problem so that it is useful for storing water during the rainy season and supplies for the dry season and so that farmers do not pump water anymore"*.

Conclusion:

This study focused on exploring the students using EDP and how they connect to develop an argument. Argumentation is a crucial way for developing critical thinking skills in EDP. The EDP process emphasized critical thinking skills in way focus, reason, inference, situation, clarity, and overview.

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IMPROVING CREATIVE THINKING SKILLS OF STUDENTS THROUGH STEM ACTIVITY IN COLLOID TOPIC (SOAP-MAKING EXPERIMENTS)

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ABSTRACT

This research is concerned with STEM activity soap-making experiments in colloid learning. This study aimed to determine the effect of implementation STEM activity on students' creative thinking skills. This study was a quasi-experimental research with a non-equivalent control group design. Data collection was from the results of creative thinking tests conducted in the experimental class and the control class. The quantitative methods were utilized to analyze student's achievement tests based on the creative thinking skills indicators in soap-making experiments. The qualitative method was applied using observation of student activity. The results showed that the creative thinking skill of students who studied with STEM activity higher than students who studied with traditional learning methods with a significance value of 0.000<0.050. A large percentage of the effect of the application of STEM activity 85.9%, that implied the student achievement test on creative thinking skills criteria in the experimental class was better than that in the control class.

Keywords: *STEM activity, creative thinking skills, soap-making experiments.*

1. INTRODUCTION

STEM Education is an interdisciplinary approach to learn science, technology, engineering, and mathemathics in contexts that enabling literacy (Suen & Duke, 2014). STEM points the way students thinking about real-life problems. The students that learn the STEM concept obtain the chance to enhance their thingking skills relate to solving the problem by doing the learning activities (Duran, et al, 2018). Creative thinking is an ability to find the best solution to solve a problem and one of the most needed skills in the 21st century (Ritter & Mostert, 2017). Creative thinking becomes a new breakthrough in using knowledge, approaches, perspectives, and ways to understand a problem (Eragamreddy, 2013). Creative thinking always emphasizes the aspects of fluency, flexibility, originality, and elaboration in thinking to solve problems (Grieshober, 2004). Through STEM education, creativity can be fostered in the inquiry environtment of the activities (Stylianidou, et al, 2018). Colloid is one of the chemistry topics taught in high school. Actually, the characteristic of Colloid topic is contextual and directly involved in students' life, such as soap-making experiments. The learning process to be held in this research will conduct the students to create and determine the composition of soap-making ingredients.

2. ANALYSIS

In this study, students in both classes were given tasks soap-making experiments. In the experimental class, STEM activities is applied. While in the controlled class, teaching still uses conventional methods with direct instructional methods. The pre-test value is used as a covariate variable in the analysis of different tests and the posttest value is used to measure students' creative thinking skills. The value of each creative thinking test indicator that is fluency, flexibility, originality, and elaboration is compared in the form of bar charts which can be seen in Figure 1.

A summary of the ANACOVA test results in both classes of research can be seen in Table 1. Significance shows 0,000 <0.05 which shows the differences in creative thinking skills of students who learn with STEM activity with controlled class. The value of the effectiveness of STEM activity is 85.9%. The students who learn with STEM activity have various creativity in determining the ingredients and method of soap-making experiment, which can be seen in Figure 2.

Table 1. ANACOVA Test Results

Aspect	Sig.	Partial Eta Squared
Class Intervention	0,000	0,859

Figure 1. Graphs of aspects of creative thinking in students' experimental and control class

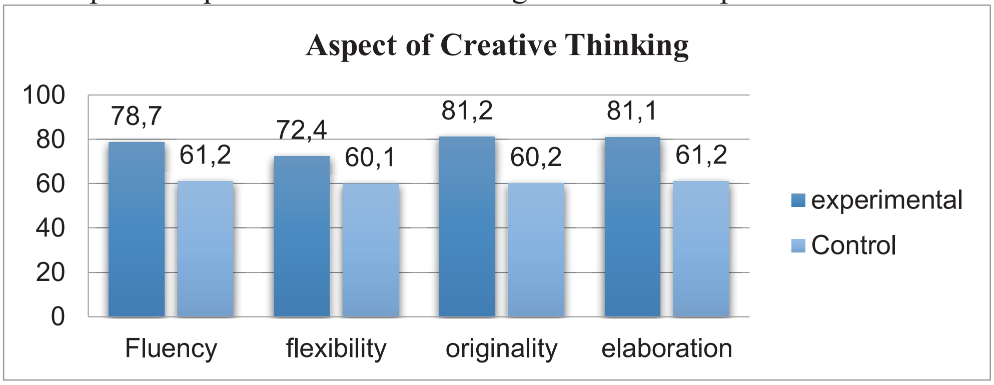

Figure 2. Various designs of soap-making experiments by the students

3. CONCLUSION

There is an influence on creative thinking using the STEM activity. This can be seen from the results that the class learning with STEM activity can improve students' creative thinking with an effectiveness level of 85,9 %. This value indicates that the effect of the implementation of STEM activity on the ability to think creatively has a high effectiveness.

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PROMOTING STUDENTS' ACHIVEMENT AND ARGUMENTATION SKILLS USING ONLINE SOCIOSCIENTIFIC ISSUE (SSI)-BASED TEACHING IN THE TOPIC OF GENETIC ENGINEERING

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ABSTRACT

This research aimed to promote student's achievement and argumentation skills using SSI – based teaching through the online learning under the covid-19 pandemic in the topic of genetic engineering. The participants were 37 students from a secondary school, Udonthani Province, Thailand, in the first semester of academic year 2020. The instruments used in this research were: 1) 3 science lesson plans 2) 40 items of 4 multiple choices learning achievements test in genetic engineering topic with reliability K-R20 equal to 0.91, discrimination value between 0.20 – 0.93 and difficulty value between 0.25 – 0.79, and 3) the argumentation skills test, consisted of 4 components which were claim and warrant, evidence, counter argument, supportive argument. The achievement score was analyzed using mean ($\bar{X}$), standard deviation (S.D.), and t-test independent for comparing mean between before and after teaching. The argumentation skills were collected by the argumentation skills test. The results showed that 1) the post-test students' achievement ($\bar{X}$=32.07, SD=3.72) had statistically significantly higher than pre-test ($\bar{X}$=19.86, SD=3.57) ($p<.01$) after learning with SSI-based teaching through online learning, and 2) the argumentation skill of 30 students (81.08%) were in good level after learning with SSI-based teaching through online learning. In addition, the researchers found that 34 students (91.89%) increasingly developed their argumentation skills.

Keywords: *Socio Scientific Issue, Argumentation skills, Online Teaching, Student Achievement*

INTRODUCTION

Today, it increasingly about the event and phenomena that make argumentation skills necessary for students. Educators have described it is ability to think scientifically, logically and creatively about a phenomenon. (Foong & Daniel, 2013) To develop argumentation skills, Socio Scientific Issue is the one approach that educators are recommended, Socio Scientific Issue (SSI) is the controversial issues, related to moral and ethics, real world situation and science. (Sadler, 2004) Many researchers used SSI in the normal classroom and reveal that it can enhance students' argumentation skills. (Dawson & Carson, 2020). However, using SSI in online teaching is important in nowadays including Thailand classroom because of Covid-19 pandemic.

In the first unit exam, 1st semester of academic year 2020, I found that 98 of 128 (76.6%) grade 9 students cannot answer the subjective test by using reason or evidence to support their answer, so argumentation enhancing is necessary for them. However, learning achievement are still important for study to insist that online learning is efficiency. In this study, the researchers applied SSI teaching step and using Lin & Mintzes (2010) argumentation framework for analyzing argumentation. The research questions are 1) How does online SSI-based teaching effect to students' learning achievement, and 2) How does online SSI-based teaching effect to students' argumentation skills.

RESEARCH METHOD

Mixed method was used in this research, based on pragmatism research paradigm. The SSI-based lesson plans were used after students had done achievement and argumentations' pre-test. Furthermore, Zoom application was used as learning platform. After finished each lesson, researchers recorded on lesson plan recording part for collecting qualitative data. Then, achievement and argumentations' post-test were used after finishing 3 lesson plans. The achievement score was analyzed by using mean ($\bar{X}$), standard deviation (S.D.), and t-test independent for comparing mean between before and after. The argumentation skills were collected by the argumentation skills test, the qualitative data was analyzed by content analysis. Qualitative data from lesson plan recording were used to support quantitative data.

RESULT AND DISCUSSION

1. The study reveal that the post-test students' achievement ($\bar{X}$=32.07, SD=3.72) had statistically significantly higher than pre-test ($\bar{X}$=19.86, SD=3.57) ($p<.01$) as shown in table 1 below.

Table 1. Students' learning achievement.

Test	Number of students	$\bar{X}$	S.D.	t
Pre-test	37	19.86	3.57	14.99*
Post-test	37	32.07	3.72	

*df = 36, at the 0.01 significant level.

2. The total argumentation skill of 30 students (81.08%) were in good level after learning with SSI-based teaching through online learning as shown in table 2 below.

Table 2. Students' Argumentation skills after using online Socio Scientific Issue-based teaching.

Level	Number of students	Percentage (%)	Level	Number of students	Percentage (%)
Excellent	1	0.03	Fair	2	0.05
Good	29	0.78	Unsatisfied	5	0.14

The teacher recording data shown that students was active, excited with online leaning and the issue that controversial, they used search engine to find the support reason for argumentation activity, it helps student to learn new knowledge when they need to know. This support student to develop learning achievement and argumentation skills as the result shown, these related to Foong & Daniel (2013) that controversial issue enhanced student argumentation skills. Moreover, some students said, "online learning made he dare to speak and shared the reason support more than face to face argument." Thus, the argumentation comparison between normal teaching and online teaching is needed to reveal for clarification.

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Oral Session 4	Day2 (June 19th) 16：30～18：00
Room4	C3-10
【Category】	3: Science Education for Middle or Secondary School and Related Areas

=Chairperson=

Dr. Irma Rahma Suwarma	Universitas Pendidikan Indonesia

=Presentation Program=

1	81-3-10-19-1（FXYC-2N7M-N1021） BIBIN RUBINI（PAKUAN UNIVERSITY） Anna Permanasari, Iqbal Habiby *Infusing Education for Sustainability Development in Science Learning: How the Nature of Science of the secondary school students' growing up along on-line learning with Socio Scientific Issues based*
2	82-3-10-19-2（FY0X-89NK-IL021） Nindy Lestarie（Indonesia University of Education） Anna Permanasari, Ida Hamidah *Science competency profile of secondary school students in the context of ESD on the environmental pollution theme*
3	83-3-10-19-3（FYPZ-FX55-DT021） Pedro DE PAULA TERRA（Chiba University） Hina MORISHIGE, Futaba SUYAMA, Tetsuya KATO *Expedition Mundus in Japan: fostering scientific literacy through a classroom game*
4	84-3-10-19-4（FY1K-GVWJ-RO021） Liang Sanxia（Northwest Normal University） Hu Shengli *Design of Project Based Learning activities based on STEM education —Take making a simple water purifier as an example*

INFUSING EDUCATION FOR SUSTAINABILITY DEVELOPMENT IN SCIENCE LEARNING: HOW THE NATURE OF SCIENCE OF THE SECONDARY SCHOOL STUDENTS' GROWING UP ALONG ON-LINE LEARNING WITH SOCIO SCIENTIFIC ISSUES BASED

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ABSTRACT

In today's global era, science learning needs to always be linked with the principles of education for sustainability development (ESD). This study tries to examine the side of students' understanding of the Nature of science (NOS) associated with the concept of ESD. The research was conducted using a quasi-experimental combined with qualitative descriptive methods, which tries to describe the phenomenon of learning qualitative data which is analysed quantitatively, and then cross-linked with observation data and other qualitative data to obtain a complete picture of NOS of student. The research subjects were 45 students of 7th grader of a private junior high school in South Sumatra, Indonesia which had a moderate view of learning. The results showed that online learning with ESD principles (Environment conservation) using the SSI approach was able to place more than 50% of students were at ***the intermediary view level*** *on 2 aspects of NOS (Subjective and Social-Cultural), most of students were at the naive view for empiric aspect of NOS, meanwhile there were a half students got the naïve view and another half of students in intermediary view level in tentative aspect of NOS. three students reached* ***the informed view level*** *on social-cultural aspect of NOS. Based on students' responses, it was revealed that actually the contexts of ESD are very familiar to students and caused them to understand better in how science contributes to sustainability education. Constraint: network along the learning.*

Keywords: ESD in Science learning, NOS, SSI

Introduction

Building Scientific literacy today is the main aims in science education[1-7]. Scientific literacy in very close related to the aspects of *Nature of Science* (NOS) [3, 7, 8, 9]. Learning with NOS will be better if it is linkage with the context related to the controversial, contemporer and natural social problems (socio scientific issues, SSI) to lead to the real and interpretative discussion[6,10,11,12]. Infusing Education for sustainability Development (ESD) framework into the SSI scope can be directed to the environmental problems such as global warming, air pollution, as well as environmental friendly energy[11].

Methods

The research method was quasi-experimental combined with qualitative descriptive to describe the phenomenon of online learning in qualitative data which is analysed quantitatively, and then cross-linked with observation data and other qualitative data to obtain a complete picture of NOS of student. The Material teaching was Environment conservation (with ESD principles). The Instrument used were test and observation sheet. The test based on two aspects of NOS: Subjective and socio-cultural.The students and then were cathegorized into view of levels: informed,intermediary, and naïve views.

Result and Discussion

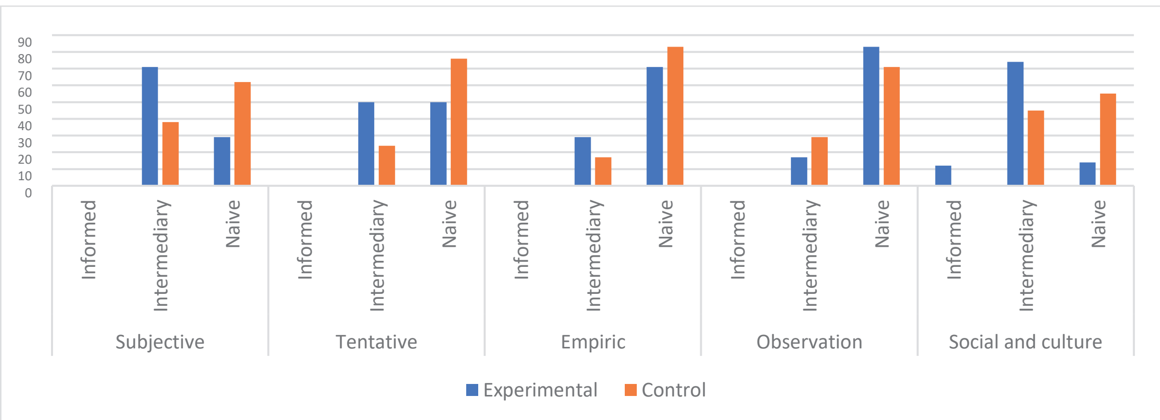

Figure: profile of Student understanding on NOS (*Khisfe category*[3])

Table. *Student understanding on NOS (SU-NOS)*

NOS Aspects	*Explanation*
Subjective	Intermediary level in experimental group; naïve in control; no informed level
Tentative	Naïve in control group, no informed level
Empiric	Naïve in both of control and experimental groups; no informed level
Observation	Naïve in both of control and experimental groups; no informed level
Social and culture	Intermediary in experimental group; naïve in control group; informed level in experimental group (Vesterinen, Zhu, Sadler & Donelly, and Eastwood.[10-13]: Student in this category have a view such as scientist do in defending their argument
Conclusion: The enhancement of Student understanding towards NOS is in intermediary view for subjective, tentative, and social culture aspects of NOS, and in naïve view in empiric and observation aspects.	

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SCIENCE COMPETENCY PROFILE OF SECONDARY SCHOOL STUDENTS IN THE CONTEXT OF ESD ON THE ENVIRONMENTAL POLLUTION THEME

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ABSTRACT

This study aims to describe the science competency profile of secondary school students in the context of Education for Sustainability Development (ESD) using quantitative descriptive methods. The research sample consisted of 113 7th and 8th grade students in the second semester of the 2020/2021 school year, from 3 state secondary schools and 1 private secondary school in West Java, Indonesia. Data were collected using a science competency test instrument in the form of 15 essay questions adapted from PISA questions that have been validated by the validator. The results show less than half of secondary school students had scientific competence (39%). For each aspect, more than half of students were able to achieve the aspect of evaluating and designing scientific investigations (53.43%), and nearly half who achieved the aspect of explaining scientific phenomena (42.06%). Meanwhile, less than half of students were able to achieve the aspect of interpreting data and proving scientifically (18.28%). The results of this study indicate the need of improvement from all parties in science education. The interview with students revealed that one of the obstacles was the lack of learning resources that were able to accommodate ESD-based literacy achievement. Meanwhile, the interview with teachers indicate generally teachers are very weak in considering the level of students' prior knowledge and only focusing on the characteristics of the science material to be taught when designing the lesson.

Keywords: *Science competencies, ESD, Environmental pollution.*

INTRODUCTION, METHOD, RESULT AND DISCUSSION

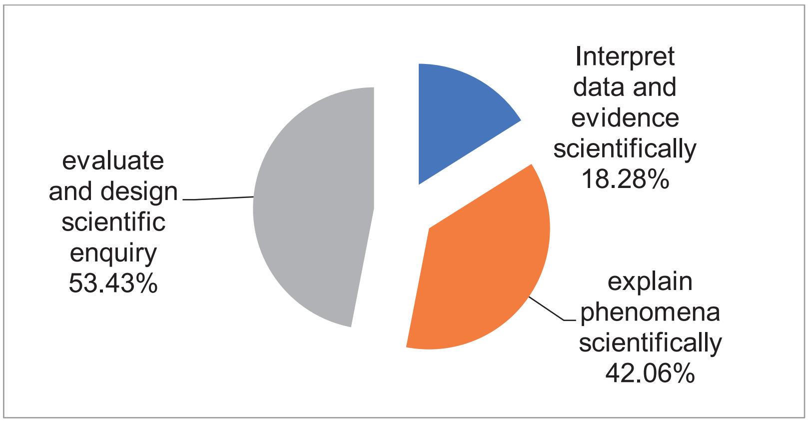
- Science learning in Indonesia is still not satisfactory, seen from the results of achievements at the international event, The Program for International Student Assessment (PISA) (Chang et al., 2017). This must be solved immediately, considering that scientific literacy is one of the main needs of students in the 21st century (Deming et al., 2012).
- Environmental pollution theme is very essential to be studied and mastered because of the increasing number and variety cases of environmental pollution that are happening nowadays.
- In 2002, UNESCO officially brought up the concept of ESD in education. Learning using the context of ESD leads students to learn clarifying one's values and have sustainable thinking (Tilbury, 2011).
- This research uses a descriptive quantitative design, that describe a condition as it is (no treatment or manipulation of variables) (Wulandari & Sholihin, 2016), consisted of 113 7th and 8th grade students in the second semester of the 2020/2021 academic year, from 4 secondary schools (SMP) in West Java, Indonesia. Data were collected using a science competency test instrument in the form of 15 essay questions adapted from PISA questions that have been validated by validator.
- The average results of science competency achievement in the context of ESD was 39.00%. This means that less than half of students have scientific competency. (in table 1)
- More than half of students were able to achieve the aspect of evaluate and design scientific investigations (53.4%), nearly half of students who achieved the aspect explain phenomena scientifically (42.06%), and the lowest achievement was aspect of interpreting data and proving scientifically, just less than half of students (18.28%). (in figure 1)

■This results can be implied in learning, such as compiling teaching materials that oriented to the balance of scientific literacy, and considering the level of students' prior knowledge before starting a learning, because different levels of prior knowledge require different learning strategies (van Riesen et al., 2018; 2019).

Table 1. The average result of students' science competency achievement in the context of ESD as a whole.

School	Science competence (%)
SMPN P	48.44
SMPN Q	43.18
SMPN R	35.39
SMP S (private)	29.00
Average	**39.00**

Figure 1. Achievement per aspect of science competency in the context of ESD



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EXPEDITION MUNDUS IN JAPAN: FOSTERING SCIENTIFIC LITERACY THROUGH A CLASSROOM GAME

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ABSTRACT
In this work, we introduce an educational game as an auxiliary tool to explore aspects of scientific literacy in science classrooms. The game, called Expedition Mundus, is an engaging and fun way for students to experience scientific research by playing. First, we present PISA's definition of scientific literacy, which underlies our teaching objectives with this activity. Then, we discuss the setting of the game and how it is played, providing instructions for handling it in the classroom. After these general aspects, we report on our own experiences applying the game in Japan. Pre- and post-activity questionnaires were used to investigate the impact that the game had in students' perspectives about science. The making and the analysis of the questionnaire are discussed in brief. Finally, we present the results from our questionnaire. In the conclusion, we show that the game was effective in deepening students' understanding about the process of modern science.

Keywords: *scientific literacy, educational game, science education*

INTRODUCTION: SCIENTIFIC LITERACY IN PISA

It is widely accepted that the main goal of science education is to promote scientific literacy among the general population. One very well-established definition of scientific literacy comes from PISA.

PISA is internationally regarded as a significant source of educational indicators that inform policymakers. In particular, PISA has widely influenced the shaping of educational policy in Japan, including recent revisions of the country`s courses of study (Ninomiya & Urabe, 2011; Tasaki, 2017). PISA assesses scientific literacy based on three competencies: explaining phenomena scientifically; evaluating and designing scientific inquiry; and interpreting data and evidence scientifically (OECD, 2019). PISA's framework further states that each of these competencies requires three kinds of knowledge: content knowledge, stemming from different areas of science; procedural knowledge, about the practices scientists use to establish scientific knowledge; and epistemic knowledge, of the constructs that are essential to building scientific knowledge (e.g.: observations, hypotheses, data) and their functions.

This description of scientific literacy led us to try implementing classroom activities that address these competencies, while emphasizing the procedural and epistemic categories of knowledge. A game allows us to incorporate experiential, social and ludic features when doing so.

EXPEDITION MUNDUS

Expedition Mundus is an analog educational game that was developed and tested by *De Praktijk* and *De Jonge Akademie* in the Netherlands (Kleinhans *et al*., 2016) and translated to Japanese by the authors of this work. Teachers can download the game for free, then print it and use it with their students.

In the game, students take the role of scientists who travel to an unknown planet, with its particular intelligent inhabitants, the Mundians, which have their own language, history and culture. Planet Mundus is populated by peculiar species of animals and plants, has its own climate and its own geography.

The game is composed of 31 A4-sized sources and 141 question and answer cards. Sources are the main sources of information about Mundus and come in the form of maps, tables, graphs, texts and pictures providing various data about the planet. They were made by scientists who preceded the players. The questions come in 3 difficulty levels. They pertain to Physics, Geology, Linguistics, Mathematics and Biology, giving a taste of the complementary roles of different fields in science.

Students should work in pairs so as to encourage collaboration and communication. Each pair receives 3 question cards and then goes around the room where the sources have been spread to look for the answers. Sometimes they need to look at multiple sources and take notes to solve a question. When they have an answer, they check it with the teacher. In case it is correct, they receive its answer card and a new question card. The answer card is then placed on their "publication board" and becomes available to all players as an additional data source. This simulates the process of publication and collaboration in science.

APPLICATION AND METHODOLOGY

We used Mundus with students in two separate occasions in 2020. In the first instance, the activity was performed in a science-related elective class with a population of 8 junior high school students. In the second instance, the target population was a group of 31 senior high school students.

The activity was divided in three stages. The first stage, lasting about 10 minutes, was dedicated to explaining the rules of the game and a pre-activity survey. The second stage consisted of playing the game for at least 60 minutes. In the final stage, we held a discussion session to highlight the connections between Mundus and real-world science, then gave a post-activity questionnaire.

The questionnaires were short and designed to gauge the effect of using Mundus. Students were asked about the interest roused by the game and their perceptions of science. Pre- and post-activity questionnaires were mostly composed of the same questions.

One question asked students to rank the features they perceived to be necessary for scientific research from a list, in order of importance. In the analysis, we gave scores to respondents' choices proportional to how high they were ranked and added the scores for a global measure of the group's thinking.

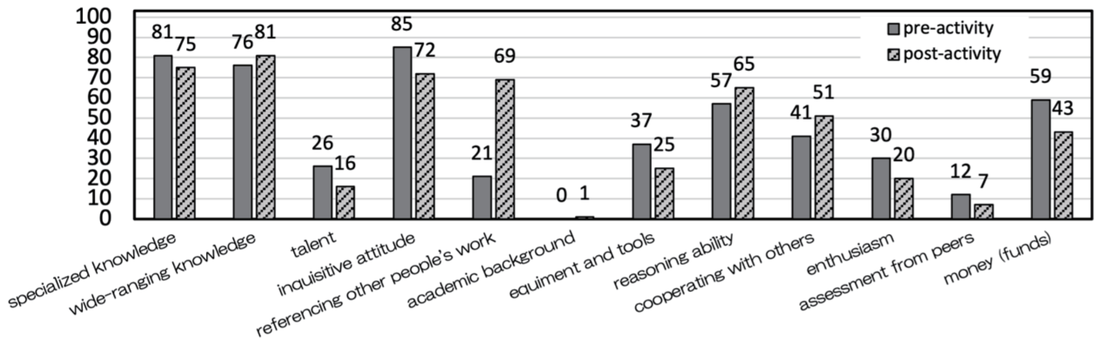

Figure 1. Scores of importance attributed by senior high school students on features necessary for scientific research.

We observed a shift in students thinking from stressing individual traits to underlining collaboration and collective aspects of scientific work, which represent the modern process of science more adequately. Also, the answers revealed that they found the activity engaging and interesting.

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Design of Project Based Learning activities based on STEM education ——Take making simple water purifier as an example

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ABSTRACT

With the rapid development of science and technology, the unique educational value of STEM education has attracted much attention from all countries. A large number of literature studies show that the combination of STEM education and project learning is a basic teaching orientation to realize STEM education, and project learning is more conducive to the implementation of STEM education. This study takes "water purification" as the theme with strong carrying capacity and rich content, and integrates the knowledge content of science, technology, engineering and mathematics and other interdisciplinary fields. It develops and designs a STEM project learning activity of "Making Simple Water Purifier" with 8 hours of content, and carries out the test in the middle school science and technology innovation group. The results show that STEM learning activities can not only promote students' situational application of knowledge, but also develop students' comprehensive ability in an all-round way.

Keywords: *STEM education；project-based learning；STEM project-based learning activity design；Water purification； Water purifier*

INTRODUCTION

STEM education itself has its own characteristics and educational value, so it has been widely concerned by researchers after it was proposed, and now it has spread a prairie fire in the global scope. There are a large number of domestic and foreign literatures on STEM education, and the research content is also very rich, including the policy interpretation of STEM education, the professional development of STEM teachers, the understanding of STEM education theory, and the practice and evaluation of STEM classroom (Julie,L,2010; Herschbach D.R, 2011). STEM education integrates interdisciplinary knowledge with task-driven teaching methods. Teaching methods based on problem solving, project and engineering design are commonly adopted in STEM education (Roger Bybee,; Burke,; Apedoex X S, 2008) In contrast, the interdisciplinary, experiential and systematic nature of project learning is more suitable for STEM education. Project learning is the foothold of STEM education, and STEM education is the foundation of project learning (Barell,J, 2006). STEM project learning activity design combines STEM education with project learning, emphasizes embedding knowledge into practical problems in real life, and uses driving questions to motivate students to design solutions to solve problems by mobilizing relevant knowledge of various disciplines, solving practical problems across disciplinary boundaries, and developing students' problem-solving ability.

Design of project learning activities based on STEM education concepts

This study adopts the design research method, conducts theoretical discussion on the basis of studying the learning theories of STEM projects, and summarizes the components of learning activities of STEM projects (as shown in Figure 1). The traditional teaching method is compared with STEM project learning to clarify the functional value of STEM project learning activities; The design principles of learning activities for four STEM programs are summarized. Water purification is in the middle school chemistry curriculum embodies an important content of interdisciplinary literacy, involves the subject content rich, bearing strong sex, teaching forms, therefore, in order to "make easy water purifier" as the carrier, such as science, technology, engineering and mathematics melting pot fusion interdisciplinary knowledge content, USES the skil contextual model put forward by the baker as the instruction, The design was carried out from five aspects of situation analysis, organizational content selection, goal formulation, implementation scheme design and evaluation planning, and a STEM project learning activity consisting of 8 hours was formed. Before the learning activity of this STEM project, students have learned interdisciplinary knowledge such as "Water in Nature", "Water Purification", "Bacteria and Virus", "Pressure", etc. At the same time, they have certain experimental operation skills and the ability to think independently, which lays a foundation for the learning activity of this STEM project. Therefore this activity can obtain certain practical effect.

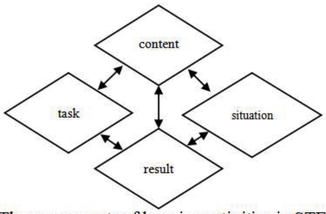

Figure 1 The components of learning activities in STEM programs

Figure 2

RESULT

According to the constructed STEM project learning process, combined with the project design and class planning with the theme of "making simple water purifier", the teaching implementation and test were carried out in a middle school science and technology innovation group composed of 10 students(as shown in Figure 2). In the process of research, students use a variety of ways to consult and analyze data, so that their research ability has been developed; Teachers' guidance helps students to think beyond the obvious and cultivate students' interdisciplinary thinking; Students in groups expressed the process of engineering design by designing and making a simple water purifier scheme, which gave full play to the students' innovative and creative ability. The process of selecting materials for production gives full play to students' critical thinking.

CONCLUSION

This research in STEM education on chemical course teaching, for chemical subject as the background, implementation discipline integration promote interdisciplinary study, the students showed high enthusiasm in the process of implementation, the implementation of the results showed that the STEM project design and implementation of the learning activities can deepen students' understanding, promote the student to the knowledge of the situation of the application. According to the STEM Cooperative Problem Solving Ability Scale compiled by Danielle's team, the students were evaluated by teachers and students. The evaluation results showed that the students' team cooperation ability and problem solving ability were improved, the students had the idea of subject integration, the interdisciplinary thinking was improved, and the students' comprehensive quality was developed.

DISCUSSION

STEM project design and implementation of the learning activities should be considered, must be from the topic selection of content, target price formulation, implementation, evaluation of planning and implementation of the object and other aspects to carry on the design, should not only accords with the practice of the students' life, and to fully exploit teaching resources, design load and fusion of STEM teaching activities is one of the focus of education researchers.STEM project learning is a long-term, repeated practice - thinking - improvements - improvement process, in practice need to continue to reflect on modification, complement, so you need to education researchers learn more STEM education idea, combining STEM and project learning, have the courage to explore, bold in teaching practice, adhere to innovation, To contribute to the development of STEM program learning in remote mountain areas.

OUTLOOK

In this study, STEM education is based on chemistry teaching and subject knowledge is taken as the background. In this way, discipline integration is realized and interdisciplinary learning is promoted, but it still fails to change the status quo of subject teaching. Therefore, based on the development of students, on the basis of the actual teaching environment, with the help of rich teaching resources, the future research direction is to design more practical and challenging STEM project learning activity cases in line with students' reality, carry out long-term teaching practice, and make STEM project learning activities into regular classrooms and become normal.

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Oral Session 4	Day2 (June 19th) 16：30～18：00
Room5	C4-5

【Category】 4: Science Education for High School and Related Areas

=Chairperson=

Prof. Zhang, Bao-Hui	Shaanxi Normal University

=Presentation Program=

1	85-4-5-19-1（FY5P-YMRC-Q0021） Irvan Permana（Universitas Pakuan） Suci Siti Lathifah, Herlina *Students' critical and creative thinking skills in learning by using anion cation disc media*
2	86-4-5-19-2（FY4K-ER66-BC021） Jirawan Nucharoen（Srinakharinwirot University） Chanyah Dahsah *Understanding Upper Secondary School Students Scientific Literacy about Food and Nutrition*
3	87-4-5-19-3（FY4K-S60Z-VO021） Indah Juwita Sari（Kasetsart University） Pongprapan Pongsophon, Wanwipa Vongsangnak *THE ANALYSIS OF ITEM DIFFICULTIES OF COMPUTATIONAL THINKING TEST USING RASCH MODEL*
4	88-4-5-19-4（FXIS-OUSM-9P021） Junye Gao（Hiroshima University） Tetsuo Isozaki *SCIENTIFIC INQUIRY IN CHINESE AND JAPANESE UPPER SECONDARY SCHOOL SCIENCE CURRICULA*

Students' critical and creative thinking skills in learning by using anion cation disc media

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ABSTRACT

This study aims to see students' critical and creative thinking skills using anion cation disc learning media. This research is a descriptive research with experimental research methods and uses a one group pretest-posttest model with research subjects divided into 2 classes with a total of 72 students. The instruments used in this study consisted of critical thinking skills questions, creative thinking skills observation sheets, creative thinking skills questionnaire sheets, and questionnaire sheets to determine student and teacher responses to cation anion disc media. The results showed that the students 'creative and critical thinking skills on compound nomenclature with an average pretest score of 39, an average posttest of 66 and an N-gain of 45% (moderate), the results of students' creative thinking skills after using cation anion plates an average of 73% (good) and an increase in creative thinking skills with r value of 0.478 (high enough).

Keywords: *critical thinking skills, creative thinking skills, anion cation disc medi*a

1. Introduction

21st Century Competencies require students to be able to develop competitive skills that focus on developing higher-order thinking skills, namely critical thinking and creative thinking. The teacher's task is to create opportunities for students to develop and improve critical and creative thinking skills so that they are able to understand the world around them and make good decisions, improve performance, and increase learning motivation (Stobaugh, 2013).

Teachers must be able to use multiple methods and multimedia in learning so that appropriate learning media are needed in the form of teaching aids/practice with the aim of building students' critical and creative thinking skills. The use of learning media has the potential to help improve students' academic performance in the form of learning outcomes in the cognitive domain (Chuang & Chen, 2007, Jabbour, 2014, Anugrah et al, 2015), students' motivation and interest in learning (Habibi & Prabowo, 2015). Fun and constructive media can overcome learning problems so as to improve student understanding and achievement (Vebrianto & Osman, 2011). The use of teaching aids as learning media has a very important meaning, namely complementing and enriching learning tools so that they can increase students' learning activities (Kozma et al, 2000).

2. Methods

This research is a descriptive research with experimental research methods and uses a one group pretest-posttest model with research subjects divided into 2 classes with a total of 72 students. The instruments used in this study consisted of critical thinking skills questions, creative thinking skills observation sheets, creative thinking skills questionnaire sheets, and questionnaire sheets to determine student and teacher responses to cation anion disc media.

3. Results and Discussion

To determine the students' initial critical thinking skills and after learning, pre-test and posttest were given to see the improvement of students' critical thinking skills. The questions tested were 15 multiple-choice questions based on the nomenclature of chemical compounds. The results showed that there was a difference between the students' pretest results before getting treatment (mean = 41.06) and posttest (mean = 66.86 in the first class. There was an increase in N-Gain of 43.23% in the medium criteria. While in the second class of pretest (mean = 36.75) and posttest (mean = 66.22), there was an increase in N-Gain by 46.33 % which was in the medium criteria. The average increase in critical thinking skills at the pretest and posttest scores for class 1 and class 2 before and after treatment are shown in Figure 1.

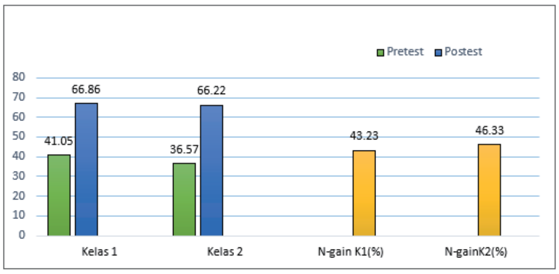

Figure 1. Improving students' critical thinking skills

The results of data analysis can be interpreted that the development of anion cation disk media used as a medium during the learning process can improve students' critical thinking skills. This is in line with the research of Lisdianto et al. (2015) which states that the ICM (Integrated Contextual Module) media which is an interactive electronic learning module is effective in increasing students' creativity and critical thinking skills. To determine the magnitude of the effect of KBKf (X) on KBK (Y) in simple linear regression analysis, it can be guided by the value of R Square or R^2 contained in the SPSS output of the Summary Model section. From the output above, it is known that R Square is 0.478. This value means that the effect of KBKf (X) on KBK (Y) is 47.8% with sufficient criteria. In this study, with the influence of creative thinking skills on students' critical thinking skills, there was an increase in students' creative thinking skills using anion cation media.

4. Conclusion

The use of anion cation disk media can increase students' critical and creative thinking skills in the moderate category

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Understanding Upper Secondary School Students Scientific Literacy about Food and Nutrition

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Abstract

In today world, people can access to the information or media on the internet faster and easier, thus citizen should be able to evaluate the quality of information scientifically. Scientific literacy helps people to be better – informed and make the best decision in making choices related to their everyday life. Thus, scientific literacy is an essential element of science and technology learning in all ages and that it is necessary for teachers to assess students' scientific literacy. This research study aimed to explore upper secondary school student's scientific literacy. Data was collected from 201 Grade 11 students in second semester, 2020 academic year from a school located in Bangkok. The research instrument was the scientific literacy test in the topic of food and nutrition. The test consisted of multiple-choices, complex multiple-choices, and short answers. The results revealed that 190 (94.53%) students were at Level 2 and lower. Only three (4.48%) students were at Level 3 and two (0.99%) students were at Level 4. The results suggested the proficiency of scientific literacy of our upper secondary school students was lower than the PISA results of our lower secondary school students. These results pointed out that science educators need to put much more emphasis on improving students' scientific literacy in an upper secondary education.

Keywords: *Scientific literacy, Upper Secondary School, Food and Nutrition, Assessment*

INTRODUCTION

Scientific literacy is an application of knowledge and understanding of scientific concepts and process for personal decision-making and engaging in scientific issues in their daily life (NRC, 2016; OECD, 2019). It is used as an indicator to reflect quality of science education in each country by the Programme for International Student Assessment (PISA). PISA 2018 indicated that students in Thailand scored lower than OECD average in science. Only about 1% of Thai students at age 15 were at the highest level of proficiency (level 5 and 6), and 76% of them were at level 2 and lower (OECD, 2019). Due to the problems that arise with Thai education, a competency-based approach has been stated in the education reform plan, and scientific literacy will include in university entrance examinations (IPST, 2020). Thus, in this study aims to explore scientific literacy of upper secondary school students to see whether they are ready for higher education.

OBJECTIVE

To explore upper secondary school students' scientific literacy on food and nutrition.

METHODOLOGY

This research is a quantitative survey research. The research instrument was the scientific literacy test in the topic of food and nutrition, consisted of multiple-choices, complex multiple-choices, and short answers. The scientific literacy consisted of three competencies and analyzed into seven levels of proficiency based on OECD (2019). Data was collected from 201 Grade 11 students who studied the fundamental science courses from a school located in Bangkok in second semester of 2020 academic year. They were selected by convenience sampling.

RESULTS

The results indicated that most of the students (73.14%) were at the lowest level of proficiency (level 1a and 1b) which was lower than a minimum level of proficiency (level 2 and above). 21.39% of the students were at level 2. Only 4.48% and 0.99% of the students were at level 3 and level 4, respectively. There were no students were at the highest level of proficiency (level 5 and 6). The average score of scientific literacy is only 5.25 out of 18.

When analyzing each competency of scientific literacy, the results indicated that the average score in all competencies were very low. The explaining phenomena scientifically competency was the highest average score which was only 2.10 out of 6. The interpreting data and evidence competency was 1.80 out of 6. The evaluating and designing scientific enquiry competency was 1.35 out of 6 which was the lowest average score. The results showed in table 1.

Table 1. Scores of scientific competencies

Scientific competency	Total score	Max	Min	Average score	SD
1. Explain Phenomena Scientifically	6	4	0	2.10	0.58
2. Evaluate and Design Scientific Enquiry	6	4	0	1.35	0.47
3. Interpret Data and Evidence Scientifically	6	6	0	1.80	0.59
Overall	18	14	0	5.25	1.64

CONCLUSIONS

According to results of the study, it was found that upper secondary school students' proficiency of scientific literacy was lower than the PISA results of students age 15 (OECD, 2019). This might be the effects of today's teaching and learning that focus on scientific knowledge rather than scientific processes (Chanapimuk, 2018). It suggested that we need to put much more emphasis on improving students' scientific literacy in an upper secondary school level by encouraging students to search and evaluate scientific knowledge, evaluate and design scientific investigation, interpret and summarize scientific data from scientific investigations, and explanatory phenomena using scientific knowledge and data (Surpless, Bushey, & Halx, 2014).

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THE ANALYSIS OF ITEM DIFFICULTIES OF COMPUTATIONAL THINKING TEST USING RASCH MODEL

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ABSTRACT

This study aimed to analyze the item difficulties of computational thinking test by Rasch analysis. We adopted 10 items of computational thinking test from Bebras Tasks that covered four components of computational thinking skills; decomposition, pattern recognition, abstraction, and algorithmic thinking. Samples in the tasks were 52 senior high school Indonesian students. We used Rasch Modelling to analyze item difficulties. As a result, the computational thinking test showed 0.55 reliability index in the moderate level. Six items in the acceptable range 0.7 to 1.3 Infit-Outfit index. The title of computational thinking test items that in the acceptable range were Rows and Columns (2018), Treasure Maps (2018), Cipher wheel (2017), Commuting (2017), Secret messages (2016), and Kix Code (2016). This instrument will benefit further research on measuring the student's computational thinking skills.

Keywords: *Computational Thinking Test, item difficulties, Rasch model, computational thinking skills, senior high school student*

INTRODUCTION

Computational thinking skills (CT) is very essential as one of the 21st century skills in the digital era. In developed countries, computational thinking has appeared formally in the K-12 curriculum (Tabesh, 2017). Indonesia as a developing country also needs to be introduced to computational thinking. High quality computational thinking tests are required to measure students' computational thinking. The test results will inform teachers how to design a lesson to promote computational thinking. This present study examined the quality of a popular computational thinking test, called Bebras with Indonesian students. The analysis of test item has several benefits, such as to get the information about the quality of individual items, item sets, and entire sets of items, as well as the relationship of each item to other items (McCowan & McCowan, 1999). The information could be used to improve item and test quality. So, the purpose of this study is to examine the item difficulties of a computational thinking test using Rasch analysis.

LITERATURE REVIEW

Students demonstrate computational thinking skills in four components including decomposition, pattern recognition, abstraction, and algorithmic thinking. Decomposition is the ability to analyze and investigate the problem from a data source. Pattern recognition is one of the skills in computational thinking to identify a pattern in a part of the data component. Abstraction is the ability to find the solution from useful information. Algorithmic thinking is the ability to use codes step by step in the programming language by computer to find the final solution (Tabesh, 2017). The Bebras task was developed by the Bebras International Contest to assess the CT skill of students through solving the real-life problem test. This assessment is independent in software or hardware and can be used to students that do not have experience in the programming language (Román-González et al., 2019).

METHOD

This research method in this study used BEAR assessment system that consists of construct maps, items design, outcome space, and measurement model (Wilson, 2005). Bebras Task UK challenges have six groups of computational thinking test based on age of participant including Kits, Castors, Juniors, Intermediate, Seniors, and Elite. In this study, we used elite group that consisted of easy, moderate, and hard levels. Based on the Bebras Task UK challenges from 2016 to 2018, we made construct map for 10 items that can be seen in Figure 1.

Easy						Moderate			Hard
Rows and Columns (2018)	Connections (2018),	Treasure Maps (2018),	Cipher wheel (2017),	Commuting (2017),	Secret messages (2016)	Digit recognition (2017),	Soda shop (2017),	Triangles (2016)	Kix Code (2016)

Figure 1. Construct map of computational thinking test

Sample size of the test taker were 52 grade XII Indonesian students. We examined the quality of 10 items Bebras Task UK challenges from the 2016 and 2018. The test took 60 minutes. Before conducting item and test analysis, we translated the instrument from English to Indonesian and was scrutinized by the English-Indonesian language specialists. We used Google form as a platform to administer the test and we validated the proposed model with empirical data using Rasch analysis by R program, package Test Analysis Module (TAM).

FINDINGS

Based on Rasch analysis by R program, we found that the reliability index of the 10 items is 0.55 or at the moderate level (Landis and Koch, 1977). Bond and Fox (2007) state that if the item has outfit and infit mean-square values 0.7 to 1.3, the item is acceptable. It can be seen at Table 1 that six items of computational thinking test are acceptable, includes Rows and Columns (2018), Treasure Maps (2018), Cipher wheel (2017), Commuting (2017), Secret messages (2016), and Kix Code (2016). However, based on Rasch difficulty result that the items number 2, 6, and 7 were too difficult for student. The implication of this study that six from ten items of computational thinking test can be used to measure computational thinking skills of this group of senior high school students.

Table 1. Summary of Rasch Fit Statistic and Difficulty

No	Title of Computational Thinking Test	Component of Computational Thinking skills				INFIT	OUTFIT	Category	Rasch Difficulty
		D	PR	A	AT				
1	Rows and Columns (2018)	√	√	√	√	**1.0**	**0.9**	**Acceptable**	1.16
2	Connections (2018)	-	-	√	√	0.9	0.3	Unacceptable	4.42
3	Treasure Maps (2018)	√	-	√	-	**1.1**	**1.1**	**Acceptable**	0.03
4	Cipher wheel (2017)	-	√	-	√	**0.8**	**0.7**	**Acceptable**	1.04
5	Commuting (2017)	-	-	√	√	**0.8**	**0.9**	**Acceptable**	1.40
6	Digit recognition (2017)	√	√	√	-	0.7	0.5	Unacceptable	1.99
7	Soda shop (2017)	-	-	√	√	0.7	0.6	Unacceptable	2.37
8	Secret messages (2016)	√	√	-	√	**1.0**	**0.9**	**Acceptable**	-0.44
9	Triangles (2016)	-	√	-	√	1.6	2.1	Unacceptable	1.04
10	Kix Code (2016)	√	√	-	√	**0.8**	**0.7**	**Acceptable**	0.62

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SCIENTIFIC INQUIRY IN CHINESE AND JAPANESE UPPER SECONDARY SCHOOL SCIENCE CURRICULA

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ABSTRACT
The term scientific inquiry has different meanings in different contexts. This study aims to analyze the meaning of scientific inquiry in Chinese and Japanese contexts. Thus, we analyzed the latest curriculum standards and the corresponding official illustrations in this study both in China and Japan. We found that developing the ability to do scientific inquiry in both China and Japan is a crucial science education objective for upper secondary school students. The Chinese science curriculum standards emphasize various abilities when students are involved in every scientific inquiry process. By contrast, in Japan, scientific inquiry is more about students' competency when solving authentic problems. Furthermore, even though knowledge about scientific inquiry is articulated in the science curriculum's official illustrations in both China and Japan, this kind of knowledge is not mentioned as an objective in either China's or Japan's science curriculum, except for the Chemistry Curriculum Standards for Senior High School (China) and the inquiry-based study of science and mathematics (Japan).

Keywords: *curriculum, scientific inquiry, comparative study.*

INTRODUCTION

Since its inception as a laboratory method in the 19th century, scientific inquiry has gained popularity in the science education field. The latest round of education reforms at the upper secondary school level in China and Japan (both in 2017) have emphasized the importance of inquiry-based learning and scientific inquiry. However, as Anderson (2006) mentioned, the meaning of "scientific inquiry" differs with context. Therefore, this study aimed to identify the similarities and differences between the definitions and explanations of scientific inquiry in the Chinese and Japanese contexts.

RESEARCH QUESTION AND METHOD

For this purpose, the following research question emerged, based on Bybee's (2006) classification of scientific inquiry: What are the similarities and differences between scientific inquiry as a learning outcome in upper secondary school science curricula in China and Japan? To answer this research question, we carefully analyzed the following documents, using "inquiry" and "scientific inquiry" as keywords: (1) the newly revised science curriculum standards for upper secondary school (for China, the 2020 version; for Japan, the 2017 version) and (2) their official illustrations. Notably, the science curriculum standards for upper secondary school consist of three separate curricula in China, namely chemistry, physics, and biology. Meanwhile, in Japan, the science curriculum consists of nine scientific subjects (science and human living, basic and advanced in each of physics, chemistry, biology, and earth science). Finally, we treated one interdisciplinary subject (inquiry-based study of science and mathematics) as part of the science curriculum in this research.

THE SCIENTIFIC INQUIRY IN CHINA AND JAPAN

The scientific inquiry in curricula

As mentioned above, because each scientific discipline has different curriculum standards in China, the description of the scientific inquiry is diverse. Regarding commonalities, scientific inquiry refers to the ability to formulate questions and hypotheses based on discipline-specific issues, to design experiments and research plans, to draw conclusions, and to communicate the process and results of scientific inquiry in all these curriculum standards. In addition to the ability to do scientific inquiry, the chemistry and biology curriculum designates several required attitudes in scientific inquiry such as the willingness to cooperate and the courage to scientific doubt. Furthermore, "understanding scientific inquiry is a scientific practice…" (MoE, 2020, p.8) was only set among learning objectives and contents in the chemistry curriculum. On the other hand, in Japan, acquiring the abilities or competencies of scientific inquiry can be considered the foremost objective, which is described as follows: "develop the necessary competencies for the scientific inquiry of substances and its changes by relating to nature and …" (MEXT, 2017, p.21). Thus, it includes necessary scientific knowledge and skills, the willingness to engage in scientific inquiry, attitudes toward life, nature, and ethics, and the ability to do scientific inquiry. However, understanding scientific inquiry as content is only ensured in the inquiry-based study of science and mathematics.

The scientific inquiry in official illustrations

In China and Japan, the meaning of scientific inquiry is detailed in the official illustrations for science curricula. These include the specific competencies of scientific inquiry performance, the core elements of scientific inquiry, and the role and value of scientific inquiry in the classroom. Additionally, the Japanese illustrations delineate the differences between scientific mathematic inquiry and inquiry.

CONCLUSIONS

Finally, scientific inquiry can be interpreted as follows. In China, scientific inquiry can be predominantly considered as process skills, while in Japan, it consists in competencies including knowledge attitude and skills.

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Oral Session 4	Day2 (June19th) 16：30～18：00
Room6	C7-1

【Category】 7: Science Education for Policies and Others

=Chairperson=

Prof. Tetsuo Isozaki	Hiroshima University

=Presentation Program=

1	89-7-1-19-1（FXH5-H7J1-ZA021） Tomoki Saito（Juntendo University） *Role of the Crosscutting Concepts in Science Curricula: A Historical Account for STEM Integration*
2	90-7-1-19-2（FY3Q-0MUQ-EF021） Tepkanya Promkatkeaw（Srinakharinwirot University） Chanyah Dahsah, Worawarong Rakreungdet, Thanapun Charlee *How to Sustain the Project for Enhancing the Development of Science, Mathematics, and Technology Teaching and Learning in Local Schools: Views from Practitioners*
3	91-7-1-19-3（FY6S-XWQ1-ZM021） Guo-feng Zhang（Wentao Middle School, Hangzhou, Zhejiang Province, China） Wenhua Zhang, Zuhao Wang *Research on the Difference of PCK Integration Mechanism between Specialist Teachers and Pre-service Teachers— Taking the "Chemical Equilibrium State" of Senior High School Education Edition as an Example*
4	92-7-1-19-4（FY5Q-67EO-EU021） Pei-Chen Wu（National Dong Hwa University） Chih-Hsiung Ku *How do people READ the internet rumors of COVID-19 with the science perspective?*

Role of the Crosscutting Concepts in Science Curricula: A Historical Account for STEM Integration

Tomoki Saito

Juntendo University, Tokyo, Japan

ABSTRACT
Explaining interdisciplinarity of STEAM Education is essential on integration research. In this study, the author seeking how Crosscutting Concepts work as the anchor of the STEAM Integration in the curriculum. By examining historical curricula and standards included those concepts, the author found that the CCCs had roles with engineering, process skills, and the contents. Not only crosscutting concepts on the Next Generation Science Standards, but also those appearances on the historical documents support us to develop disciplined integration in the present curriculum development and the coherency with the content standards with less alternation.

Keywords: *STEAM education, interdisciplinary, DS-Id, crosscutting concepts, curriculum*

The Crosscutting Concepts (CCCs) are the second dimension of 3D learning in the Next Generation Science Standards (NGSS; Achieve, 2013). The author examined the role of the CCCs in the historical standards or curricula documents.

The US standards, curricula, and the related documents had dealt with such concepts. The examined documents range from 1960s curriculum reform era to present. Under text search of such documents, all the concepts were explored and identified. Most of explored documents also emphasized such concepts and structured framework included them. The role of those concepts or the placement on the frameworks, the appearances, had changed through the history. In turn, their means on the students' learning.

First, the Science Curriculum Improvement Study (SCIS) had a framework Process-oriented Concepts along with the Major Scientific Concepts and Processes. SCIS curriculum had CCCs also in the curriculum units. The units wove CCCs with in the science contents. Engineering Concepts Curriculum Project also listed concepts in the final repot "*the Man Made World*". It referred System, Materials, and Energy as the "part of modern technology", and they were "rather arbitrarily" chosen (p. iv). However, they also add some concepts as "educational objectives" for the technological literacy.

Second, the discussion in the preparation for the "*Educating Americans for the 21st Century"* (NSF, 1983) also included those concepts. Particularly, ad hoc subcommittee of the NSF engineering advisory reported "*Integrating Concepts of Engineering and Science into Instruction in Grade Levels K-12*" (1982). They referred the concepts on "*the Man Made World* " and add Synthesis and Design which was generally absent from the fields of mathematics and science (p.63). The committee also suggested that this was not a call for the addition of special new courses.

Third, the discussion for the Project 2061 by AAAS identified "contents" for the science literacy. Therefore, CCCs called common themes at that era, was put as content in the "*Science for All Americans*" (1989) and "*Benchmarks for Science Literacy*" (1993).

Fourth, the "*National Science Education Standards*" (NSES; NRC, 1996), again, intertwined those concepts with Process and were called "*Unifying Concepts and Processes*". When we use those historical terms above, the NSES put Processes and Process-Oriented Concepts together.

Finally, NGSS put CCCs as second dimension. They expect students engage in a set of Performance Expectations (PEs). In PEs, students integrate CCCs by performing through process skills with Contents (DCIs), and Science and Engineering Practices (Saito, 2020).

In conclusion, the role and placement of CCCs changed and intertwined with the other framework on each document. From the early in the history, the curricula put CCCs as contents and process. They also taken as the concepts related to technology and engineering. The CCCs were, virtually, the core of the curricula, orienting concepts, and process-oriented concepts. Although, this study referred limited documents, they were essential examples dealt with CCCs in the history. We can apply these understanding to the recent curriculum development and make sure the effect on to the learning for the other dimensions.

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How to Sustain the Project for Enhancing the Development of Science, Mathematics, and Technology Teaching and Learning in Local Schools: Views from Practitioners

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ABSTRACT
The Institute for the Promotion of Teaching Science and Technology (IPST) has run the three-year-long project for enhancing quality in science, mathematics, and technology (SMT) education of 23 local schools in Prachuap Khiri Khan Province since 2019. This project provided professional development (PD) programs for school administrators and teachers; supported SMT learning materials and resource; and provided experts to follow up, coach, and mentor teachers and supervise school administrators. To explore participants' views on how to sustain the project for enhancing the development of SMT teaching and learning in their own schools, 8 school administrators and 40 teachers whom participated in the project were interviewed by online structured interview with the questions developed based on CIPP evaluation model. The results indicated 9 strategies which would possibly enhance local schools sustain the development of SMT teaching and learning in their schools with less relying on the support from government agencies.

Keywords: *science, mathematics, and technology education; enhancing teaching quality, sustainability of project, program evaluation, CIPP model*

INTRODUCTION

The Institute for the Promotion of Teaching Science and Technology (IPST), Thai government institute under the Ministry of Education, has run the three-year-long project for enhancing quality in science, mathematics, and technology (SMT) education of 23 local schools in Prachuap Khiri Khan Province since 2019. This project provided PD programs for school administrators and teachers and supported leaning materials and resources for SMT teaching and learning. The participant schools had to set school plans and develop teaching quality to raise students' SMT learning achievement. The experts from IPST visited each school to follow up, coach and mentor participant teachers and supervise school administrators at least twice a year. Typically, after the government agencies finish the projects or withdraw from local areas, the developmental process of the project in the area would gradually grow faint and disappear. To avoid this pitfall, the research conducted to monitor and evaluate the effectiveness of this project and develop a guideline for helping local schools sustain the development of quality of their SMT teaching and learning after IPST withdrawing by using CIPP Evaluation Model.

OBJECTIVE

The objective of this study is to explore views of school administrators and teachers on how to sustain the project for enhancing the development of SMT teaching and learning in their own schools.

METHODOLOGY

Online structured interview was used to interview 8 school administrators and 40 school teachers whom participated in IPST project. The interview questions were developed according to CIPP Evaluation Model in the part of product evaluation and subpart sustainability evaluation (Stufflebeam, 2015). Each participant was interviewed by researcher via VDO call application or mobile phone according to their convenience for about 45 minutes with voice recording. Then, their answers as qualitative data were coded and categorized by content analysis.

RESULTS

The results from interviewing school administrators and SMT teachers with the questions about how to sustain the project in long term indicated 9 strategies. These strategies are: 1) continually coaching and mentoring teachers by experts; 2) supporting teaching and learning materials and resources; 3) making connection with the offices of school district; 4) continually following up, assessing and evaluating the project; 5) raising understanding and collaboration among school administrators and teachers for supporting the project; 6) building up models of successful teachers, school administrator, and schools; 7) publicizing and expanding the project to other schools; 8) continually conducting teacher PD in various forms; and 9) having extracurricular activities for students e.g. science and mathematics camps.

CONCLUSION

These results were aligned with the findings from various research which indicated that the effective PD program for SMT teachers should endure for long terms with enhancing participation and collaboration of teachers, using models of effective practices, and provide coaching and expert support (Scher & O'Reilly, 2009; Krajcik, 2014; Darling-Hammond, Hyler, & Gardner, 2017). These strategies also aligned with National Science Teacher Association (NSTA)'s position statement which suggested that to sustain PD in science education, the school districts and administrators must give full support with the funding, materials and ongoing support (NSTA, 2021). The government agencies should bring these 9 strategies from practitioners' point of views for consideration and improvement of their projects' policy and practices for enhancing the development of SMT teaching and learning in local schools. These strategies would possibly enhance the sustainability of the projects in the local schools and help local schools to sustain the development of their SMT teaching and learning with less relying on the support from government agencies.

ACKNOWLEDGEMENT

This study was financial supported by the Institute for the Promotion of Teaching Science and Technology (IPST), Thailand.

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Research on the Difference of PCK Integration Mechanism between Specialist Teachers and Pre-service Teachers—— Taking the "Chemical Equilibrium State" of Senior High School Education Edition as an Example

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2. Central China Normal University, Wuhan, China
3. East China Normal University, Shanghai, China

ABSTRACT
In this study, an expert teacher and a pre-service teacher who teach in a provincial key high school in Zhejiang Province were selected as the research objects. The four elective courses "Chemical Equilibrium State" in Jiangsu Education Edition were selected as the research carrier, and the research materials were obtained through classroom observation and semi-structured interview. The PCK assessment scale designed based on the Pentagon model was combined with the interview data to encode the transcripts of classroom teaching, draw the PCK Map, find out the differences in the PCK integration mechanism between the two teachers, and provide reasonable suggestions for the professional development of PCK for pre-service teachers.

Keywords: *Chemistry classroom， Expert teacher， Pre-service teacher， PCK, the pentagon model*

As one of the most important components of teachers' professional knowledge, Pedagogical Content Knowledge (PCK) has the characteristics of individual, situational and experiential. It is found that the PCK integration mechanism of expert teachers is significantly better than that of pre-service teachers. Therefore, by studying the mechanism of integrating PCK between expert teachers and pre-service teachers and finding out the differences, pre-service teachers can learn the advantages of expert teachers, improve their own integration mechanism and promote their own professional development.

1 Selection of PCK integration mechanism analysis model

This study adopts the PCK integration mechanism evaluation scale compiled by Park and Oliver, who proposed the PCK five-component integration model[1] in 2008, to conduct a comprehensive and in-depth analysis of teachers' classroom teaching. In order to clearly describe the integration mechanism of all dimensions of PCK, this study adopted the Pentagon model of PCK drawn by Park and Chen in 2012 based on the encoding of the PCK five-component integrated structure model [2].

2 The research methods

In this study, relevant concepts of PCK were defined by literature method, and appropriate analytical tools were selected. Then, the classroom teaching of an expert teacher T1 and a pre-service teacher T2 was recorded, analyzed and studied through the classroom observation method, and the interview method was used to supplement the research data to support the viewpoints.

3 Data collection and analysis

Through interviews to understand the teaching plans of the two teachers, this study selected the elective four "State of Chemical Equilibrium" from the Jiangsu Education Edition as the research carrier.

In the data processing stage, this study first transcribed the classroom teaching videos of two teachers into texts. After transcribing the text, the PCK Integration Mechanism Assessment Scale was used to encode the text. Here, manual encoding was used, and a total of three researchers participated in the encoding. After the completion of coding, the frequency of each dimension of PCK of the two teachers in the teaching process was counted, and then all fragments were summarized to obtain the total frequency of each dimension in the whole teaching process. Finally, the PCK map of the two teachers in the class of "State of Chemical Equilibrium" was drawn (see Figure 1 and Figure 2).

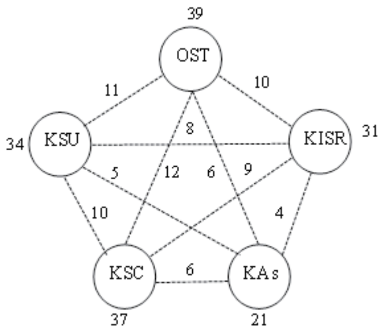

Fig.1 Teacher T1's PCK map of chemical equilibrium

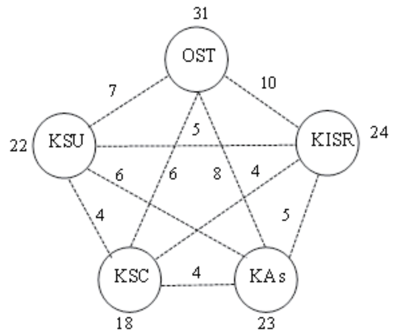

Fig.2 Teacher T2's PCK map of chemical equilibrium

Through a detailed analysis of the PCK integration mechanism of teachers T1 and T2, this study found the following differences in the integration mechanism of PCK in the teaching process between expert teachers and pre-service teachers:

(1) Compared with pre-service teachers, expert teachers are more closely connected in all dimensions of PCK;

(2) Expert teachers have a more comprehensive and in-depth understanding of students than pre-service teachers, and can design appropriate teaching strategies according to students' levels;

(3) Specialist teachers have a deeper understanding of the curriculum than pre-service teachers;

(4) Orientation to Teaching Science of expert teachers has a stronger guiding effect on other dimensions than that of pre-service teachers.

4 The research conclusion

It is found that the reasons why the PCK integration mechanism of expert teachers is better than that of pre-service teachers are as follows :(1) Expert teachers have more experience in front-line teaching; (2) Specialist teachers study the courses they teach far more than pre-service teachers.

In order to ensure that Pedagogical Content Knowledge of pre-service teachers can be developed, the author proposes the following three suggestions based on the research conclusions of this study:

(1) Improve teacher education curriculum

Most normal colleges, psychology and pedagogy only open 48 hours each; Subject teaching class courses are only opened in the third year, the number of arranged hours is also less. Therefore, normal universities should increase the number of hours of teacher education courses and allocate them to each semester reasonably.

(2) Pay attention to educational practice and improve subject teaching knowledge

Normal colleges should pay more attention to educational practice, which is the biggest moment for pre-service teachers to change, so the time of educational practice can be appropriately extended, and the internship assessment should be more standardized and strict, so as to effectively improve the ability of pre-service teachers.

(3) Pre - service teachers should attach importance to professional knowledge

Nowadays, many normal university students think that they will work in the basic education industry in the future, and college knowledge is not necessary for them. However, the basis of PCK is subject expertise, and university expertise has a great role in promoting PCK.

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HOW DO PEOPLE READ THE INTERNET RUMORS OF COVID-19 WITH THE SCIENCE PERSPECTIVE?

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ABSTRACT

Since 2019, it broke out the serious and irreversible virus, Novel Coronavirus (COVID-19), affecting the entire world, until now people are still facing the different stories and rumors about the pandemic daily. Therefore the purpose of the study is to understand under the Social Constructionism theory how the reactions of people after receiving the internet rumors of COVID-19. Further, the qualitative research method was supplied in the study, after the first step, content analysis of the analysis of COVID-19 internet rumors since 2019-2021, the four themes about science concept were emerged and extracted which were 1.Evolution 2. Fact 3. Hypothesis 4. Data that provided the datum for the following step Semi-structured interviews, the 6 Participants were interviewed via LINE and SKYPE for 3 times from 2020-2021, the information of COVID-19 were mass and mess during the period, the content of interviews were focusing on how the Participants read the internet rumors with the science perspective and the Social Constructionism theory was used to exam the participants' notions that operated on the coordination with the world during the three times interviews. The findings presented as below, as time goes on the more and more evidences shows, the researcher divided the results into 3 parts for discussion 1. the notion of wearing a mask; 2. the notion of getting a COVID-19 Vaccine shot ; 3. the notion of getting information. The reactions of participants were corresponded with the core of the Social Constructionism theory. And through the discussions that showed that participants did care to see the evidences with science explanations that provided the implications for governments developing a policy.

Keywords: *COVID-19, science education, internet rumors, the Social Constructionism Theory.*

INTRODUCTION

The world is still under the control of COVID-19 pandemic since 2019 (World Health Organization [WHO], 2020b), as everyone knows it could be just a cold or asymptomatic at the very beginning , once people who are infected Coronavirus have the common symptoms throat disorders, loss of taste and smell…etc, and no doubt it is a powerful contagious disease. Therefore it became the New Living Norms to wear a mask, sterilize, and keep a social distance…etc.

Importance of the study for research

The pandemic surroundings is not just affecting few people, few groups or few countries but also making a difference to everyone's life, and it will still be continuing for a long time. Therefore the research was based on using the Social Constructionism theory to unveil how human beings coped with the chaos information of Covid-19 to develop the common knowledge and provided the implications for governments developing a policy.

Research question

The purpose of the study is to understand that how the reactions of people after interpreting the internet rumors of COVID-19 under the Social Constructionism theory.

How do people READ the internet rumors of COVID-19 with the science perspective?

Theoretical framework

Under the Social Constructionism theory, the researcher aims to explore the principle that people adjust their behavioral and psychological changes after reading and digesting the news, internet rumors and information of COVID-19 because "all human psychological and social phenomena arise out of social life, from the interactions between people."(Burr, 2015)

RESEARCH METHOD AND DESIGN

The information of COVID-19 was mass and mess during the period, how to deal with the impact and the collective crisis (American Psychological Association, 2020) was very important, the Social Constructionism theory was used to exam the participants' notions that operated on the coordination with the world during interviews. 6 participants, half Canadians and half Taiwanese, all the participants used internet to read information. Three times online interviews via SKYPE and LINE from 2020-2021, it was 8th MARCH 2020, 9th August 2020, and 7th MARCH 2021. The content of interviews was collecting between 2019/12-2020/2, 2020/3-2020/7and 2020/8-2021/2 through reading and analyzing news and internet rumors about Coronavirus disease on 5 websites : Government of Canada (CA), Ministry of Health and Welfare (TW), MyGoPen (TW), New Scientist (UK), HEHO (TW). The researcher used the two official Governments' websites to ascertain the new reports and policies of disease.

FINDINGS

The classification of notions was based on interviews, the participants mentioned the notion of 1. wearing a mask; 2. getting a COVID-19 Vaccine shot; 3. getting information. Participant A said that "I am not wearing a mask….well it's just cold" at the first interview, and then the following interviews A had adapted the attitude after reading lot of news. A said that "we stay in the house all the time, I feel so bored….we wear a mask when we go out….yeah…we have enough masks". F showed that the consistency of this issue, "Luckily, I bought enough masks, everyone needs to wear a mask." B mentioned "I am waiting for getting the Vaccine…many people died…", B was happy that Vaccine finally invented, it was stressful to not work for a year. E was doubting the Vaccine situation, "I am still gathering more science research report…", later " I will get the Vaccine, I just need to plan it…"on the 3rd interview. The findings presented as below, the reactions of participants were corresponded with the core of the Social Constructionism theory. Participants needed to deal with the massive unassured information that affected their decisions of adapting the indications of government policy and there were ethical issues that Reiss (2020) had mentioned that health care rationing and vaccination, it was a battle outside and inside.

Discussion of findings and implications

The result of the study showed that participants did care to see the evidences with science explanations, people prefer to gain more facts and data then hypothesis and evolution, it showed that people were trying to understand the coronavirus with scientific perspective and method that provided the implications for governments developing a policy.

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Oral Session 5

Day3 (June20th) 13:00～14:30

Room1	C1-3	Science Education for Young Children and Related Areas
Room2	C2-3	Science Education for Elementary School and Related Areas
Room3	C3-11	Science Education for Middle or Secondary School and Related Areas
Room4	C4-6	Science Education for High School and Related Areas
Room5	C5-2	Science Education for Undergraduate or Graduate School Students
Room6	C6-2	Science Education for Informal Setting or Life-Long Learning or In-Service Teacher training
Room7	C7-2	Science Education for Policies and Others

East-Asian Association for Science Education
EASE 2021 ON-LINE CONFERENCE

Oral Session 5	Day3 (June20th) 13：00～14：30
Room1	C1-3

【Category】 1: Science Education for Young Children and Related Areas

=Chairperson=

Assist. Prof. Chaninan Pruekpramool — Srinakharinwirot University

=Presentation Program=

1	93-1-3-20-1（FY4T-OWOR-1A021） Jirayute Ruennakarn（Srinakharinwirot University） Chaninan Pruekpramool *A STUDY OF THAI EIGHTH GRADE STUDENTS SCIENTIFIC PROBLEM - SOLVING ABILITY ON THE TOPIC OF GLOBAL AND NATURAL RESOURCES*
2	94-1-3-20-2（FY4U-CRTL-NX021） Tian-Da Hsieh（National Taipei University of Education） Shih-Jung Huang *Exploring the cognitive learning of the causes of the moon phases in the fifth grade of elementary school*
3	95-1-3-20-3（FY50-GQA1-CL021） Suppamai Promkaew（Kasetsart University） Vudipong Davivongs and Pongprapan Pongsophon *A Case Study of Thai Teachers Implementing Gardening Education for Green Design Project on Their Understanding of Engineering Design Process*
4	96-1-3-20-4（FY5I-C2C3-3W021） Yuan-Li Liu（Graduate Institute of Science Education, National Taiwan Normal University） Fang-Ying Yang *USING EYE TRACKING METHOD TO EXPLORE THE SCIENCE LEARNING PROCESS IN A DIGITAL DYNAMIC AND INTERACTIVE LEARNING ENVIRONMENT*

A STUDY OF THAI EIGHTH GRADE STUDENTS SCIENTIFIC PROBLEM - SOLVING ABILITY ON THE TOPIC OF GLOBAL AND NATURAL RESOURCES

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ABSTRACT

Scientific problem-solving ability is important for students in learning science. Exploring this ability will help teachers to know how well students perform to solve the scientific problems and enable teachers to use this information for further develop their students. The purpose of this research was to study Thai eighth grade students' scientific problem-solving ability on the topic of Global and natural resources. The samples were 150 eighth grade students from a school in Samutprakarn province, Thailand, who studied in the 2nd semester, 2020 academic year using cluster random sampling. The research instrument was a multiple-choice scientific problem-solving ability test. The test composed of 5 situations and 20 questions covering 4 components of scientific problem-solving ability. The difficulty index of the test was in the range between 0.33-0.70. The discrimination power of the test was in the range between 0.27-0.80 and the reliability of the test equaled 0.73. The data were analyzed using descriptive statistics which were frequency, percentage, mean and standard deviation. The results indicated that students' scientific problem-solving ability mean score was in the moderate level ($\bar{x}$=10.16, S.D.=1.22). Considering in each component, the results revealed that students gained the highest mean score in analyzing the problem ($\bar{x}$=2.93, S.D. = 1.27) followed by identifying the problem-solving method (= 2.80, S.D. = 1.30), verifying the problem - solving method ($\bar{x}$ = 2.31, S.D.= 1.21 and identifying the problem ($\bar{x}$= 2.12, S.D. =1.10), respectively. Therefore, this group of students still need to improve in all components of scientific problem-solving ability especially the first component, identifying the problem. The scientific problem-solving ability test used in this study is a content specific test. Teachers who desire to use this test need to be concern about students' concept of Global and natural resources before using it.

Keywords: *Scientific problem-solving ability, Global and natural resources, Secondary school students*

INTRODUCTION

The problem-solving ability is one of the higher order thinking skills and 21st century skills that need to promote to students (Partnership for the 21st Century Skills, 2009: online). Presently, students need to face various problems in daily life under the rapid changing of the world situations. Therefore, problem-solving ability is necessary for students especially in science subject that studies about natural phenomena. This subject is related directly to using the reasoning, attitude, method, and the systematic processes of acquiring the knowledge (The institute for the Promotion of Teaching Science and Technology, 2017: 32). There are many research studied about students' scientific problem-solving ability but in different contexts and levels of students. Considering Thai eighth grade students, they need to study the topic of global and natural resources in science subject. The problems in this topic are suitable and related to their daily life situations. However, based on researcher experience, students could not use the knowledge for solving problems properly and reasonably. Moreover, there is no specific evidence to point about this problem. For these reasons, this research aimed to study scientific problem-solving ability on the topic of global and natural resources of Thai eighth grade students. The results from this research will be a basic information to enhance students in the future.

RESEARCH OBJECTIVE

To study scientific problem-solving ability on the topic of global and natural resources of Thai eighth grade students.

RESEARCH METHODOLOGY

This research is a survey research. The research instrument was a multiple-choice scientific problem-solving ability test composed of 5 situations and 20 questions on topic of global and natural resources covering 4 components of scientific problem-solving ability; 1) identifying the problem 2) analyzing the problem 3) identifying the problem-solving method and 4) verifying the problem solving method. The difficulty index of the test was in the range between 0.33-0.70. The discrimination power of the test was in the range between 0.27-0.80 and the reliability of the test equaled 0.73.

The samples were 150 eighth grade students from a school in Samutprakarn province, Thailand, who studied in the 2nd semester, 2020 academic year using cluster random sampling.

RESULTS

The students' scientific problem-solving ability on topic of global and natural resources can be seen in table 1.

Table 1 Students' scientific problem-solving ability levels and mean scores

The components of the scientific problem - solving ability	Numbers of students (Percentage) each level			$\bar{x}$	S.D.	Ability level
	High	Moderate	Improvement			
Identifying the problem	14 (9.1)	91 (59.5)	48 (31.4)	2.12	1.10	Moderate
Analyzing the problem	62 (40.5)	67 (43.8)	24 (15.7)	2.93	1.27	Moderate
Identifying the problem-solving method	48 (32)	80 (53.6)	25 (17.6)	2.80	1.30	Moderate
Verifying the problem-solving method	26 (17)	84 (54.9)	43 (28.1)	2.31	1.21	Moderate
Overall				**2.54**	**1.22**	**Moderate**

From table 1, the result found that students' scientific problem-solving ability in overall mean score was in the moderate level ($\bar{x}$ = 2.54, SD = 1.22). Considering in each component, the results revealed that students gained the highest mean score in analyzing the problem ($\bar{x}$=2.93, S.D. = 1.27) followed by identifying the problem-solving method ($\bar{x}$ = 2.80, S.D. = 1.30), verifying the problem-solving method ($\bar{x}$ = 2.31, S.D.= 1.21 and identifying the problem ($\bar{x}$= 2.12, S.D. =1.10), respectively.

CONCLUSION

Thai eighth grade students' scientific problem-solving ability was in the moderate level in both overall and each component.This is possibly because students learning experiences in the past were not adequate to promote this ability to the students. The traditional lecturing focuses on the scientific concepts. Students barely think by themselves in class. Therefore, the appropriate teaching and learning approaches and strategies need to be developed to enhance scientific problem-solving ability for these students.

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Exploring the cognitive learning of the causes of the moon phases in the fifth grade of elementary school

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ABSTRACT
Elementary school children often have various misconceptions or alternative concepts about the moon phases. Therefore, it is necessary to understand school children's perceptions of the moon in order to prepare for the teaching design of science activities. This study focuses on the reasons for the changes in the shape of the moon and the writing content illustrated by drawings by the fifth-grade elementary school students as data for actual evaluation. The content hopes to detect the true performance of the students' cognition of the moon, and explore the understanding of the moon shape change. In this study, a total of 103 students in the fifth grade of an elementary school in New Taipei City were selected as the subjects of the writing assessment. Experts and science teachers with expertise in the field analyzed the students' answers and found that the students' main answers can be divided into the moon itself, the moon and the sun, the moon and the earth, and the earth's running time. Through the analysis results, it is found that: (1) the students believe that the moon phase changes are caused by date or time factors, (2) the students' moon phase regular changes are combined with the lunar calendar date and cannot recognize the reasons for the formation of the moon phases, and (3) students still believe the moon obscured by objects. The research results is recommended to use specific teaching tools to simulate the parallel light of the sun, and at the same time, learn the causes of the moon shape changes through the operation of the students themselves.

Keywords: *the causes of moon phases, writing evaluation.*

Introduction

One of the learning points of the Moon unit is to understand the causes of the formation of the moon phases by observing and discussing the changes of the moon phases. This research tries to analyze the concept of the cause of the lunar phases of the research object by using the discussion mode of the relationship between the moon itself, the moon and the sun, the moon and the earth, and the earth's running time. By analyzing the writing evaluation results of the fifth grade students of elementary school on the causes of the moon phases, and comparing the concept of the cause of the moon phases of the fifth grade students in elementary schools, the purpose of the research is to explore the fifth grade students' perception of the moon. Reference for future moon phase unit teaching.

The questions to be answered are as follows:

1. What are the differences in the explanation of the causes of moon phases by fifth-grade elementary school children?
2. What is the connection between the explanation of the causes of the moon phases and the recognition of the causes of the moon phases by the fifth grade students in elementary school?
3. What are the differences in the concepts of the fifth grade students in elementary school explaining the causes of the moon phases?

Method

This research refers to the analysis models of Chiu, Mei-Hung & Chen, Ying-xian (1995) and Chen, Cui-wen ＆ Hou, Yil-ing ＆ Liu, Jia-ru (2010), and tries to analyze the cause of the lunar phases of the research objects by discussing the relationship between the moon itself, the moon and the sun, the moon and the earth, and the earth's running time. concept. Based on self-compiled writing assessments, 103 people in Class 4 of Grade 5 explained data on the causes of specific moon phases, and analyzed and categorized them. The writing assessment questions and analysis methods are set with the assistance of experts and senior teachers. In addition to using writing assessments to obtain students' conceptual situation of the causes of moon phases, this study also hopes to understand the perceptions of fifth grade students on the moon's cognition, so as to prepare for the follow-up teaching design and research in the field of nature.

Results

In the writing assessment, students' personal thoughts on the causes of the moon phases are discussed. In the process of explaining the causes of the moon phases, the statistician explores the concept and ideas of the fifth-grade elementary school children in the process of explaining the causes of the moon phases, the moon itself, the moon and the sun, the moon and the earth, and the earth's time, Sub-item statistics are shown in Table 1.

Table 1. Mode of discussion about the causes of moon phases among fifth-grade elementary school children (unit: person).

Mode / class	the moon itself	the moon and the sun	the moon and the earth	the earth's running time
501	7	4	3	11
502	3	7	1	16
503	5	5	2	13
505	5	4	2	15
Subtotal	20	20	8	55

It can be seen from Table 1 above that when explaining the causes of the moon phases, the fifth grade students think that the reason for the different moon phases is the operating time (53.40%), followed by the moon itself (19.42%) and the moon and the sun. (19.42%) Relationship discussion. Regarding the causes of the moon phases, most students put forward the regular presentation of the moon phases, and could not explain why this is the case. Some students think that it is the earth blocking the sun, or clouds blocking the moon, and the sun blocking the moon.

The results of the writing assessment of the schoolchildren can be seen in the schoolchildren's concept of the cause of the moon phase. After the fourth grade study of the moon unit, there are still many incomplete or other concepts, so how to effectively change the teaching method to help the schoolchildren change Their concept suggests that specific teaching tools can be used to simulate the parallel light of the sun, and students can use their own operations to understand the causes of the moon shape changes.

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A Case Study of Thai Teachers Implementing Gardening Education for Green Design Project on Their Understanding of Engineering Design Process

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ABSTRACT

The engineering design process is a key to develop students' problem-solving thinking skills in STEM-based education. Teachers' understanding of the engineering design process is pedagogical knowledge that enables to them to teach STEM more effectively. The research objective was to investigate the understanding of the engineering design process of the teachers who had been implementing a national-scale, royal - initiated gardening education program for sustainability which has an ultimate goal to help students get inspired from a plant of interest to create green design and product. The informants were 12 female teachers who participated in a professional development workshop on the gardening education program in Sakon Nakhon Province, Thailand. An open-ended questionnaire was used to elicit their understanding of engineering design process. Their responses were compared and grouped into predetermined framework. The findings showed that most of teachers understood engineering design process partially. By 43.48, they thought that engineering design process was a problem-solving process to solve a problem and serve need of human being. By 21.74 percent, they thought that engineering process was done to design and create a new product. Other teachers (17.39 percent) viewed that engineering design process was conducted to find the best solution to a challenging problem. It was remarkable that no teachers mentioned many essential features of engineering process including the authenticity of a problem, conditions, constraints of the problem, the iteration of a process, and teamwork and collaboration.

Keywords: *Engineering Design Process, Pedagogical Understanding, Green Design Project.*

Rationale and Significance of study

Implementing integrated - STEM teaching is Thailand's recent policy to raise the competency of Thai People for disruptive world. STEM Education in Thailand has been driven by the Institute for the Promotion of Teaching Science and Technology, a government body in charge of teaching science and technology. This policy was implemented and well received by students and teachers. Though, many teachers do not know essential features of integrated STEM, in particular, engineering design process. This study aims at examining the teachers - implementing a royal - initiated garden education program that has an ultimate goal to design an innovation for sustainability from a plant of choice - on their understanding of engineering design process. The findings would inform the design and development of a professional development program to promote the understanding of integrated - STEM teaching and engineering design process.

Literature review

Botanical Garden in School Program (BGSP) was initiated by HRH Princess Maha Chakri Sirindhorn in 1994. There are a great number of schools, colleges, and university nationwide implementing it. This program encourages students to get to know, appreciate and see the value of plants in their school through well-crafted activities so they are gradually aware the necessity to conserve plant diversity in their community. There are many modules in this program. The last module, which is the focus of this research, asks students to get inspired by a plant or its parts to create an innovation for sustainable development in their community. The program was implemented and supervised by teachers from various subjects. Integrated-STEM education and engineering design process plays a big role in the last module. The teachers need to have pedagogical knowledge of integrated-STEM and engineering design process to be

fully equipped to supervise students doing a project.
Engineering design process (EDP) is the backbone of engineering (Asunda & Hill, 2007). It features creating a new product and process to solve a challenging problem in real life situation using critical thinking and creativity. It takes into account various perspectives from stakeholders. It has conditions and constraints to consider. It is a complex, collaborative, and iterate process to develop an optimal solution. Vichaidit & Faikhamta (2017) and Ladachart et al. (2019) explored pre-service and in-service science teachers' understanding of engineering design. They found that the teachers mostly had partial understanding of EDP viewing that it is a process for design a new production and an innovation.

Method of study

This study is a survey research. We interviewed 12 female teachers participating in a workshop organized to train them to implement BGSP in their schools. They aged 25-55 years old. Eleven teachers taught at a secondary school and the other taught at a vocational college. The group taught various subjects. We explored their idea using a questionnaire. This questionnaire consists of two sections. The first section asked about their personal information and the second section asking their understanding about engineering design process. The data were analyzed using deductive approach. Each response was read thoroughly, grouped, and compared with the features of engineering design as mentioned in the literature review.

Result and Discussion

In general, the respondents had partial understanding of EDP. Forty three percent of them thought that it was a process or steps to solve a problem affecting people. Twenty-two percent of them viewed that EDP was conducted to design and create a product. Seventeen percent of them thought that EDP was the selection of methods to get the best solutions. It is noticeable that the teachers teaching STEM-related subjects emphasized on the problem-solving process. "...It always starts with a problem, identifying a problem, thinking, analyzing [problem], and choose the best way to solve it". Teachers of other subjects tended to think of EDP being an invention of a product or an innovation. Some teachers thought that EDP was the integration of different disciplines, unnecessarily to solve a problem. A computer teacher thought of novelty and the utilization of technology to search for information. It notes that teachers' educational background and subject they taught somehow influence their ideas of EDP. All participants did not mention other essential features of EDP including authenticity and challenge of the problems, conditions, constraints, iteration, and teamwork. These findings are consistent with Vichaidit & Faikhamta (2017) who found pre-service teachers had partial understanding and alternative conceptions about EDP. Partial understanding about EDP would lead to ineffective STEM activities; more focusing on the problem-solving process rather than discussing the goal, the analysis of a problem, collaboration, the use of creativity and critical thinking and the systematic and iterative process of EDP.

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USING EYE TRACKING METHOD TO EXPLORE THE SCIENCE LEARNING PROCESS IN A DIGITAL DYNAMIC AND INTERACTIVE LEARNING ENVIRONMENT

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ABSTRACT

The major purpose of this study was to explore the relationship between victual attention patterns during digital-based interactive learning on the topic of moon phase and learners' characteristics such as learning achievements, spatial reasoning ability, and other background traits. An interactive learning APP was created for the study, which demonstrated how the related movements of the sun, earth and moon (observable from the space (allocentric) frame) would result in changes in moon phases (observable from the egocentric frame). Data collection tools included an online survey for subjects' background information, the spatial ability test, and the pre- and post-test on concepts about moon phases. The eye tracking system recorded students' eye movements during the interactive learning to indicate the learning process. This research is still in progress. The study found that the interactive learning environment can effectively improve students' conceptual understanding, and eye movement patterns are correlated with learning achievements.

Keywords: *eye tracking method, digital learning, interactive learning moon phases*

INTRODUCTION

With the development of science and technology, the digital learning environment is usually designed to incorporate multimedia materials and functions such as human-computer interactions, simulation, and 3D presentations. In recent years, the interactive digital learning environments have gained more and more attention from educators for such environments have the potential to make instruction more interactive and authentic and make learning abstract concepts more concrete (Ramasundarm, Grunwald, Mangeot, Comerford, & Bliss, 2005).

However, when new technological products are transferred to teaching applications, can they effectively improve learning? How to assist learners with different learning characteristics to learn effectively in the dynamic interactive digital learning environments? These issues are waiting for more explorations. Just and Carpenter proposed the eye-mind assumption in 1980 and mentioned that in reading text messages, the eyeballs would continue to stare at the text, indicating that the brain is processing the received information at this time. The eye-mind assumption suggests that by examining learners' eye movements, we can further understand how students learn in a specific learning environment and what specific parts of the instructional design are most effective.

Thus, the major purpose of this study was to use the eye tracking method to explore the relationship between the students' visual attention during a digital interactive learning environment on the topic of moon phases, learning achievements and other cognitive characteristics such as spatial reasoning ability.

METHOD

The participants of the study were 40 college and graduate students (20-27 years old). Twenty of them came from the liberal arts majors and the other 20 from science majors. All of these participants had studied general concepts about the moon phases in high schools. An interactive learning APP was created for the study, which demonstrated how the related movements of the sun, earth and moon (observable from the space (allocentric) frame) would result in changes in moon phases (observable from the egocentric frame). Data collection tools included an online survey for subjects' background information, the spatial ability test, and the pre- and post-test on concepts about moon phases. Students' eye movements during the interactive learning were recorded by the Tobii 4C eye tracking system. For the data analysis, descriptive statistics, t-test, and Pearson correlation analysis were applied.

RESULTS

By the pair *t-test* analysis, a significant difference between posttest and pretest(pre = 7.28, post = 8.70 out of 15, t =4.02, p<0.001) indicated that students' conceptual understanding about moon phases had increased significantly after the interactive learning. There was no significant correlation found between learning gain (post-test minus pre-test mean scores) and the pre-test results (r =-0.21, p >0.05) while learning gain was significantly associated with the post-test (r=0.50, p <0.01). The findings suggested that the learning gain should have resulted from interactive learning. The t-test analysis also showed no significant differences in the learning gain between gender (male and female) and between majors (arts and science). Meanwhile, significant correlations were found between the spatial test result and pre-test (r=0.44, p<0.01), post-test(r=0.64, p<0.001) and learning gain (r=0.37, p<0.05). This result demonstrated that conceptual understanding of moon phases was related to spatial ability.

Preliminary analyses on participants' test results and eye movement measures found that the learning gain was significantly correlated with the eye movement measures of total time spent in the zone (r=0.29, p<0.1), average fixation duration (r=0.32, p<0.05), revisited fixation duration (r=0.27, p<0.1), and saccade duration (r=0.30, p<0.1) in the explanatory text AOI (area of interest). It also correlated significantly with the eye movement measures of total time spent in zone (r=0.28, p<0.1), total fixation duration (r=0.33, p<0.05), average fixation duration (r=0.40, p<0.05), proportion of fixation duration (r=0.38, p<0.05) and revisited fixation duration (r=0.31, p<0.1) in the AOI of explanatory picture. The findings revealed that visual attention to the explanatory text and pictures was critical for conceptual understanding. Although the learning achievements and eye movement measures in explanatory animation were not significantly correlated, as Table 1 shows, some significant correlations were found between eye movement measures in animation AOI and those in AOIs of text and pictures. Accordingly, it is inferred that the explanatory animation might have an indirect effect on students' learning performance.

Table 1. Correlations between eye movement measures in explanatory animations and texts and pictures

AOI	Total Time Spent	Total Fixation Duration	Average Fixation Duration	Proportion of Fixation Duration (%)	First Pass Time	Revisited fixation duration	saccade duration
Explanatory texts	0.436**	0.393*	0.363*	-0.447**	0.289(*)	0.117	0.383*
Explanatory pictures	0.376*	0.350*	0.390*	-0.300(*)	-0.226	0.182	0.542**

Note. (*)p<0.1 *p<0.05 **p<0.01

DISCUSSION

This research is still in progress. The preliminary findings indicated that the interactive learning environment can effectively improve students' conceptual understanding, and eye movement patterns are correlated with learning achievements. Further data analysis will be presented at the conference.

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Oral Session 5	Day3 (June20th) 13：00～14：30
Room2	C2-3
【Category】	2: Science Education for Elementary School and Related Areas

=Chairperson=

Dr. LI, Wai Chin	The Education University of Hong Kong

=Presentation Program=

1	97-2-3-20-1（FXY1-AWWJ-LT021） DongYoung Lee（Pusan National University） Younkyeong Nam Elementary Student's Perception Changes about Their Creativity During Engineering Design Process
2	98-2-3-20-2（FXI8-K673-SO021） LIN MEIHUI（National Taipei University of Education Department of Natural Science Education） *A Study on the Learning Effectiveness of STEM Education in the Sixth Grade of Elementary School*
3	99-2-3-20-3（FXZ0-7RON-79021） Ying-Tai Hsu（National Changhua University of Education） Silvia Wen-Yu Lee, Kun-Hung Cheng *Investigating the impact of advance organizers in an immersive virtual reality environment for science learning*
4	100-2-3-20-4（FY09-WK6R-OM021） Tetsuya YAMADA（Minatogawa College） Mao KOSAKA, Takekuni YAMAOKA *A Study of the Educational Methods for Computational Thinking in Elementary STEM Education*
5	120-2-3-20-5（FY50-GQM5-BJ021） Pattaraporn Pikunkwan（Kasetsart University） Jeerawan Ketsing *Primary School Students' Social Skills in Science Classroom: A Confirmatory Factor Analysis*

Elementary Student's Perception Changes about Their Creativity During Engineering Design Process

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2. Pusan National University, Korea

ABSTRACT

This study aimed to discuss the effect of science instruction based on engineering design on convergent problem solving ability for elementary school students, focusing on the perception of creativity. In December 2018, twelve lesson hours engineering design-based science program was implemented in an elementary science classes for 6th graders. The Elementary School was located in the P metropolitan city. A convergent problem-solving ability test collected before and after the class. Convergent problem-solving ability statistically analyzed by a paired t-test, and based on the results, post-response results were further analyzed using One way ANOVA. As a result, it was confirmed that learners' convergent problem solving ability was improved (p<.05) compared to the pre-test results. In addition, it was confirmed that creativity among the constituent factors of convergent problem-solving ability differs according to the type of group organization of learners (male single> female single> male mixed, female mixed).

Keywords: *Elementary students, One way ANOVA, Convergent Problem Solving ability, Creativity, Group organization.*

ENGINEERING DESIGNED SCIENCE CLASS AND ELEMENTARY STUDENTS

The participants of this study 131 elementary school students in B metropolitan city, Korea. The study is designed to investigate the impact of engineering-based science lesson convergence problem-solving abilities proposed as the core strategy of STEM education by Next Generation Science NGSS Lead States ,2013). A engineering based science lesson with 12 lesson-hours was implemented in 6tha convergence problem-solving ability test was conducted before and after the session. The convergence problem-solving ability test paper developed by Lee et al. (2020) was used. For analyzing the test results, Paired t test and Repeated Measured ANOVA were performed using SPSS 23.0.

1. **Engineering Design and Convergent Problem Solving Ability.**

As a result of paired t test measuring the change in convergence problem-solving ability, it was confirmed that there was a statistically significant difference in Pairs 1, 3, 4, 5, 6, and 8. Therefore, it can be said that learners showed significant changes in individual propensity, convergence attributes, problem solving and convergence thinking, creative thinking, convergence thinking areas, and total. The test results are shown in Table 1.

2. Engineering Design and Creativity Perception by Type of Group Organization.

After confirming that the subjects of the study were homogeneous groups in advance, ANOVA was performed on the factors constituting the test strip according to the variables (Group Organization-Male Only, Female Only, Male-Mix, Female-Mix) that divided the subjects (For post hoc analysis, Scheffe analysis was used). As a result of the analysis, it was confirmed that the Creative Thinking factor among the factors appeared differently depending on the variable, and it was confirmed that it was classified into three groups. The profile diagram of the test results and the group classification of the post-hoc analysis are shown in Figure 1.

Table 1. Paired *t* test result.

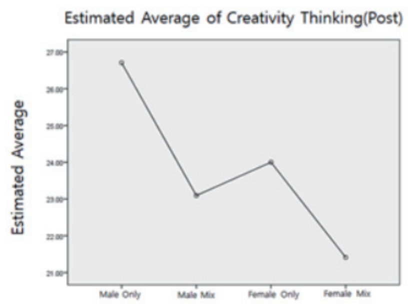
Pre−Post		Average	SD	SE	t	F	*p*
Pair 1	Individual propensity	−1.05725	2.72558	.23813	−4.440	130	.000*
Pair 2	Social propensity	−.46947	3.92269	.34273	−1.370	130	.173
Pair 3	Convergence attributes (Sum of Pair 1&2)	−1.52672	5.59838	.48913	−3.121	130	.002*
Pair 4	Problem solving and Convergent thinking	−1.22901	5.65674	.49423	−2.487	130	.014*
Pair 5	Creative thinking	−2.30534	3.98635	.34829	−6.619	130	.000*
Pair 6	Convergence thinking (Sum of Pair 4&5)	−3.53435	7.81079	.68243	−5.179	130	.000*
Pair 7	Convergence literacy	−.37405	2.61853	.22878	−1.635	130	.104
Pair 8	Total(Sum of all)	−5.43511	12.86109	1.12368	−4.837	130	.000*

Figure 1. Result of ANOVA and Post-hoc

Result of Post-hoc

Scheffe[a,b]

Group Organization	N	Group 1	Group 2	Group 3
Female Mix	34	21.4118		
Male Mix	21	23.0952	23.0952	
Female Only	35		24.0000	
Male Only	41			26.7073
Probability		.191	.708	1.000



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A Study on the Learning Effectiveness of STEM Education in the Sixth Grade of Elementary School

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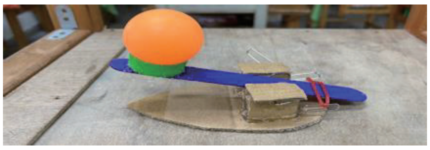
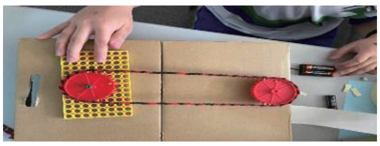
Abstracts

The purpose of this research is to explore the learning effectiveness of STEM Education for sixth grade elementary school children. Research methods include qualitative and quantitative research methods. The subjects of the study were 28 sixth-grade students from a elementary school in New Taipei City. STEM Education's teaching activity design includes (1) Knowing the lever: Through experiments and discussions, let students understand the principle of levers and the tools used in life; (2) Pulleys and axles: Let students know about pulleys and axles through experiments and discussions Tools based on the principle of leverage can also be used; and (3) Transmission of power: Through experiments and operations, it is known that fluids such as gears, chains, air, water, and oil can transmit power, And fully integrated into the teaching concepts and strategies of STEM Education. The data collection of this research includes: classroom observation data of qualitative data and learning achievement test of quantitative data. The findings of the study include: (1) School children can understand that levers, pulleys, axles and other tools can solve problems in life; (2) School children find that many machines are also used in gears, chains or flows to transmit power in life; (3) The pre-test score of the school-child achievement test is 82.3 and the post-test score is 92.9, which shows that the learning effectiveness of STEM Education for children has made significant progress; (4) The labor-saving and easy-to-operate situation of the use of lever principle tools by school children, the labor-saving and labor-saving situations of pulleys and axles; (5) Explore the use of related tools in daily life; observe the transmission of power and observe the transmission mode of gears and chains; and detect air and water Oil and other fluids can also transmit power; (6) Common brooms, bicycles, rotating chairs (haircutting chairs) and excavators, etc., are used to make hydraulic robotic arm science toys; it shows that this teaching activity does promote the ability of STEM Education for students . Therefore, this study believes that this teaching activity does indeed enhance the learning effectiveness of STEM Education in the lives of schoolchildren.

Keywords: Leverage Principle, Science Education, STEM Education





(Figure 1) Shooting device (Picture 2) Pulley drive

Pivot point(PP): When working, the position that remains stationary is shorter than the pivot point.

Resistance point(RP): when working, the place where the heavy object is hung.

Force point(FP): where the force is applied.

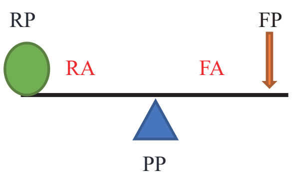
Force arm(FA): the distance from the point of force to the fulcrum.

Resistance arm(RA): the distance from the resistance point to the fulcrum.

The principle of leverage → with / according to:

- Effortless → FA=RA → Pivot in the middle → Libra
- Effortless → FA>RA Has:
  - Pivot in the middle → Nail puller
  - The pivot is not in the middle → Paper cutter
- Laborious → FA<RA:
  - Pivot in the middle → scissors
  - The pivot is not in the middle → tweezers

EX



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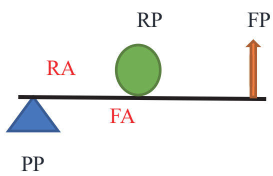

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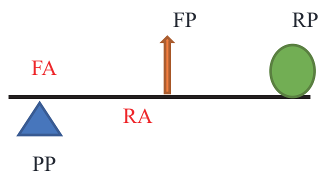

(圖五)

Figure (3): The fulcrum is located between the point of force and the weight. Scissors, pliers, and seesaw use this kind of lever.

If the force arm is long and the resistance arm is short, it is a labor-saving tool.

The opposite is laborious tools

If the force arm is equal to the resistance arm, then this tool does not save effort or effort.

Figure (4): The point of resistance is located between the fulcrum and the point of force.

Trolleys, bottle openers, and paper cutters use such levers.

This kind of lever, with a long force arm and a short resistance arm, is always labor-saving.

Therefore, heavier objects can be lifted or moved with less force.

Figure (5): The force application point is located between the fulcrum and the resistance point.

Tweezers, chopsticks, and brooms use this kind of lever.

This kind of lever, with short force arm and long resistance arm, is always laborious.

The advantage is that it saves time

Investigating the impact of immersive virtual reality environment on science learning

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ABSTRACT

This study aims to understand the role of advance organizers in students' learning of science in immersive virtual reality (IVR). This study compared the scientific learning outcomes, as well as the affective factors, including presence, positive emotional engagement, and negative emotional engagement, between the concept map (CM) group and the non-concept map (NCM) group. Data collection included survey questionnaires and a test assessing scientific knowledge of plant concepts. The results show that the CM group had significantly higher scores in scientific concepts based on ANCOVA. The NCM group also had stronger negative emotional engagement of the IVR than the CM group. We conclude that when providing a concept map to the students prior to the use of IVR, the concept map can help students reduce negative emotions and can result in better learning outcomes than that of the students who did not receive the concept map. Implications for future research and instructional design are proposed in the study.

Keywords:
Immersive virtual reality, affective factors, scientific learning outcomes.

Introduction

Immersive virtual reality (IVR) with proper instructional design can enhance, guide, and stimulate students' interest in learning of subject matters including science. Nevertheless, some researchers (Makransky et al., 2019) have argued that IVR learning environments only have a significant influence on learning perception but not on learning performance. Past studies had suggested that pre-training could enhance students' learning effectiveness in immersive virtual reality (IVR) environments (Meyer et al., 2019). However, few studies have examined the effects of concept map, an approach of pre-training. This study aims to understand the role of using concept maps in students' learning of science in IVR. In this study, we posed the following research question: 1) To what extent have students from the two groups developed different scientific concepts of plans after using the VR application? 2) To what extent have students from the two groups had different affection towards using the VR application?

Methods

In this study, we used an IVR system developed for learning plants at elementary level (Cheng et al., 2019). Learners can freely explore the two virtual scenes in the system to learn the appearance, propagation, and reproduction of plants. The students in the concept map (CM) group received a concept map previewing the concepts in the IVR, while the students in the NCM group did not receive the concept map. Data collection included survey questionnaires that were used to measure students' affective factors in VR environments. Pre- and post-test were also developed to measure their understanding of scientific concepts related to plants. T-test and ANCOVA analyses were used to compared different variables and outcomes between the control and experimental groups in this study. Affective factors include presence, positive emotional engagement, and negative emotional engagement.

Participants of this study were from an elementary school in central Taiwan. Seventy-four sixth-grade students were randomly assigned into the concept map group (CM; experimental group) and the non-concept map group (NCM; control group).

Results

The results show that the CM group had significantly higher scores in scientific concepts based on ANCOVA. The t-test analyses also showed that the students who did not receive the concept map (ie., NCM group) had developed stronger negative emotions in IVR than the students in the CM group. The results show no significant differences in the perceived sense of presence and in positive emotional engagement between the two groups. Implications for future research and instructional design are proposed in the study.

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A Study of the Educational Methods for Computational Thinking in Elementary STEM Education

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ABSTRACT

In Japan, programming education has begun to be implemented from elementary school. STEM education and STEAM education need to be based on scientific logical thinking. However, programming education in elementary school tends to fall into education for computers. We conducted lessons in elementary school smoothly, practiced lessons that combined unplugged lessons and watching movies so that the significance of learning could be felt effectively, and evaluated the results. The use of subroutines was common in the upper grades when they didn't watch movies. It was found that the link between the movies moving in XY coordinates and the teaching material moving in XY coordinates may raise children's awareness, and there is no difference in grades. Ishizuka et al (2013) make clear that computer science unplugged is easy to accept in Japanese elementary schools because it aims at learning without using a computer. Nagayasu et al (2020) have practiced a combination of unplugged and social awareness in relation to early childhood education.

Keywords: *STEM education, Computation Thinking, Programming Education, Elementary School*

Introduction

The curriculum of Japanese elementary schools seems to need "learning activities to acquire the logical thinking ability necessary for children to do intended processing while experiencing programming". In fact, programming education in primary education is positioned. In addition, it is desired to foster an attitude of actively participating in the information society and contributing to its development by appropriately and effectively utilizing information and information technology. Programming education is indispensable for science education, STEM education, and STEAM education in Japan.

Purpose

In this study, we decided to consider an educational methods to develop the educational content by using unplugged teaching materials that are familiar from the lower grades of elementary school. Furthermore, the purpose is to consider the educational method at the stage of introducing scientific programming education and to show the cross-curricular development by grade.

Research Method

In July and November 2019, we confirmed the educational effect of 14 and 16 elementary school students from 4th grade to 6th grade in S city, Japan, using Cubetto of Primo Toys. In the first survey group, seeing after the robot tractor movies related to the utilization in the real world, the contents conscious of the development to the automatic driving bus, drone, etc. and the contents conscious of the development to the numerical control machine tool, etc. was incorporated. In the next survey group, we did not handle movies related to social utilization, but explained each process. Behavioral observations were made during practice. After the implementation, the descriptive words were analyzed by taking free descriptive impressions.

Results and Discussion

Figure 1 shows a class using cuvettes. Figure 2 shows a photo of a movies of a robot tractor.After class, as shown in Fig. 3, the total number of times to use the subroutine was frequently done in the upper grades who did not watch the movie. Descriptive words were analyzed by taking a free descriptive impression. As shown in Fig. 4, words related to society were recognized regardless of grade.As a result of analyzing each behavior observation and free description, when using a movies, there are cases where even applications other than the movies are noticed. It was found that the link between the movies that moves in XY coordinates and the teaching material that moves in XY coordinates may raise children's awareness, and that there was no difference between grades.

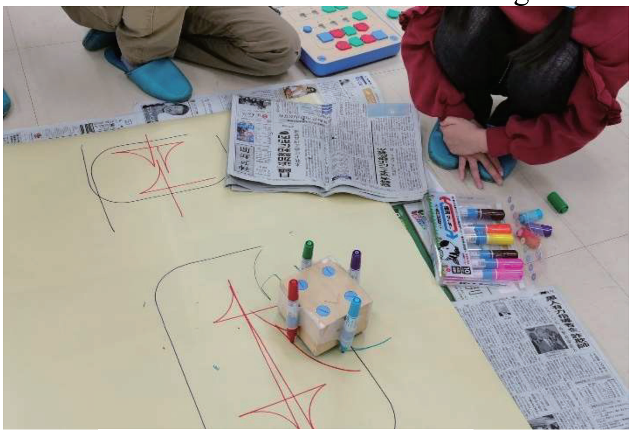

Figure.1 Practice of Cubetto

Figure.2 Movie about Robot Tractor

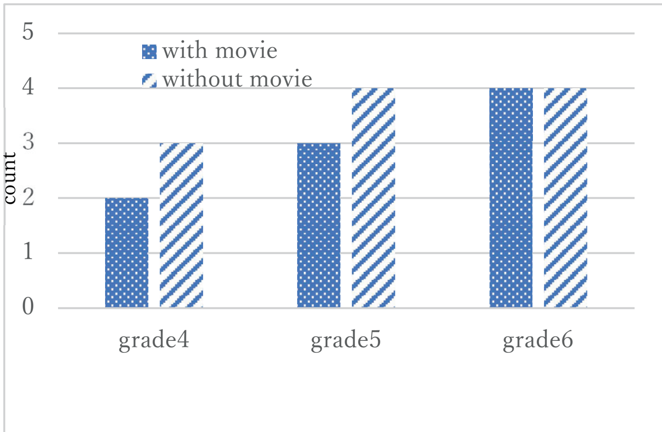

Figure.3 Pass Count of Subroutine

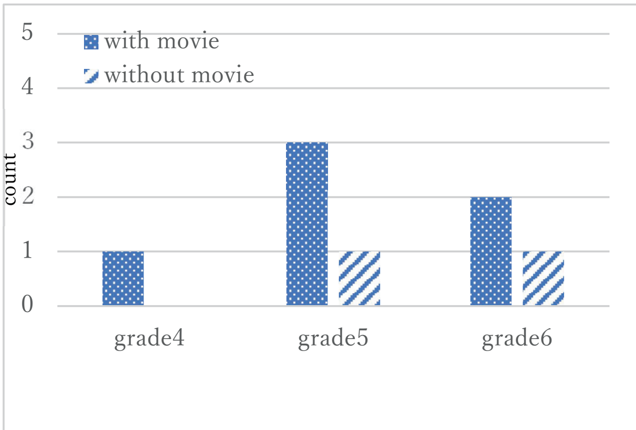

Figure.4 Words Count /Related to Society

When the students were asked to perform activities focusing on processing without using movies, many descriptions of thinking were observed. However, although they were also motivated to do the activity, they did not notice the connection with society. These differences in thinking about the processing of subroutines by grade level were observed by behavioral observation.

In the future, it was suggested that scientific programming will lead to concrete teaching methods that connect with society through practice based on the characteristics of teaching materials. We also found the possibility that new awareness of children will be born from cross-curricular tasks.

Acknowledgement

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Primary School Students' Social Skills in Science Classroom: A Confirmatory Factor Analysis

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ABSTRACT

Social skills are basic element for human development. It supports a person's success in education, career and well-being. This study explored primary school students' social skills in science classroom context. Data were obtained from 139 primary school students an old capital city of Thailand, 200 kilometers away from Bangkok. A questionnaire used for eliciting students' social skills consists of 28 items in Likert's scale format. It involves 7 components of social skills, including: 1) communication 2) cooperation 3) empathy 4) assertion 5) self-control 6) responsibility and 7) engagement. The reliability is .94. A confirmatory factor analysis (CFA) was employed via R program to verify the constructed model of social skills derived from literature. Findings proves that the constructed model of social skills is acceptable at chi-squared = 0.459, CFI = 1.00, TLI = 1.00 and RMSEA = 0.00, factor loading of all components ranges 0.61 to 0.73, and the construct reliability is 0.86. In short, the model can explain the primary school students' social skills at moderate level. This information can be used as a baseline to design learning activities and classroom atmosphere to support social skill improvement in science classroom.

Keywords: *Confirmatory factor analysis, Science classroom, Social skills, Primary school students*

Introduction

Social skills have long been recognized in the literature as a significant source for human development and success in career. Research indicates that people with good social skills are well proficient to develop their potential in the workplace than those who have solely cognitive ability. In the field of education, educators know that primary school students are at a significant age for social skill development. At this age, within school context, children are provided with rich opportunities to learn how to interact with peers and teachers in various situations. They learn to be a part of the school/classroom community by internalizing themselves to fit with the school social norm. As such, primary school functions to cultivate children's development of social skills and prepare them to be qualified workers. However, in term of social skills not everyone attained it through educational context. Sometimes, the interaction with peers and/or teachers can be problematic for the children. Ample studies presented evidence that children with social skill deficits often encounter difficulties in the educational system. For instance, they show low academic achievement, dropout of school, mental illness that could potentially lead to suicide. Developing the students' social skills can be a challenging task for science teachers, particularly in a setting by which academic achievements and test scores concludes the major learning outcomes. Therefore, this study aimed to explore primary school students' social skills in the science classroom.

Method

In the current study, social skills refer to an effective interaction by which a child has with others. A child with social ability can collaborate and assert respectfully with other people based on social norms (Gresham & Elliot, 1990). In this survey research, data were obtained from 139 primary school students age 10-12 years in an old capital city of Thailand – 200 kilometers away from Bangkok. We assessed the children' social skills through a self-assessment questionnaire adapted from SSIS – RS (Gresham & Elliot, 2008). The instrument included 28 items in Likert's scale format. The questionnaire consists of 7 components of social skills: 1) communication 2) cooperation 3) empathy 4) assertion 5) self-control 6) responsibility and 7) engagement. The instrument was validated by five experts in the field of science education, and educational psychology. The Cronbach's α coefficients of the instrument is .94. The confirmatory factor analysis (CFA) was used via R program to validate if our constructed model of social skills derived from literature is suitable with the empirical data from the students.

Result and discussion

Results from the CFA show the congruence between the empirical data and the constructed model. The model's acceptable range is chi-squared = 0.459, CFI = 1.00, TLI = 1.00 and RMSEA = 0.00 (table 1), factor loading of all components ranges 0.61 to 0.73, the standard weight ranges 0.613 to 0.765 at the .05 statistic significant (fig. 1). The construct reliability is 0.86. In summary, the statistical analysis proves that the constructed model of social skills can explain the primary school students' social skills. In addition, we found that the social skills are obtained a medium level at the .05 statistic significant. These findings reveal that the primary school students have the highest social skills in the component of empathy. However, their social skills are limited in terms of communication, self-control and responsibility (table 2). Previous study shows that their model poorly fits with the empirical data of CFI = 0.83, TLI = 0.83 and RMSEA = 0.08 (Wu et al., 2018). While our social skills model slightly strong fits with the empirical data. In addition, factor loading of all components show moderate to high correlation between each component and observation variable (0.61 to 0.73), these reveal that the social skills model should be consisted of 7 components: 1) communication 2) cooperation 3) empathy 4) assertion 5) self-control 6) responsibility and 7) engagement.

Scan QR code to see the result (table 1, table 2 and fig. 1)

Conclusion

In conclusion, this study shows that our constructed model of social skills fits with the empirical data obtained from students. The model able to explain the primary school students' social skills that all components of model affected the primary school students' social skills. The constructed model can be used for creating learning experiences in science classroom that emphasize holistic development of a child.

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Oral Session 5	Day3 (June20th) 13：00～14：30
Room3	C3-11
【Category】	3: Science Education for Middle or Secondary School and Related Areas

=Chairperson=

Dr. Nurul Fitriyah Sulaiman	Universitas Mulawarman

=Presentation Program=

1	101-3-11-20-1（FY5M-W0IR-TO021） Ka Lok Cheng（The University of Hong Kong） *Taming nanotechnology into curriculum content: Textbook analysis through the lens of dark pedagogy*
2	102-3-11-20-2（FY5L-K4G3-VN021） Sunisa Numdee（Srinakharinwirot University） Theerapong Sangpradit *EXPLORING 7th GRADE STUDENTS'　SCIENTIFIC ARGUMENTATION SKILLS*
3	103-3-11-20-3（FY60-EEQQ-6L021） Xie Xiaoyu（Beijing Normal University） Luo Ying *USING PBL IN CHINESE PHYSICS CLASS: A NEW INSTRUCTIONAL MODE*
4	104-3-11-20-4（FY60-M6O6-08021） Gao Ling（Capital Normal University） Qi Yan, Zhang Yingzhi *Analysis of the Image of Scientists Portrayed in Chinese Science Textbooks*

TAMING NANOTECHNOLOGY INTO CURRICULUM CONTENT: TEXTBOOK ANALYSIS THROUGH THE LENS OF DARK PEDAGOGY

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The University of Hong Kong, Hong Kong S.A.R.

ABSTRACT

The current study is an attempt to explore how the perspectives of "dark pedagogy" and, more broadly, "New Materialism" could be deployed in the interpretation of socioscientific issues-related curriculums. The concept of "hyperobject" was particularly deployed to understand how well curriculum materials could support the challenge of anthropocentrism brought about by the presumed divide between culture and nature. The nanotechnology-related sections in three senior secondary Physics textbooks commonly used in Hong Kong have been included in the current analysis. Through considering how well the characteristics of "hyperobjects" are being included in the textbooks, it is asserted that the impossibility to grasp the totality of nanotechnology has not been given due attention. The ignorance of the withdrawal of nanotechnology was suggested as contributing to the sustaining of anthropocentrism in the discussion of socioscientific issues. To combat the manipulative mindset resulted, a reframing of the curriculum through a dark pedagogy lens that foregrounds the emergence of agency and the feeling of surprise is being suggested. It is further recommended that the New Materialist perspective be more broadly deployed in the science education research community.

Keywords: *Dark Pedagogy, Hyperobject, Textbooks*

BACKGROUND

Lysgaard, Bengtsson, and Laugesen (2019)'s "dark pedagogy" presents itself as a New Materialist perspective that calls for a rethinking that promises fundamental transformations in all critical aspects of human society amid the Anthropocene. The reconsideration involves challenging the privileging position of humans, reconnecting to the non-human "things", and awakening the state of wonder.

Their perspective was suggested as a possible means to handle education content (of, for example, Environmental and Sustainable Education) about which we can be knowledged in part, while a total understanding of such content appears to be impossible (Lysgaard and Benntsson, 2020). With such recommendation in mind, the current small-scale study serves as a "proof of concept" of deploying the New Materialist perspective in analyzing the socioscientific issue (SSI)-themed curriculum materials. The concept of "hyperobject" was particularly deployed in the analysis.

Nanotechnology should be understood as a hyperobject. Morton (2013) suggested five characteristics of hyperobjects: viscosity, nonlocality, temporal undulation, phasing, and interobjectivity. Since nanotechnology entangles with us despite the possible effort to escape, presents itself as human-created things despite irreducible into isolated "things", stays in the ecosystem for a long time from now despite the short history of technological use, withdraws from our sense despite best observational efforts, and forms networks with humans that result in emergent agency despite the sum of the individual agency, nanotechnology should be considered as a hyperobject that our finite cognition can never grasp in full.

PROBLEM, METHOD & FINDINGS

Such consideration of nanotechnology implies an assumption that any attempts to tame the inapprehensible nanotechnology into textbook content could never be entirely successful, and any textbook discussions should admit the finitude induced by the impossibility of a total grasp. The current analysis intends to examine whether such impossibility has been probably indicated. Such indication is essential for avoiding the neglect of the "darkness" of the issue that gives rise to a false sense of security.

To illustrate how dark pedagogy could inspire the analysis of socioscientific issue (SSI)-related content in the curriculum artifacts, the list of characteristics of hyperobjects was deployed to consider nanotechnology-related content in the three selected Physics textbooks (indicated with asterisks in the references section) published after the minor curriculum change in 2014. The chosen section is a marginalized topic under the elective topic of "Atomic World" in the Physics curriculums for senior secondary students in Hong Kong.

The examined textbooks deliver certain messages on the viscosity and nonlocality, with limited implied notes on the phasing and interobjectivity of nanotechnology. Through the statement of the accumulative effects of nanoparticles on human health and their dispersal in the ecosystem, students were told that nanotechnology stays in the biological systems with no easy way of removal, and the presence and effect of nanoparticles are widespread and challenging to be identified in an isolated manner. The insufficiency of current understandings of the effect of nanoparticles, including the possible ones that emerged from unforeseeable interactions, serves as an implicit message on the possible withdrawal of nanotechnology and the emergence of properties due to the nanotechnology-involved assemblages. However, there is virtually no message on the temporal undulation of nanotechnology, despite that their viscosity implies the long-term stay of the nanoparticles at both organismic and ecological levels.

The textbook analysis demonstrates that the attempt at complexity reduction results in the lack of attention to the assemblages formed due to the research on nanotechnology and the use of its product in the textbooks, which leads to the fragmented perspective of the human-technology relationship. Besides, the limited attention on the emergence of agential properties, together with the lack of awareness towards temporal dispersity, has led to a false sense of security resulting from the overconfidence of the human agency. The analysis demonstrates that the insufficiently satisfying coverage of SSI in the curriculum materials is not solely a matter of comprehensiveness but perspective.

IMPLICATIONS

The deployment of the perspective of dark pedagogy entails the need for curricular changes. The curriculum artifacts should present SSI through a balanced view of the agency and finitude of humans. The emergent outcomes resulted from complex interactions should be given more highlights to combat the manipulative mindsets. The feeling of surprise and fear should be there together with the virtues of prudence and courage, which permit an engaging discussion of the SSI without being "information dump" that leads to Morton (2019)'s "trauma dreams".

Besides, this paper also demonstrates how the science education research community could deploy the ideas of dark pedagogy outside environmental and sustainability education. It is hoped that the current study could trigger further dialogues on the potentials of New Materialists' ideas and concepts in the analysis of curriculum artifacts and processes.

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EXPLORING 7th GRADE STUDENTS' SCIENTIFIC ARGUMENTATION SKILLS

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ABSTRACT

Scientific argumentation skills play an important part in a science classroom because it helps students to express their opinions, make decisions and solve problems in daily life. The purpose of this study was to explore argumentation skills of 7th grade students. The sample of this study was 175 seventh-grade students in the second semester of the academic year 2020, using a stratified random sampling method from big size schools under the Secondary Educational Service Area Office Pathum Thani. The research instrument was scientific argumentation skills test. The test was an open-ended question with two scenarios. In each scenario, there were four questions according to the 4 components of scientific argumentation which were claim and warrant, evidence, counter argument and supportive argument. The data were analyzed using frequency, percentage, standard deviation and content analysis.

The results were as follows: The mean score of scientific argumentation skills was 5.29 (S.D.=3.30), the most students (57.14%) had scientific argumentation skills at a low level. In each components of the scientific argumentation skills, the mean score of claims and warrants was 2.63 (S.D. =1.13), the most students (46.29%) had claims and warrant at a high level, the mean score of evidence was 0.77 (S.D.=1.06), the most students (67.71%) had evidence at a low level, the mean score of counter argument was 0.85 (S.D.=1.05), the most students (65.43%) had counter argument at a low level. the mean score of supportive argument was 1.04 (S.D.=1.29), the most students (61.14%) had supportive argument at a low level. The results revealed that the students lacked of skills to find the evidence to support a credible reason, counterargument and supportive argument.

Keywords: *Scientific argumentation skills, 7th grade students, The 21st-century skills*

INTRODUCTION

Argumentation has gained considerable attention and research in scientific studies. This is to encourage learners to develop science argument skills to be science literate and promote higher thinking. Scientific argumentation is the ability to make reasonable explanations to support hypotheses. There is evidence to support their own claims and ability to predict the answer or the reason for disagreement, and can reduce the disagreement to agree with themselves and to modify an incorrect idea. It does not make sense to a rational idea by interpreting the available information and based on credible evidence supporting that idea and leading to the creation of rational knowledge through expressions. Together, Lin and Mintzes (2010) presented four elements of the scientific argument: 1. Claim and Warrant, representing their opinions on the issue under consideration. 2. A counter argument is a counter argument made up of a different explanation (counterclaim) and credible reasons to support a different claim 3. Supportive arguments are reasons in favor of an argument to be more credible. 4. Evidence can be used to support any element in an argument, taking into account the appropriateness of evidence as well. Therefore, the researcher is interested in studying such scientific argumentation skills.

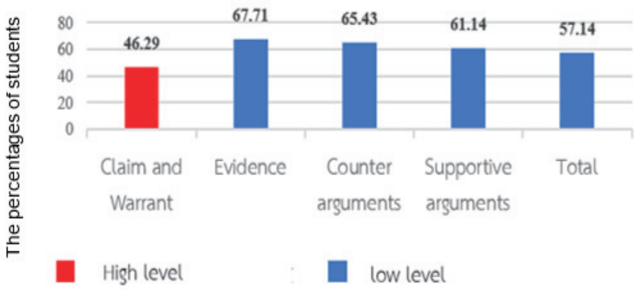
RESEARCH METHODOLOGY

This survey research was study the level of scientific argument skills of 7^{th} grade students where the researcher collected the data by asking the sample students to measure the scientific argument skills and analyze the study results from the competency measure. Individual They were graded according to the quality level of the scientific arguments are divided into 3 levels: low (0 points), moderate (1 point) and high (2 points). The scores obtained are analyzed by basic statistics to analyze students' scientific argumentation ability. The concept of Lin and Mintzes (2010) was adapted.

RESULTS

The results of the Scientific argumentative measures classify the competence of students' scientific arguments and then present the data by percentage based on four components of the scientific argument: claim and warrant, evidence, counter argument and supportive argument. Including the overall presentation of every element, the results of the analysis appear in the figure 1, showing the level of competence in each element of the scientific argument of 7^{th} grade students.

Figure 1 Scientific argumentation abilities of the students



CONCLUSION

The students' scientific argumentation ability was used to measure the scientific argumentation skills in situations of social issues related to science. It can be concluded that the students' scientific argument skills for all elements are low. Although there are some learners that can build advanced scientific counter-skills. But the quality of the arguments for these learners was found to be low. It showed that the learner was well informed and justified in supporting the claim. And their own feelings of explaining information or evidence to support the claim that the information or evidence is less reliable. The value learners give to others' perspectives can be less according to their own ideas. This shows that learners have a difficult time choosing to use information or evidence to support them. Therefore, in managing scientific learning, more students should be taught to develop scientific argumentation skills.

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USING PBL IN CHINESE PHYSICS CLASS: A NEW INSTRUCTIONAL MODE

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ABSTRACT

PBL can effectively promote the development of students' scientific literacy, which has become the consensus in education in the world today. The new round of basic education reform in China aims at students' core literacy. Scientific literacy is an important part of core literacy. Therefore, the landing of project-based learning in middle school physics classroom is an effective way to implement the development of students' core literacy. Under the educational background of China, this research puts forward a new teaching mode of "project-based instruction", which includes four elements: project carrier, project support, project achievement and problem-driven cooperative inquiry learning. Its instruction procedure consists of three stages. According to this teaching mode, this study designed the project learning course about matter and energy, conducted teaching experiments(N=546), and applied Classical Test Theory and classroom observation to verify the effectiveness of this teaching mode., during which three teachers finish 384 classes in total. After teaching, the test is carried out from concept understanding (Cronbach's α=0.73). The result of concept shows that the correct rate of students exceeds 80%. By observing students' performance in class, it is found that students can demonstrate based on evidence and express their scientific views smoothly.

Keywords: *Project-based Learning; Middle School Physics Instruction; Instructional Mode*

PBL can effectively promote the development of core literacy, which has become the consensus in education in the world today. The latest research on science education also fully proves that PBL has a significant positive impact on students' scientific concept construction and academic achievement (Chen, C. H, & Yang, Y. C. 2019), especially on scientific problem-solving (Chen, S. Y et al.,2019) and motivation (Shishigu, A. A.,2016), which are undoubtedly important components of core literacy. In recent years, PBL in China still stays at the stage where a few teachers try individual teaching contents, and it is difficult to fully integrate into the regular physics classroom in middle schools. This is because the contents involved in PBL far exceed the scope and requirements of physics courses in middle schools. Therefore, this research makes an in-depth study on how to effectively integrate project-based learning into daily physics teaching in middle schools, creatively constructs a new mode of middle school physics instruction based on project, and applies it to junior high school physics teaching practice to explore new ways promoting the development of middle school students' core literacy of physics.

1.Instruction program based on project

(a) the project splitting stage

The project splitting stage includes two links: project interpretation and project splitting. At the beginning of teaching, teachers should first guide and help students understand the project, interpret the project, and seek concrete methods to achieve the project goals with students.

Project interpretation includes clarifying the tasks required by the project, and defining the symbol of project completion, that is, the specific form of project results. -First, on the basis of project interpretation, analyze and determine the key steps needed to complete the project, and then divide the project into several specific tasks. Then, the tasks are decomposed one by one into specific problems that are suitable for students' foundation and accord with students' cognition and ability level, so that students can solve these problems through group cooperative inquiry learning and meet the requirements of teaching objectives.

(b) the problem-solving stage

Project splitting transforms the completion of project objectives into the solution of a series of problems. These problems constitute the driving problem of project-based teaching, which lays a foundation for teaching in the stage of problem solving. Because physics content in middle school can be divided into three categories: physical concepts, physical laws and their practical application, according to the core physical content needed to solve problems, the driving problems can be divided into three categories: understanding physical concepts, exploring physical laws and applying physical knowledge practice, The teaching classes implemented to solve these three types of problems are called concept learning classes, experimental inquiry classes and practical application classes.

The problem solving stage can be summarized as the following four links: First, before class, the group cooperates and learns to acquire debris knowledge, accumulates factual experience, and initially establishes the mapping between physical phenomena and physical concepts, laws or methods through group discussion; The second is to communicate with students in class, study physics concepts and laws in depth, and apply them in practice; Third, teachers and students communicate in class, and teachers promote, so that students can acquire correct physical knowledge; Fourth, after class, students expand and apply what they have learned, solve problems and form process project results.

(c) the achievement display stage

Achievement display is the typical feature of PBL. This stage includes two links: display exchange and project evaluation, which not only promote knowledge integration and build knowledge system, but also further develop students' core literacy of physics. At this stage, students review the project implementation process in a group cooperation way after class, summarize the learning process of project splitting and problem-solving stage, analyze the relationship between physical knowledge, build their own physical knowledge system, sort out a series of achievements generated in the project process, and summarize them into a general report of project achievements. In class, the results of the project are displayed in groups, and teachers and other students participate in discussion and exchange and evaluate the project.

2.Instruction achievement

Taking the design of future energy-saving houses as the background, the teaching practice based on project teaching was carried out in a junior high school in Beijing. The teaching practice is aimed at the energy and material theme of junior high school physics, including four projects, covering 546 students in 12 experimental classes, generating 384 classes, and making video tracking observation on some of them. The following results were found:

(a) Academic achievement

The test consists of 36 items (Cronbach's α=0.73), which indicates that the test is credible, the specific results are shown in Table 1. For the physics concepts and the laws, students not only understand in place, also can well grasp and the application and the mastery.

Table 1. Test results of experimental class.

class	N	Average scoring rate	class	N	Average scoring rate	class	N	Average scoring rate	class	N	Average scoring rate
1	46	85.45%	4	42	83.00%	7	43	81.43%	10	48	90.55%
2	48	91.86%	5	46	83.96%	8	47	90.13%	11	47	82.68%
3	44	88.09%	6	47	90.91%	9	41	83.33%	12	47	94.41%

(b) Demonstrate communication skills

Through project-based teaching, students have changed the way of answering questions only by right and wrong. They can collect data by means of news, internet and so on, and use it as evidence to demonstrate their own ideas. For example, a group showed the process of completing the project from the aspects of design concept, material selection, material function, communication and harvest, etc, Through the hand-painted plan of the future energy-saving room, the group's material selection scheme was clearly described in detail, and the materials and reasons for the selection were systematically explained with illustrations.

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Analysis of the Image of Scientists Portrayed in Chinese Science Textbooks

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ABSTRACT
Our research presents an analysis of how scientists are portrayed in the Chinese science textbooks. We have two major purposes in this research. The first purpose is to modify the analytical framework of scientists' images to make it more suitable for Chinese science textbooks. The second purpose is to use it to analyze the image of scientists in Chinese science textbooks. In our research, the modified analytical framework includes three aspects: individual characteristics, work-related characteristics and moral values of scientists. Combined with the method of text analysis, three versions of Chinese science textbooks in junior middle school were analyzed. Our result showed that there are a number of stereotypical images in the science textbooks. Most scientists are male from the West with rational and objective personal traits. As for the work-related characteristics, they are portrayed as conducting experiments in their labs by following scientific methods and dealing with direct evidence. They are also mostly portrayed as engaged in an enterprise that is objective, which aims for discovering the truth out there. In terms of moral values, Chinese science textbooks are inadequate in this part but emphasize the sense of social responsibility.

Keywords: *analytical framework; the image of Scientist; Chinese Science textbook; stereotype*

INTRODUCTION

The image of scientists in textbooks has an important influence on the formation of students' attitude towards science and their aspiration of science career (She, 1998). Since 1957 (Mead & Metraux, 1957), many scientists found that students had stereotyped images of scientists. In China, there is little analytical framework for the stereotype of scientists in Chinese science textbooks at present. Therefore, our research questions are: (1) Which items are included in the framework of analyzing the images of scientists in Chinese science textbooks? (2) What image of the scientist is portrayed in the Chinese science textbooks?

Method

We used text analysis in this research. According to the adapted framework (Table 1), we randomly select 9 Chinese science books in 4 versions as research objects and make a statistical analysis on the images of scientists(Table 2). The materials of the images of scientists involved in the textbook are evaluated. The evaluation can be divided into three dimensions: stereotypes; reverse stereotypes; Neutral.

Table1. Analytical framework based on evidence-based stereotypes of scientists

individual characteristics	work-related characteristics	moral values
Bald; Wears eyeglasses; Disheveled; Wears white lab coat; Middle-aged or elderly; Male; White; Westerner; Has innate interest in science ; Crazy; Lonely; Objective; nerd ;Unemotional; Competitive;	Works within Eurocentric paradigms; External factors do not influence his work; Works alone; Works only in the lab; Follows the scientific method; Does work which involves dealing with direct evidence; Aims for discovering the truth that is out there; Produces end-results that are durable and fixed over time; Engages in an enterprise which is objective; Engages in dull, non-creative, non-imaginative work; Experiment is long; Great	Patriotism; Peaceful; Self-giving; Responsible

Table 2 Textbook basic information statistics

Items	Version	Subjects	Grade
1	People's Education Press	biology	The first semester of the seventh grade
2	People's Education Press	biology	The second semester of the eighth grade
3	People's Education Press	chemical	The first semester of the ninth grade
4	People's Education Press	chemical	The second semester of the ninth grade
5	People's Education Press	physics	The first semester of the eighth grade

6	Shanghai Science and Technology Press, Guangdong Education Press	physics	The first semester of the ninth grade
7	Beijing Normal University Press	biology	The second semester of the seventh grade
8	Beijing Normal University Press	physics	The first semester of the eighth grade
9	Beijing Press	chemical	The first semester of the ninth grade
Total	4	3	5

Results and Conclusion

This research framework summarized the image of scientists into three aspects: individual characteristics, work-related characteristics (Yacoubian & Al-Khatib, 2017) and moral values. The presence of a particular stereotype in a relatively high frequency (arbitrarily more than 20% of the cases) and without being significantly counter-balanced by its corresponding non-stereotype was sufficient for us to conclude that the textbooks collectively portrayed a particular stereotypical image of scientists. This study found that there are some stereotypes of scientists in Chinese science textbooks (Figure 1). Scientists are mainly white, middle-aged men from Western countries. They are rational and objective, follow the scientific method aimed at discovering the truth of the outside world, and become great people. In addition, Chinese textbooks mention the moral values of some scientists, especially their sense of social responsibility.

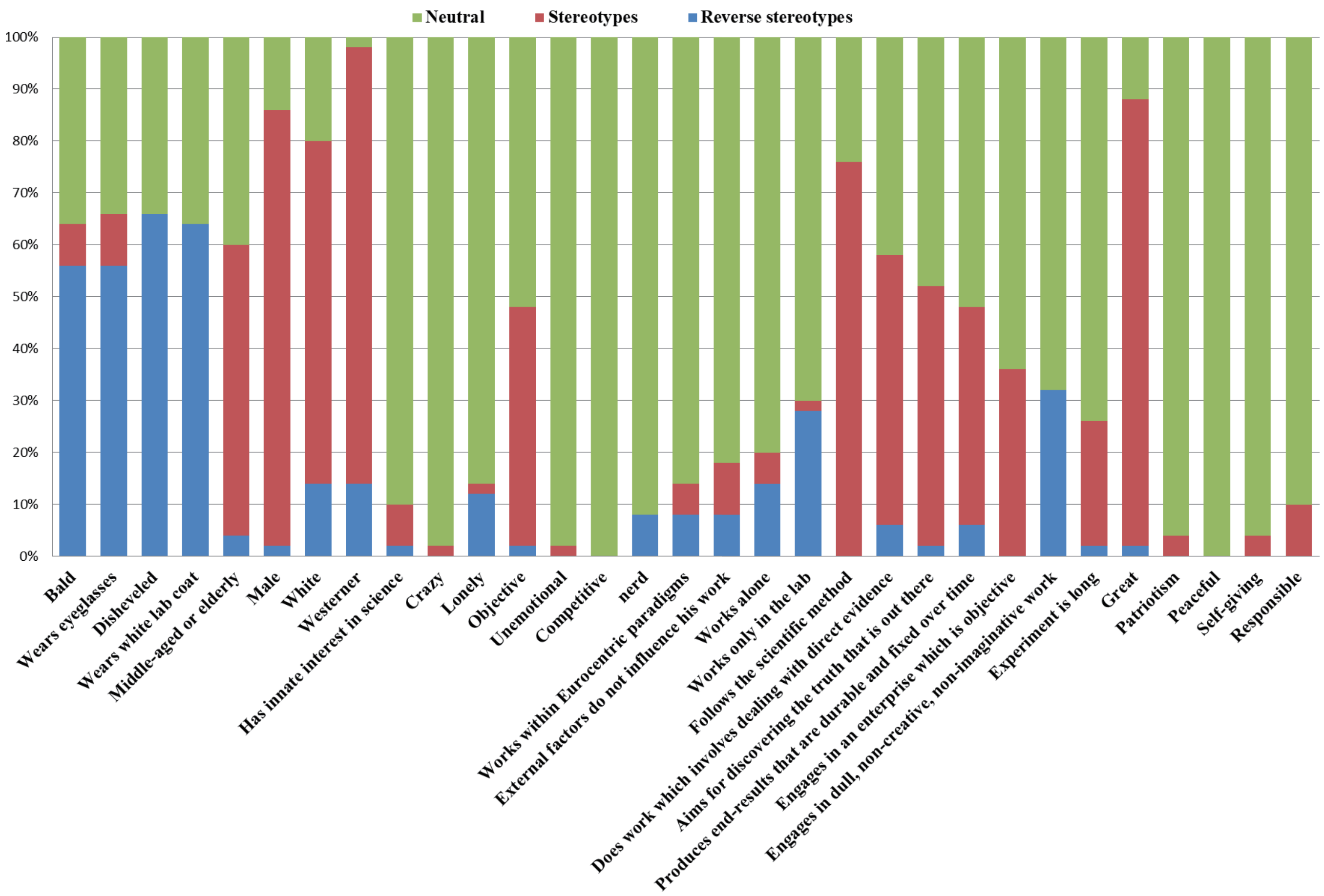

Figure1. Proportion of references showing stereotype, reserve stereotype and neutral.

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Oral Session 5	Day3 (June20th) 13：00～14：30
Room4	C4-6

【Category】 4: Science Education for High School and Related Areas

=Chairperson=

Prof. Zhang, Ying-Zhi	Capital Normal University

=Presentation Program=

1	105-4-6-20-1（FX8R-R53I-L9021） Stephen Okonkwo（Faculty of Education, Chiba University） Jun Nomura *CONDITION OF SCIENCE EDUCATION IN NIGERIA: A COMPARATIVE ANALYSIS OF PUBLIC AND PRIVATE SCHOOL IN ABUJA, NIGERIA: SECOND REPORT*
2	106-4-6-20-2（FY4O-M26D-13021） Naphat Suknarusaithagul（Kasetsart University） Chatree Faikhamta *Learning progression of grade 12 students' representational competence in electrochemistry during model-based learning*
3	107-4-6-20-3（FXIW-YKRW-KQ021） Ying-Ju Chen（The National Kaohsiung Normal University） Tai-Cheng Tso, Chia-Ju Liu *An Exploration of Senior Students’ Mental States When Learning About Quadratic Function*
4	108-4-6-20-4（FY62-LVKJ-E0021） Mengyun Xie（Beijing Normal University） Ying Luo *Analyze The Students’ Experimental Text of Chinese Mainstream High School Physics Textbooks From The Perspective of Scientific Inquiry*

CONDITION OF SCIENCE EDUCATION IN NIGERIA: A COMPARATIVE ANALYSIS OF PUBLIC AND PRIVATE SCHOOLS IN ABUJA, NIGERIA: SECOND REPORT

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ABSTRACT

This study aims to comparatively analyze the condition of science education in private and public schools in Abuja metropolis, Nigeria. A descriptive research survey design was adopted, and data was collected through a well-structured questionnaire and by direct observation. Effective teaching and learning of science are dependent on many factors; prominent among them is the condition of the learning environment. The academic performance of students is considerably higher when they learn in positive environments. The condition of Nigerian schools is polarized to the rich and poor educational environment based on its stakeholders. If these educational conditions are left unattended, a disparity of citizens may magnify and adversely affect the country's overall development. This study recommends some strategies for improving the condition of science education in Nigerian public schools by improving teaching methodologies, improvisation of instructional materials, provision of zonal laboratory tools and equipment, and sourcing for funds from other Non-governmental organizations.

Keywords: *Academic performance; Educational environment; Nigeria; Public and Private Schools; Science education.*

INTRODUCTION

The previous study revealed different educational conditions in public and private High schools in Abuja. In this report, detailed inequality of learning opportunities between those schools was analyzed.

Research Background: Although education is a top priority for the Nigerian government, providing a fair and equal learning conditions for all students remains elusive. Students of public and private schools in Nigeria learn science in widely distinct and different conditions. There is an already existing massive lacuna in the learning conditions of both groups of schools, which if left unattended to, will magnify the disparity among students thereby adversely affecting overall development. The focus of this report is to suggest strategies for improving the condition of science education in Nigerian schools.

Methodology: A descriptive research survey was adopted for this study. The study involved a total of forty-five science teachers, twenty-six of them teach in private schools, while the remaining nineteen are public school teachers.

Results: This study employed the following parameters for comparing the condition of science education in public and private schools in Nigeria: average class size, average number of students per science group, frequency of conducting science experiments, availability of infrastructure and laboratory equipment, availability of teaching (audio-visual & kinesthetic) aids. The results are compared and analyzed in figure 1 and table 1 below.

Figure1. Some schools in Nigeria. 1A,B are public school's classroom and laboratory, while figures 1C,D are private schools.

Table1: comparison of science education conditions of private and public schools in Abuja, Nigeria.

Parameters	Public schools	Private schools
Average class size	65	24
Average number of students per science group	9	4
Frequency of conducting science experiments (termly)	2	10
Percentage availability of basic infrastructures	52	100
Percentage availability of laboratory equipment	25	82
Percentage availability of teaching (audio-visual & kinesthetic) aids.	59	98

Figure1 and table1 above show the gaping disparity in the science education learning conditions of Nigerian schools. The average class size and number of students that make up each science group for public schools are 65 and 9; while that of private schools stand at 24 and 4. Science experiments are usually conducted once or twice in a term for public schools, but conducted weekly or an average of 10 times in a term for public schools.

DISCUSSION AND RECOMMENDATIONS: To foster greater social equity, promoting more equal learning conditions in schools must be a priority for Nigeria (Adesina, 2006). Nigerian public schools should consider augmenting their income through private financing such as endowments, instead of relying primarily on government funding (The Guardian Newspaper (2020)). Figure 2 outlines strategies recommended by this study for improving the conditions of science education in Nigerian public schools.

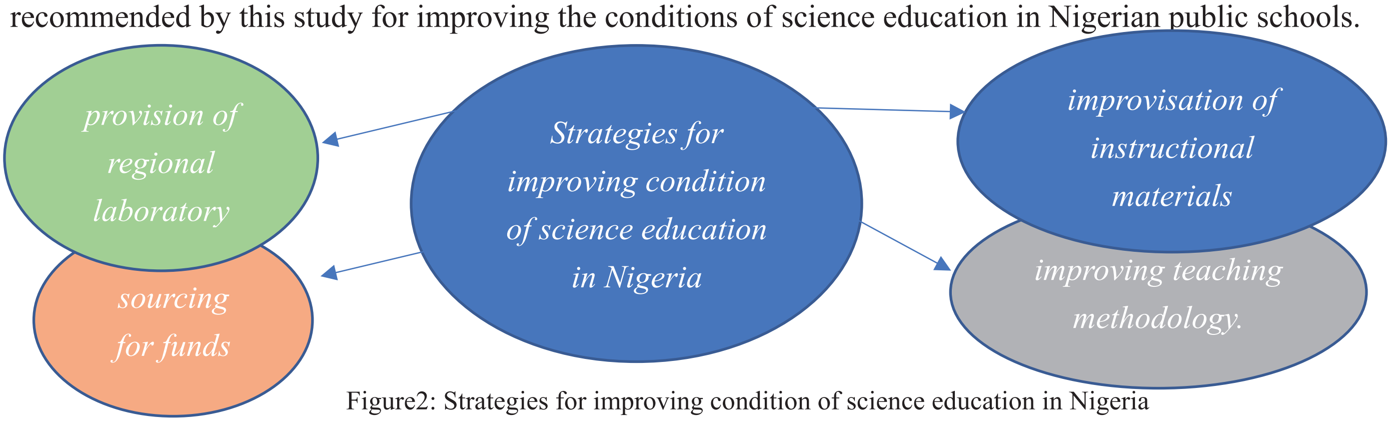

Figure2: Strategies for improving condition of science education in Nigeria

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LEARNING PROGRESSION OF GRADE 12 STUDENTS' REPRESENTATIONAL COMPETENCE IN ELECTROCHEMISTRY DURING MODEL-BASED LEARNING

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ABSTRACT

Electrochemistry uses a number of abstract concepts at the macroscopic, submicroscopic, and symbolic levels, and students can face challenges in generating visual representations of the chemical processes involved. Students' representational competence (RC) should therefore be developed; this is the ability to identify, transform, and reflect using multimodal depictions of perceptual and physical entities and processes in order to think about, communicate, and act on them. This study aims to examine electrochemistry students' progression in RC while engaging in model-based learning (MBL). Data were collected using pre-post tests, worksheet activities, audio recordings, and reflections from both teachers and students and subsequently analyzed inductively. The findings indicate that the pathways of progression in RC varied between students and that most progressed from the depiction to the syntactic level of formal representation. The students were able to develop a higher level of RC because they were engaged in MBL and, particularly, in generating model steps. Students were provided with support in generating and presenting internal and external representations via a co-construct process and with opportunities for justifying their representations. Moreover, the use of dynamic simulation visualization to translate the three evaluation levels helped shift the students' progress in RC to an even higher level.

Keywords: *Electrochemistry, Learning Progression, Representational Competence, Model-based Learning*

INTRODUCTION AND THEORETICAL FRAMEWORK

The main goal of this research was to examine how learning progress in representational competence (RC) is made by electrochemistry students. Electrochemistry is considered a challenging subject to visualize at the submicroscopic level and to link to macroscopic themes because of the abstract chemical concepts it involves (Tien & Osman, 2017). RC can be defined as the ability to identify, transform, and reflect using multimodal depictions of perceptual and physical entities and processes in order to think about, communicate, and act upon them (Chang, 2018; Kozma and Russell, 2005). Kozma and Russell (2005) propose five essential levels of progress in RC: 1) depiction; 2) early symbolic; 3) syntactic; 4) semantic; and 5) reflective or rhetorical. Informed by these levels, we develop a framework for measuring learning progress in RC, and we find that model-based learning (MBL) can play an important role in developing student competence through its generating, evaluating, modifying, and elaborating processes (Clement, 2000; Gilbert & Justi, 2016).

METHODOLOGY

This research included 23 female students enrolled on a grade 12 chemistry course. Materials such as pre-post RC tests, worksheet activities, audio recordings, and the reflections of students and teachers were used to assess RC through six MBL cycles of two electrochemistry tasks. An inductive method was used to analyze the data in terms of RC progression adapted from Kozma and Russell (2005).

RESULTS AND DISCUSSION

The students' RC was categorized into five progression levels (Fig. 1). Prior to engagement with the MBL activities, the number of students in level 1 was high at 85.95% and 43.48% for the redox reaction and electrochemical cell tasks, respectively. We found that after six cycles of MBL, students progressed to a higher level of RC with 17.39% in level 2 and 82.06% in level 3 for redox reaction as compared to 56.52% in level 2 and 43.48% in level 3 for electrochemical cell. This demonstrates that there are various routes to RC development. In commencing the MBL cycles, we found that many students shifted from higher to lower level 1 during model generation, and so a group co-construct process was implemented instead. Consequently, we found that RC tends to progress to higher levels in the evaluating step of each cycle indicating that the process supports the building and assessment of mental representations (Núnez-Oveido, Clement, & Rea-Ramirez, 2008). In MBL evaluation, we also found that using dynamic simulation visualization to translate the three levels could shift RC progression to a higher point in levels 2 and 3 because it allowed the students to connect observable processes with unobservable phenomena (Zhang & Linn, 2013). Moreover, in the modification and elaboration steps, some students progressed even further in cycles 2, 5, and 6, demonstrating the ability to connect different representations based on shared meanings as featured in level 4 RC progress.

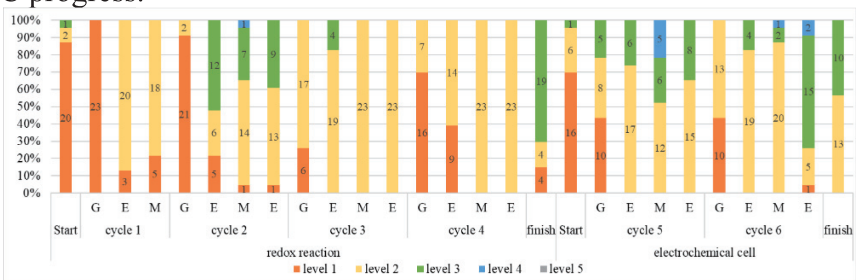

Figure 1. RC progression of electrochemistry students.

CONCLUSION AND LIMITATIONS

In this study, an MBL approach was found to support higher-level RC progression using co-construction and dynamic simulation visualization. However, the students' RC did not shift to level 5. The findings presented in this research suggest that MBL should focus on reasoning and argumentation which are critical for progressing to level 5.

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An Exploration of Senior Students' Mental States When Learning About Quadratic Function

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ABSTRACT

This study aimed to develop Metal State Questionnaire of Quadratic Function (MSQF) with good reliability and validity. The construction was a two-stage process. In the first stage, the draft of the MSQF with 32 items was completed based on the related literature. Next, a pilot study with 455 tenth grade students as the subjects was conducted for removing the items with unsatisfying item analysis results from the MSQF draft. The modified MSQF contained four subscales and 24 items. Then, reliability analyses were performed with the subscales. The obtained Cronbach's α-value were between 0.90 and 0.96, of which the MSQF was 0.97, meaning that the reliability of this inventory was good.

The second stage aimed to explore the differences in mathematical reasoning among students from different mathematical mental thinking disposition groups with 284 tenth grade students as the research subjects. The purpose was to examine the construct validity of the inventory. It was found that the differences in mathematical reasoning test scores between the groups of high MSQF scores and that of low MSQF scores were significant ($p < .001$), showing that the construct validity of this inventory was high.

Keywords: *Mental state, Quadratic function, Mathematical literacy.*

RESEARCH PURPOSES

Problem solving (mathematical modeling) is one of the main directions of the Programme for International Student Assessment (PISA) to evaluate mathematical literacy (OECD, 2018). Several instruments have been developed to assess students' mathematical literacy, but few studies have reported how students' mental states may play a role in learning mathematics. However, students often face many difficulties in the process of mathematical modeling, such as difficulties in generating images of situations, in identifying variables, and in establishing mathematical representations (Ikeda & Stephens, 1998). In order to improve mathematics literacy, we need to more effectively measure the mental state of students while studying mathematics, so as to develop more suitable strategies for mathematics teaching. The study focuses on quadratic function concept learning and propose the development of the Mental State Conceptual Learning Inventory to identify students' mental states before and after learning about quadratic function.

METHOD

The draft of the MSQF with 32 items was completed based on the method of classifying the mental state of concept learning by Liu and Hou (2002) and was presented using 5-point Likert's scale for the tool. Then, two experts in mathematics education research and three junior high school math teachers were invited to offer their opinions to modify the draft to improve the content validity. In the first stage, a total of 455 tenth grade students from 3 schools participated in the pretest. In the second stage, 284 tenth graders who were not among the participants in the first stage were selected as the research subjects. The reliability and validity of MSQR are proved through factor analysis and mathematical achievement test.

RESULTS

The results of each stage of this study are summarized as follows. In the first stage, we obtained a Kaiser-Meyer-Olkin (KMO) value of 0.964 ($p < .001$), which meant that there were common factors among the items. The result of factor analysis shows that there are four factors extracted, namely learning emotion, learning intention, internal mental representation and external mental representation. It was found that eight of the 32 items belonged to two or more factors at the same time, so they were deleted. The four factors loadings of the remaining 24 items were between 0.59 and 0.81, between 0.61 and 0.83, between 0.59 and 0.76, and between 0.59 and 0.74, 77.49% of the total variation of the 24 items inventory could be explained. Then, reliability analyses were performed with the subscales. The obtained Cronbach's α-value were between 0.90 and 0.96, of which the MSQF was 0.97, meaning that the reliability of this inventory was good.

In the second stage, we found that the correlation between MSQF and the math score test was 0.47 ($p = .000$), which is a moderately positive correlation. Therefore, we further tested the performance differences of the mathematics achievement test among student groups with different mental states to explore the construct validity of the MSQF. Because the p-value of Levene's test of homogeneity in the variance test of the high MSQF subarray group and the low MSQF subarray isn't significant ($F = 3.795$, $p = .053$), it means that the variance of the two groups isn't homogeneous. Then, one-way ANOVA test was performed on the mathematical achievement test results. The results show that $F(1,153)= 66.70$ and $p < .001$, which means the mathematics between the high MSQF fractional group and the low MSQF fractional group Performance tests vary. That is, students with high MSQF scores score high in the math achievement test.

CONCLUSIONS AND SUGGESTION

This study aimed to develop a MSQF with good reliability and validity. The results clearly showed that the item analyses and the validity and reliability tests were ideal, so the MSQF was an efficient tool for examining senior students' mental states when learning about a quadratic function. Specifically, low-achieving students tend to have negative emotions and low intentions, and they have obvious obstacles to generate scene images, identify variables, and establish mathematical representations. The research results mean that students' mental states are important for problem solving (mathematical modeling). Therefore, teachers can use MSQF to understand students' mental states, to examine their changes in mental states to further explore their learning characteristics, or to design teaching activities which is helpful for students to develop mathematics literacy.

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Analyze The Students' Experimental Text of Chinese Mainstream High School Physics Textbooks From The Perspective of Scientific Inquiry

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1. Beijing Normal University, China

ABSTRACT

In recent years, improving studen*ts' ability of inquiry-based problem solving has become a fundamental and vital demand in many national science curriculum standards. In order to effectively provide students with sufficient, real and effective inquiry opportunities to improve their inquiry literacy, Chinese physics curriculum standard presents higher requirements for the design of "21 compulsory students' experiments" in textbooks to ensure the inquiry activities is sufficient enough for students. To analyze whether the latest revision of "students' experiments" in high school physics textbooks meet the corresponding requirements, we constructed a three-dimensional analytical framework through literature review, including 20 items of supporting learning and using knowledge, supporting inquiry practice and developing the metaknowledge that guides and motivate scientific inquiry. After scoring the text of 21 compulsory students' experiments, we find that learning and using knowledge and developing inquiry process skills get a lot of attention in the text of students' experiments. Some other poor performances items illustrate that current textbooks do not provide enough words to support students establish a comprehensive understanding about scientific inquiry, such as 15 and 18. These findings provides valuable reference evidence for the improvement of subsequent physics textbooks.*

Keywords: *Physics textbooks; Text analysis; Student experiments; Scientific inquiry;*

In recent years, engaging students in scientific inquiry reflects in many national science curriculum standards, like *Framework*, *NGSS* (NRC, 2006; 2012), and *Physics/ Chemistry/ Biology curriculum standards for senior high school* (Ministry of Education, P. R. China, 2017). Especially in Chinese revised physics curriculum standards, regard scientific inquiry as a dimension of students' core competences in physics discipline. In order to effectively improve this ability, physics textbooks must provide students with sufficient, real and effective inquiry opportunities. The "compulsory student experiments" are the strongest exploration and practical experience arranged in Chinese physics curriculum standards. Effective design for these experiments in physics textbooks are expected. To this end, we analyzed relevant texts in the newly revised high school physics textbooks in 2019, to examine how does the students' experiment texts perform.

Theoretical framework

Referred to an tool developed by other scholars (Yang, 2019) for inquiry tasks in biology textbooks and basing on physics curriculum standards, we revised and building the three-dimensional analytical framework for analyzing students' experimental texts is determined as below:

■Dimension 1: The text of this task assists in the construction of understandings about scientific concepts (item 1).

1. The task help students understand better on scientific concepts involved in this lesson

■Dimension 2: The text of this task engages students in following process (item 2 to 12).

2. Asking question
3. Presenting hypotheses
4. Defining the purpose
5. Selecting of experimental methods
6. Formulating experimental procedures
7. Gathering evidence and data
8. Operating normatively

9. Describing evidence and processing data
10. Argument or explaining evidence and data
11. Evaluating
12. Communicating and cooperating

■Dimension 3: The text of this task reflects the following understanding about scientific inquiry (item 13 to 20).
13. Scientific inquiry all begin with a question, but do not necessarily test a hypothesis
14. There is no single set and sequence of steps or methods followed in all inquiries
15. Inquiry procedures are guided by the question asked
16. All scientists performing the same procedures may not get the same results
17. Inquiry procedures can influence results
18. Conclusions must be consistent with the data collected
19. Scientific data are not the same as scientific evidence
20. Explanations are developed from a combination of collected data and what is already known

Methods

Two faculty members participated in the scoring procedure. By comparing two raters' responses to all items, it showed 91.8% agreement.

■The three-dimensional analytical framework above is the analysis tool (20 items in total).

■The texts of students' compulsory experiments in Chinese most mainstream high school physics textbooks (Published by People's Education Press) are taken as the analysis object (21 texts in total).

■Scoring every texts with 20 items. If there is an expression of each item in this text, score 1, otherwise score 0**.**

Results

The given line chart below (figure 1) A line chart (see Figure 1) was drawn to present the observed scoring probabilities per item and show the arrangement of students' experiments in the textbooks. In Figure 1, the xaxis is the item number, and the y-axis is the observed scoring probability of 21 texts. from Figure 1 that:

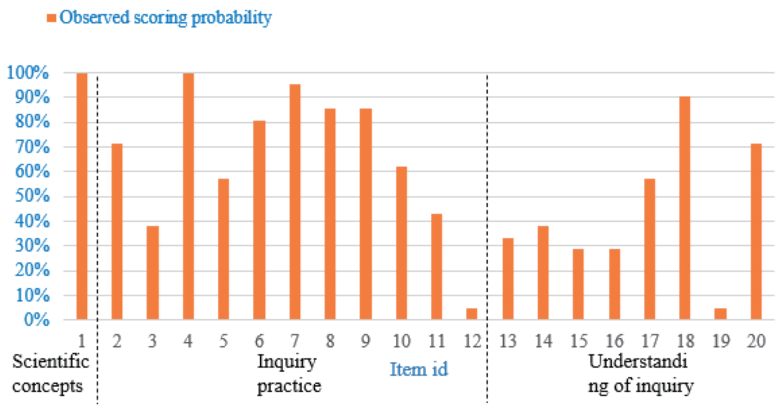

Figure 1. Line chart of the observed scoring probability for 21 texts in the latest physics textbooks on each item.

■The scoring probabilities on dimension 1 were relatively high. 100% of students' compulsory experiments could assist students in constructing scientific concepts.

■The scoring probabilities on dimension 2 were better than dimension 3, overall. But the frequency of various exploratory activities still varies. Defining the purpose (item 4), formulating experimental procedures (item6), gathering evidence and data (item7), Operating normatively (item8) and describing evidence and processing data (item9) were used frequently, while communicating and cooperating (item 12) were seldom encouraged in words.

■The scoring probabilities on dimension 1 were generally low, which means these experiments tasks do not provide enough opportunities to help students establish a comprehensive understanding about scientific inquiry.

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Oral Session 5	Day3 (June20th) 13：00～14：30
Room5	C5-4
【Category】	5: Science Education for Undergraduate or Graduate School Students

=Chairperson=

Prof. Mei-Chun Lydia Wen	National Changhua University of Education

=Presentation Program=

1	109-5-4-20-1（FY3G-MX8S-U5021） Nuryani Rustaman（Universitas Pendidikan Indonesia） *SYSTEMS THINKING FOR LIFE-LONG LEARNING IN QUALITY SCIENCE EDUCATION*
2	110-5-4-20-2（FY2K-Q2SD-IK021） Witchayada NAWANIDBUMRUNG（Waseda University） Sara Samiphak, Noriyuki Inoue *MAKING SENSE OF TEACHERS’ BELIEFS FOR EFFECTIVE IMPLEMENTATIONS OF INQUIRY-BASED LESSONS: THE NATURE OF HANDS-ON ACTIVITIES IN THE SCIENCE CLASSROOMS*
3	111-5-4-20-3（FY3L-WAHX-YZ021） Sudarmin（Universitas Negeri Semarang） W. Sumarni, S.Diliarosta, E. Pratiwi, and H. Pancawardani *DEVELOPING STUDENT'S LIFE SKILLS WITH THE MAKING OF BATIK METABOLITE FROM TAXUS SUMATRANA WITH ETHNO-STEM PROJECT LEARNING*
4	112-5-4-20-4（FY7S-7DO8-97021） Wanting Qiao（Central China Normal University） lan zhang; wenhua zhang *Pre-service chemistry teacher PCK to classroom practice Research on transformation process and influencing factors*

SYSTEMS THINKING FOR LIFE-LONG LEARNING IN QUALITY SCIENCE EDUCATION

N Y Rustaman

Universitas Pendidikan Indonesia, West Java

ABSTRACT
System and System thinking have been considered as essential components in Science and Science Education, whether in PISA, STEM Education movement, and Education for Sustainable Development.. Previous research resulted in findings that many topics in middle school science consists of system and need system thinking skills for concept mastery through real experiences supported by learning material for the students. Empowering three middle school science teachers who were joining master's program, life organization system topic in 7th grade was chosen as the topic for STEM-PjBL, covering concept mastery, creativity and collaboration and system thinking within supplementary/enrichment learning material. The research findings were still separated between the first two and the learning material study. Later still using STEM approach (STREAM) for students teachers focusing on system thinking in solving agricultural problem in east part of Bandung, it was found that the achievement of students' teacher are still low, even though they were actively engaged with the teaching learning processes. Using meta-analyses of some researches and literature review, it is then hypothesized that in order to achieve high level of system thinking in science education, real well-plan system thinking based learning material should be prepared as well as their teachers' guide for equipping middle school science teachers to implement and develop quality science education for their students with some revision in STEM delivery instruction to accommodate the art of system thinking. By maximising systems thinking in Science learning for middle school level, it means for all citizen as well, as it is compulsory for Indonesia.

Keywords: *system thinking based learning material, STEM-PjBL, middle school science. ESD.*

INTRODUCTION

System and System Thinking in Science Education

System has been introduced in Scientific Literacy in PISA since 2006, and become one of cross cutting concept in STEM education movement. Systems thinking has been used in many context, such as in Education for sustainable development (ESD), specifically in Competencies according to UNESCO and in STEM approach as well (Rustaman, 2020). In the art of Systems thinking (O'Connor & McDermott, 1997; Rustaman, 2019) it was found that in order to be in balance, the loops should be more than once. System thinking can be and has been implemented in STEM-based learning material for seventh graders on Life Organization System Topic (Rustaman et al., 2017), just for "cell" (Sembiring, 2017). System thinking has been implemented for prospective biology teachers using STREAM as modification of STEM (Rustaman, 2020). Those studies resulted in non-convincing findings about its role in quality Education for science. There is problem to be solved or investigated through research for middle school science and for prospective science teachers who are going to teach middle school students.

RESEARCH STRATEGY AND DISCUSSION

Research Method

Meta-analyses towards previous research results and literature review have been carried out to focus how to solve problem found. The problem that can be solved among others is like this. Well plan learning/teaching material (module) might be prepared to complete the previous research conducted by middle school science teachers, in the form of a complete sets of learning materials (plant and animal cells; tissue systems for plant; organ systems in animal) to be implemented in the same middle school(s) for the seventh graders.

Strategy and Discussion

The modules are suggested accompanied with teacher's guide. Some revision should be done in lesson plan on Organization of Living System. At least three-four modules on learning/teaching materials should be implemented in alliance for seventh graders (cells; tissue systems + organism and its environment), and for eighth graders (organ systems).

Total modules inserted system and system thinking skills in life sciences can be shown in Table 1. While the hypothesis for that problem can be like these: The STEM-PJBL instructions will results in high performance in concept and in system thinking as well (i); certain type of system thinking can be inserted into each module for middle school students (ii); there should be combination on types of system thinking for prospective science teachers to maximize their system thinking in terms of the art of system thinking (iii); If the modules can be prepared in the form of e-book or online materials, then it can be tried out to more middle school in some provinces in Indonesia (iv).

	Topics of Modules	New Concepts	Grade	Type of System Thinking
1a	Cell (prokaryote, plant cell, animal cell)	prokaryote, membrane, organelle,	**7**	General System Thinking
1b	Tissue System in Plant	derm, vascular, ground tissue.	**7 &** (8)	Cybernetic System
2	Organ System in Animal	Structure and function	(7) & **8**	Cybernetic System
3	Organisms and their Environment	Interdependent, interaction, balance; individual, community, ecosystem	**7** & **9**	Dynamics System

Strategy to revise lesson plan is suggested like these: there should be more than one activity in one lesson plan. Every student should have experience in observing cells and design one type of plant cell and one type of animal cell within small groups. Module writers should be decided/determined among middle school science teachers, been supervised by biology major teachers or lecturer with STEM experience.

CONCLUSION

From this paper, fix findings have been achieved yet, as no program for middle school science teachers is launched in near future. Middle school science teachers tend to move upwards to higher levels of teaching science. After being graduate from master's degree mostly they want to move upwards to become lecturers.

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MAKING SENSE OF TEACHERS' BELIEFS FOR EFFECTIVE IMPLEMENTATIONS OF INQUIRY-BASED LESSONS: THE NATURE OF HANDS-ON ACTIVITIES IN THE SCIENCE CLASSROOMS

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ABSTRACT
Even if science teachers consider inquiry-based teaching as an important and valuable approach for teaching science effectively, their inquiry lessons are not guaranteed to be successful. Teachers' beliefs have been argued to have a strong influence on such a pedagogical practice. In this research, we investigated how Thai pre-service science teachers' beliefs actually function in their inquiry lessons through analysis of interviews and classroom observations. This research reported that in their practicum, they all agreed on the importance of helping students make sense of what teachers told them, but in actual lessons, they gave a ready-to-do hands-on activities to students only to eliminate students' loss of focus and classroom situations that teachers failed to anticipate. Also, they seemed to believe that checking over how students engaged in hands-on activities could allow them to check whether students were doing right things that did not lead them to get lost. The implication of this study provides recommendations for science teacher educators to find effective ways to transform each of these pre-service teachers' pedagogical beliefs through an institutional support system so that the future teachers would be capable of sustainable improvement in their inquiry-based teaching in their future classrooms.

Keywords: *Pedagogical Belief, Inquiry-Based Teaching, Teaching and Learning Science*

INTRODUCTION

Despite growing consensus regarding the value of inquiry-based teaching as a central strategy of teaching science effectively (NRC, 1996), the implementation of such a pedagogical practice continues to be challenge for many science teachers around the world, especially pre-service teachers who are known to struggle with implementing this pedagogical approach in the real setting (Inoue and Buczynski, 2011). However, the literature recommended that teachers' beliefs about teaching and learning was a significant element that impacted their implementations of inquiry lessons (Wallace and Kang, 2004)

Science teachers are likely to design their science lessons in the way they believed is the best for them and their students' learning (Pajares, 1992; NRC, 1996;). In doing this, it was teachers' pedagogical beliefs that can make inquiry-based lessons that they teach effective or non-effective (NRC, 1996; Wallace and Kang, 2004)

As far as we are concerned the significance of science teachers' pedagogical beliefs, the number of studies on Thai science teachers' pedagogical beliefs seemed to be limited. Therefore, this research seeks to fill this gap by investigating Thai pre-service teachers' pedagogical beliefs for actualizing effective implementations of inquiry-based lessons in science classrooms. Specifically, the study also analyzes the roles of their pedagogical beliefs in what they implemented as inquiry-based lessons in their science classrooms. We began our study with an assumption that all pre-service teachers already had preconceptions of inquiry pedagogy. In order to capture the reality in social phenomena, we agreed with Lincoln and Guba (1985) to use qualitative methods such as interviews and classroom observations as the main data source for tracking how their pedagogical beliefs affected on their actual teaching in this study.

FINDINGS

This research reported that even though all the pre-service science teachers agreed on the value and importance of inquiry-based lessons, many of the lessons they tried out in their classroom had fundamental problems from an inquiry-based teaching point of view. Looking into this more closely, these problems seemed to originate from their pedagogical beliefs. One of the problematic beliefs that they seemed to have was about the nature of hands-on activities in the science classrooms. They often stated that hands-on activities should serve as an avenue to help students make sense of what teachers told them in terms of the concrete experiences. Therefore, giving a ready-to-do hands-on activities to students was good enough to eliminate students' loss of focus and classroom situations that teachers failed to anticipate. Several lessons observed in the study belonged to this case. A representative example of this could be seen in Teacher Sandra's lesson of a spherical mirror. She first had students learn the experimental procedures from the textbook. After that, she explained the procedures briefly and asked some questions to confirm their understanding of what they need to do, without overly supporting them in making sense of experimental design and purpose. As students began to work, she walked around the classroom, spending a few minutes at each table to explain what their results entailed. Before proceeding further, she asked them for a "check-in" conversation. Interestingly, when we interviewed her after the lesson, she expressed her beliefs that a cookbook activity played an important role in building students' understandings around the scientific concepts. Despite clear instructions, students would still be confused about where to start or what was being asked of them. This tells us that her teaching was significantly underlined by her beliefs. As in this example, teachers' beliefs seemed to devalue the hands-on activities in inquiry-based lessons, just for the sake of information-gathering. This could be because they seemed to believe that their students would not be able to make their own discovery to truly understand scientific concepts through their own self-generated scientific investigation procedures.

DISCUSSION AND IMPLICATION

As we discussed above, the weakness observed in participants' lessons seemed to stem from the beliefs. Ample literature supports this point that teachers' beliefs on teaching significantly impact the effectiveness of teaching within a real setting (Wallace and Kang, 2004). In details, the findings revealed that participants focused more on their own performances and needs than their students' performance. They often used their authorities to control their classrooms following their beliefs such as defining the experiment/activity procedures, giving their own explanations, and making students to agree with their opinions. Similar to Inoue & Buczynski (2011), their research reported that pre-service teachers had a tendency to concentrate on their actions, rather than students' actions. Based on these findings, it can inform us the necessary information of helping them learn to consider their beliefs and implementation of inquiry lessons in reference to the support of learners' meaningful construction of knowledge. We suggested that providing pre-service teachers with the possible opportunities to critically examine their beliefs and practices, for example, Japanese lesson study may pull these future teachers to intentionally look back at their beliefs and actions, and would be capable of sustainable improvement in their inquiry-based teaching.

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DEVELOPING STUDENT'S LIFE SKILLS WITH THE MAKING OF BATIK METABOLITE FROM *TAXUS SUMATRANA* WITH ETHNO-STEM PROJECT LEARNING

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Abstract

This research aims to equip students with life skills by producing chemical batik products from the secondary metabolite structure of the taxus sumatrana plant as one of Indonesia's tropical forest plants. The learning design applied to the research is the thno-STEM integrated Project Learning Model with the "Sudarmin" stage. This research is applied research with as many as 22 research subjects of Chemical Education UNNES taking Natural Products courses in 2020. In this research, before students are given the task of designing a chemical batik motif design project with secondary metabolite structures in the Taxus Sumatrana plant, students are given lectures. The results of the research can conclude that the implementation of the Ethno-STEM integrated learning project with the "Sudarmin" stage can run well and produce chemical batik design products from Taxus Sumatrana with very good categories and are worthy of being used as life skills based on the batik expert's assessment.

Keywords*:* Project learning, life skills, Ethno-STEM, and Chemical Batik

1. INTRODUCTION

In this era of disruption, entrepreneurial character is very important in an effort to create an independent, intelligent, creative, innovative, hard work and responsible society. However, at this time, university graduates are not ready to develop entrepreneurial products as a form of life skills. This study aims to provide the basics of entrepreneurship for Chemistry Education students of Semarang State University (UNNES) through integrated project learning of Ethnoscience and STEM (Ethno-STEM). The Ethno-STEM approach was chosen because the innovative approach developed by Sudarmin et al. (2019, 2021) showed that it was able to equip students with competence and life skills in the global era. In this lesson, students are provided with life skills and the ability to understand secondary metabolite science, batik technology, coloring, engineering in producing good and highly competitive batik products, so that they are economically profitable.

The importance of this research, because the rapid development in science and technology in the 21st century is a challenge for the Indonesian nation to make new breakthroughs in order to produce quality graduate output. Indonesia has made a significant overhaul of the current national education system (Musnidar, 2018, Sudarmin et al, 2020). The government is developing Merdeka and Merdeka Learning Campuses to prepare university graduates as Indonesian human resources who are ready to face the 21st century. In this century, life skills and entrepreneurial character are important for the younger generation (Permanasari A, et al., 2016, Sudarmin, 2019, Wells, 2019). This is in line with Prasetyo's (2019) statement that developing the potential for life skills and entrepreneurial character is one of the main keys in producing quality and quality human resources. In the research that has been done, the character of entrepreneurship as a form of life skill is developed through Natural Products lectures, with the project being developed from designing motifs to producing batik based on secondary metabolites, taxus sumatrana. It is hoped that this life skill will become a student's expertise as a provision to live independently or be an entrepreneur.

2. METHOD

This research is applied research with 22 research subjects participating in natural product lectures. Student project assignments are related to the study of secondary metabolites of Indonesian Tropical Forest Plants. This research stage began with theoretical lectures in class for four meetings regarding secondary metabolites related to types, methods of isolation, phytochemical tests of secondary metabolite compounds of Indonesian tropical forest plants including Taxus Sumatrana. In this lecture, students are given a project assignment to design batik motifs from the chemical structure of secondary metabolites from the taxus sumatrana plant as an example of Indonesian tropical forest plants, which is followed by the production of batik with motifs designed by students.

3. RESULTS AND DISCUSSION

In this research, the Ethno-STEM integrated project learning developed is the Ethno-STEM integrated project learning with the Sudarmin model. The Sudarmin stages include the activities of Present, Performance, Design and Submit project assignments, Design and Strengthen the batik project, and Implement and Value the results of the batik project. In this research, the results of the project activities produced the Taxus sumatrana batik motif as presented in Figure 1..

Figure 1. Chemical Batik Motif Products from Taxus Sumatrana

The main structure of the secondary metabolites in this batik is the Taxol compound of the paclitaxel type as a taxol essential oil compound and is contained in Taxus sumatrana. Paclitaxel compound is a secondary metabolite that is used as an anti-tumor and anti-cancer drug, and the taxus plant is proven by the public as a cancer drug.

This batik motif has a chain taxol structure with leaf, stem, taxus flower motifs, and the UNNES logo which forms a lurik motif with dark blue lataer doiminan as a symbol of the spirit of life. With the presence of this batik motif can be an alternative choice of batik motifs for the community. This motif can be a developer of entrepreneurial character and also become a characteristic of Indonesian batik motifs. The price for each piece of this batik is IDR 200,000 / piece with a size of 200 cm x 115 cm. The results of the assessment from batik experts show that this student batik product is in the very good category and is feasible to produce.

4. CONCLUSIONS

The results of the research can conclude that the implementation of the Ethno-STEM integrated learning project with the "Sudarmin" stage can run well and produce chemical batik design products from Taxus Sumatrana with very good categories and are worthy of being used as life skills based on the batik expert's assessment.

ACKNOWLEDGMENT

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Pre-service chemistry teacher PCK to classroom practice Research on transformation process and influencing factors

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ABSTRACT

Science education is an important part of the education system. There is a big gap between the current situation of science education in China and the development trend of national middle school education. Therefore, the times have put forward higher requirements for teachers' teaching quality. Teaching content knowledge (PCK) is the embodiment of teachers' professional knowledge and ability. The transformation of teachers' PCK thinking mode to classroom practice is the key to whether teachers can achieve effective teaching and develop students' chemistry core literacy. This research uses a variety of literature research, text analysis and classroom observation methods. In this study, two chemistry junior high school students from a normal college in Wuhan were used as the research objects to study their PCK levels, changes and influencing factors. Through research, it is found that the PCK and classroom teaching behaviors of two pre-service chemistry teachers have different degrees of difference. The conclusions are as follows: (1) The transition from orientation to teaching science is slow. The PCK thinking model of the two pre-service chemistry teachers has a high OTS level, but the teaching action is weak, and the teaching purpose cannot be achieved well in the teaching practice. (2) KISR and KSC are difficult to integrate, and the conversion level is low. (3) The conversion level of KA is low. (4) There is a potential KSU and cannot be converted well. The factors that affect the PCK transformation of pre-service chemistry teachers are: the direction of teaching science; teaching reflection; PCK; chemistry topic knowledge; teacher intervention; views on students; peer cooperation.

Keywords: *PCK; pre-service chemistry teacher; PCK transformation*

Introduction

Studies have shown that teaching should be rooted in deep subject knowledge (Content Knowledg, CK) and subject teaching knowledge (PCK). To promote the development of teacher education in China and improve the quality of education, the development of teacher professional knowledge should be the focus The content of interest. Pre-service teachers are the successors of future education. Research on the transformation of pre-service teachers' PCK thinking model to classroom PCK and influencing factors is of great value to the development and training of pre-service teachers' teaching ability. Therefore, this research mainly focuses on the following three questions: 1. Are the PCK thinking models of the two pre-service chemistry teachers consistent with their classroom teaching behaviors? What is the difference? 2. What are the characteristics of the conversion of the PCK thinking model of the two pre-service chemistry teachers to the classroom PCK? 3. What are the factors that affect the conversion of pre-service chemistry teachers' PCK thinking model to classroom PCK?

Methods

This research adopts literature research method, text analysis method, classroom observation method, case study method and other methods. Based on Park's PCK Pentagon model, the coding system is constructed, and authoritative literature at home and abroad is examined to develop the evaluation tool for this research. In-depth analysis of the process and influencing factors of pre-service chemistry teachers' PCK thinking model to classroom PCK under the theme of "the law of the element cycle" (first class hour).

Results and Discussion

In previous studies, domestic and foreign researchers paid more attention to the conversion of in-service chemistry teachers PCK, and paid less attention to pre-service chemistry teachers. This article is a research on the conversion of pre-service chemistry teachers PCK, and puts forward relevant suggestions for promoting the improvement of pre-service teachers' conversion level. Through text analysis and classroom observation, the collected data was coded and in-depth analyzed, and the following conclusions were drawn: The PCK thinking model of the two pre-service chemistry teachers is quite different from the classroom PCK, and the level of the PCK thinking model is high. In its classroom PCK level. It exhibits the following characteristics: (1) The transformation of science teaching orientation (OTS) is slow; (2) The teaching strategy and knowledge of representation (KISR) and science curriculum knowledge (KSC) are difficult to integrate, and the conversion level is low; (3) The knowledge of scientific learning evaluation The conversion level is low. At the same time, five factors that affect the conversion of pre-service chemistry teachers' subject teaching knowledge to classroom practice are summarized: (1) scientific teaching orientation; (2) teaching reflection; (3) subject teaching knowledge, whether each component of subject teaching knowledge is perfect , Whether the teacher can integrate the various components of PCK is the reason that affects the transformation; (4) chemistry subject knowledge, teachers should have deep chemistry subject knowledge; (5) teacher's guidance; (6) views on students, Expectation of students' knowledge and ability; (7) Peer cooperation. In this regard, two suggestions are put forward: (1) Focus on the value of the subject and promote the improvement of teachers' scientific teaching orientation .(2) Increase teaching practice, and improve the conversion level of PCK in practice and reflection.

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Oral Session 5	Day3 (June20th) 13：00～14：30
Room6	C6-2
【Category】	6: Science Education for Informal Setting or Life-Long Learning or In-Service Teacher training

=Chairperson=

Prof. Hae-Ae Seo	Pusan National University

=Presentation Program=

1	113-6-2-20-1（FY4T-U86B-9E021） Shelly Efwinda（Mulawarman University） Nurul F. Sulaeman, Pramudya D.A. Putra *EXPLORING PHYSICS TEACHER READINESS TOWARD STEM EDUCATION IN INDONESIA*
2	114-6-2-20-2（FY5G-EF8Q-0Z021） Ting-Hsuan Huang（Tatung University） Ming-Hsiu Mia Chen *EMOTIONS OF AUDIENCES TOWARDS ANIMATED SCIENCE VIDEOS*
3	115-6-2-20-3（FY5S-6H6G-WQ021） Anupong Praisri（Kasetsart University） Chatree Faikhamta *EXPLORING SCIENCE TEACHERS’ MODELLING PRACTICES THROUGH THE LENSES OF EPISTEMOLOGICAL MODELLING*
4	116-6-2-20-4（FY61-8XCD-P6021） Hsin-Yi Chiu（National Kaohsiung Normal University） Chia-Ju Liu *Develop cognitive structure tool that integrate self-discrepancy theory into STEM cognitive structure*

EXPLORING PHYSICS TEACHER READINESS TOWARD STEM EDUCATION IN INDONESIA

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ABSTRACT

Teachers play a crucial role in bridging the innovation in education to actual classroom activity. In classroom practice, teacher readiness to conduct integrated Science-Technology-Engineering-Mathematics (STEM) learning is essential for its successful implementation. This study explores physics teachers' readiness for STEM education after a Professional Development activity in STEM education at the National University in Indonesia. Data collection is based on 100 teachers' responses to six open-ended questions. Content analysis is conducted on all the data. Interestingly, all the teachers showed strong alignment with STEM education and how to implement it. Most of them have known STEM education as integrating technology, engineering, and mathematics to science (physics), but only about half of them have experience conducting STEM lessons. They have the basic capabilities of identifying the possibilities of implementation in various physics curricula. Some topics have a more substantial possibility to be taught with STEM education. However, in the online learning made necessary by the COVID-19 pandemic, the possibility of implementation is weakened. The teachers showed their engagement to explore more detail in designing and implementing STEM in their classrooms. Also reflected in teacher responses is a significant challenge in pedagogical and time management. Therefore, professional development in STEM education is essential to support readiness. For conducting STEM education in physics, teachers need to enhance their conceptualization and experiences in STEM education. Professional development in STEM education needs to be seriously conducted with sufficient duration of practice.

Keywords: *STEM, Teacher Readiness, Physics Teacher.*

INTRODUCTION

Science and technology are two elements that shape the future growth of society and the economy (Lin et al., 2021). In 21st century learning, individuals are expected to have the skills to transform what they have learned in real life and to use technology effectively and efficiently to face globalization and international competition (Indriyanti et al., 2021). Technological developments are often associated with the potential to have a significant impact on the world of education. One learning approach that has emerged as a result of this development is STEM education, and this approach has attracted much attention in recent years (Ozkan & Topsakal, 2019). In Indonesia, the STEM approach has been widely introduced through teacher professional development activities. Still, the readiness of Physics teachers in Indonesia in implementing STEM-based learning approaches has not been well measured. Teacher readiness in implementing the STEM approach is an essential factor that can affect the quality of implementing the STEM approach (Abd. Rauf et al., 2019). Therefore, their readiness for STEM education needs to be explored.

METHOD

This research is exploratory study research. The research subjects consisted of 100 physics teachers in Indonesia. Research procedures in the form of problem identification, research instrument development in the form of eight open questions, expert judgment, instrument revision, data collection, analysis, and conclusions about the readiness of physics teachers in Indonesia in implementing STEM learning.

RESULT AND DISCUSSION

Physics Teacher Knowledge about STEM Learning

Most of the physics teachers who participated in this study already knew about STEM learning and stated that the STEM learning approach could be used to develop creativity and problem-solving skills. The answers given by physics teachers about their knowledge related to STEM learning are presented in graphical form, which can be seen in Figure 1 below:

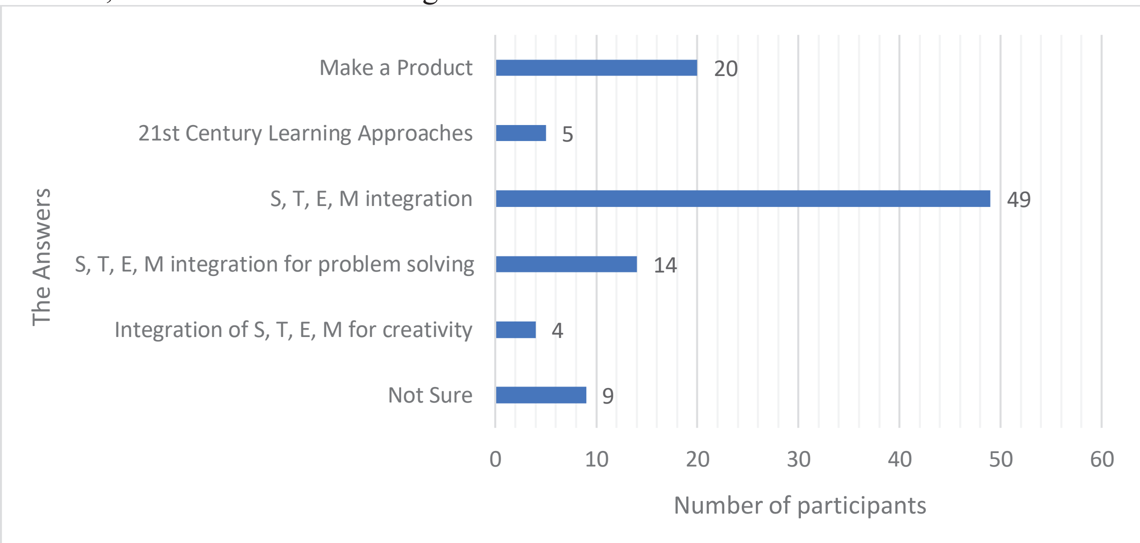

Figure 1. Physics Teacher Knowledge about STEM Learning

Physics teacher readiness to implement STEM learning

All physics teachers believe that STEM learning can be implemented in physics learning in the classroom at all levels and many topics. As specific examples, on issues about motion, electricity, fluids, and rigid body equilibrium. They also argue that the implementation of STEM learning can also be carried out in distance learning, but with various challenges and require extra preparation. Physics teachers who participated in this study did not have much experience in implementing STEM learning. They want to learn more about the design and application of STEM learning and examples of contextual problems that can be presented in STEM learning. Therefore, there is a need for further training for physics teachers to implement STEM learning. This is consistent with (Aşiroğlu & Koç Akran, 2018), which recommends that a STEM education training program for teachers be conducted because it takes teachers who are creative and can integrate different disciplines and scientific methods in STEM education.

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EMOTIONS OF AUDIENCES TOWARDS ANIMATED SCIENCE VIDEOS

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ABSTRACT
Animated science videos are popular and appear on various Web platforms. These animations are not only for kids to learn about science as school subjects but also for adolescence to gain knowledge of science. The present study explored contents of online animated science videos investigating which type of animation scripts, expository or narrative, could arouse positive emotions of audiences. 30 adults were recruited and watched animation randomly mixed of expository type with narrative ones. The data were collected through electroencephalography (EEG) by BR8, a portable, wireless, 8-channel digital impedance detection dry sensor system. The results showed that animation scripts of expository type aroused positive emotions of audiences better. Through the analysis of laterality coefficients, left frontal lobes of audiences who watched animation of the expository type in this study were significantly active. We hope the result of this study can help science educators and science animation designers have better understanding of the emotional state of their audiences as well as a reference when developing scripts for science animations in the future.

Keywords: *Animated science videos, Instructional design, Popular science*

BACKGROUND

Online science animation videos are flourishing in number, pointing to the progress of digital technology. Television channels distribute contents of science animation videos on their Web platforms (e.g. PBS Digital Studios, BBC Science News), and many enthusiastic science educators and interest groups have opened their own channels to disseminate scientific concepts over the Internet using animation. By visualizing unseen worlds and abstract concepts, animations make science more accessible and appealing for wider audiences. Studies have shown that animations enhance students' motivation to learn about science in their classes (Barak, Ashkar, & Dori, 2011; Chan, 2013; Barak and Hussein-Farraj, 2013; Turkay, 2016) and via online environments (Rosen, 2009). As people generally rely on the Internet as their primary source of science information today, the contents of online science videos have become trendy research topics (Welbourne & Grant, 2016). Nevertheless, science animations, among different genres of science videos, have not yet been examined specifically. The fact that audiences can gain scientific information at the same time as enjoying animatic moving images needs to be asserted. In this study, audiences' emotions towards science animation videos based on aspects of scripts have been examined. Two types of text genres used in science educational writings, expository or narrative, were employed for classifying online scientific animations to evaluate the type of scripts for their effectiveness in fostering positive emotions among audiences.

METHOD

The independent variables in this study were science animation videos that employed different methods to convey the information. The selected online animation videos were divided into expository and narrative based on types of their scripts. The dependent variable was, collectively, brain wave changes produced after the subject had viewed the two types of videos. The asymmetry of brain waves and changes in the mean value of alpha waves were used to examine differences in subjects' emotions. The length of each video, measurement time, education levels of subjects, narration, language of narration and subtitles, and background music were controlled. The same person dubbed all segments. The subjects were all right-handed, and Chinese was their mother tongue. All subjects were free of brain disease.

The experimental materials for this study were eighty video segments edited from animated videos on the Internet. Then, all video segments were classified into four categories as: positive emotions and expository, negative emotions and expository, positive emotions and narrative, and negative emotions and narrative.

The BR8 PLUS eight-channel brain wave dry sensor amplifier was used to measure emotional reactions, and signals from Fp1 and Fp2 electrodes placed on the subjects' forehead were collected. The subjects were 30 volunteers who had earned a university bachelor's degree or higher. They were placed in a soundproof room with no other interference and fitted with electroencephalographs to watch videos played on the computer screen. The researcher simultaneously recorded the brain wave activity of the subjects.

RESULTS AND DISCUSSION

The mean values of alpha waves and t-test results of brain lateralization were used for analysis.

First, the t-test was used to analyze the results of the four groups of videos, showing that the significance of the positive emotion and expository type of videos was 0.002 (< 0.05). Therefore, the lateralization coefficients for positive emotions and expository type of animation revealed significance. On the other hand, the mean alpha value analysis showed that scientific animations of both types of narrative and expository scripts could both induce joy in the subjects, but there was no significant difference.

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EXPLORING SCIENCE TEACHERS' MODELLING PRACTICES THROUGH THE LENSES OF EPISTEMOLOGICAL MODELING

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ABSTRACT

Modelling is an important practice for teaching and learning science. However, few studies have investigated science teachers' modelling practices from the perspective of epistemological modelling. This study explores science teachers' modelling practices regarding specific aspects of epistemological modelling, including the nature of the model, the purpose of the model, and the modelling process. Data were collected through interviews with teachers, classroom observations, and lesson plans. Data were analysed using the inductive process, namely interpreting and identifying the shared features of concrete data and making an abstract conclusion to be synthesised as a theme. The findings indicate that science teachers mainly use models as teaching tools rather than scientific inquiry tools. They encourage students to use models for representing scientific concepts rather than engaging them in the construction of models for predicting something related to natural phenomena, thus helping them reconstruct scientific knowledge. Given the modelling process, science teachers engaged students in developing their models by scaling or copying the target phenomena to create visual representations. Besides from this, the development of models based on experiments and the interpretation of data by students was not considered for process modelling. The study concludes with a discussion of how the findings contribute to developing teachers' modelling practice.

Keywords: *modelling practices, science teachers, epistemological models, modelling*

INTRODUCTION

Modelling practices represent the work of scientists in establishing scientific knowledge using the process of modelling. In other words, students play a role as scientists to construct and develop their models for explanation and prediction to make sense of natural phenomena (Schwarz et al., 2017). In particular, models then can be developed based on students' interpretation of data from experiment results (Lazenby et al., 2020). This is an example of modelling practices from the perspective of epistemological modelling. To be successful in modelling practice in a science classroom, teachers must not only engage students in the construction of models as explorative and predictive tool, but they must also engage students in constructing models as scientific inquiry tools. Teachers may, for example engage students by using models to ask questions, to generate data for making predictions, or to revise scientific explanation, leading to theoretical reconstruction. On the other hand, following literature reviewed, most teachers view models as teaching tools for pedagogical purposes. For instance, they use models to explain scientific concepts to students (Kite et al., 2020) or to represent phenomena (Krell et al., 2019), rather than engaging students in practices of scientific inquiry via cyclical modelling (e.g. GEM cycle). However, few studies have investigated science teachers' modelling practices from the perspective of epistemological modelling.

RESEARCH QUESTION

The purpose of this study is to explore, through only one research question, science teachers' modelling practices regarding specific aspects of epistemological modelling: to what extent do science teachers' teaching modelling practices relate to epistemological models and modelling.

METHODOLOGY

In this study, a qualitative research approach based on an interpretive paradigm was used to build an understanding of how science teachers taught the use of modelling practices. The participants included two science teachers (Ms M and Ms O) at primary schools in Thailand. These particular school were chosen for their convenience and proximity; they developed science teaching methods through the professional learning community (PLC) organised by researchers. Thus, these teachers were chosen by purposive sampling. Data were collected through mainly classroom observations, interviews with teachers, and lesson plans and were analysed using the inductive process, namely interpreting and identifying the shared features of concrete data and making an abstract conclusion to be synthesized as a theme.

FINDINGS AND DISCUSSION

Theme 1: Science teachers mainly used models as teaching tools rather than scientific inquiry tools.

Sub-theme 1.1: Constructing models for representing scientific concepts: Science teachers encouraged students to construct models for representing scientific concepts. Ms M engaged students to construct solar systems model for evaluating scientific concepts. Ms O also engaged students to draw circuit diagrams for re-thinking scientific concepts and to conduct experiments for verifying, rather than collecting, empirical data to support their constructed model.

Sub-theme 1.2: Evaluating and revising models converging on existing single-form models and comparing peer models and empirical testing: Ms M engaged students by evaluating and revising models original models. She suggested that models should copy target phenomenon, like solar systems sizing; colouring and the positions of stars should be correct or close to the target. Meanwhile, Ms O gave students the opportunity to present and discuss constructed models for evaluating and revising models. She picked different models and asked students: were there different? Why is the light bulb in this group off? Students then collaboratively discussed this, using peers' models and data from the experiment.

Theme 2: Science teachers primarily made instructional decisions based on standards books.
Ms M conducted activities to explain solar eclipse by promoting students to draw the sun and the moon at different distances, but she had no the reason to underpin the activity regarding modelling practices; she said that many books including standards books recommend this activity and that she adopted it with her students. Furthermore, Ms O taught students to draw circuit diagrams before conducting experiments as she followed standards book and the Ordinary National Educational Test (O-net).

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Develop cognitive structure tool that integrate self-discrepancy theory into STEM cognitive structure

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ABSTRACT

This study was based on the self-discrepancy theory (Higgins, Klein, & Strauman, 1985). Self-discrepancy theory indicated that actual-ideal discrepancy and actual-ought discrepancy were generally associated with different emotional syndromes. The aim of this study was developing cognitive structure tool to realize STEM field teachers whose self concept and views of STEM Teacher. Moreover, knowing the teachers' self-discrepancy of STEM.

The study had eight STEM field teachers. All participants were recruited to accomplish the "Views of STEM Teacher Questionnaire " and interview. This measure asked participants to list up to 10 traits or attributes associated with different self-concepts of STEM Teacher.

Thereafter, we compared the attributes in each self-concept and in the other dimensions to determine which attributes matched or mismatched. The self-concept discrepancy scores range of our study is +7 to -1. The data reavealed that the participant had more interdisciplinary experience had less self-discrepancy. Some attributes pairs were nonmatched, the meaning of attribute have partial overlap. So, we suggest to develope "STEM Field Chinese Semantic Space Construction". On the other hand, some participants felt shy to describe themselves or who couldn't figure out enough adjective. We consider to modify "Vews of STEM Teacher Questionnaire " question type to multiple choice can be improved. This project will enable researchers in the STEM field to have a deeper understanding of the current situation of STEM teachers in Taiwan.

KEYWORDS: STEM, self-discrepancy, self-concept

INTRODUCTION

STEM is an interdisciplinary subject. There are no specified STEM teachers. Not all Teachers are willing to teach a STEM class. With the challenges of interdisciplinary, disciplinary integration, inquiry, etc., how will the teacher's PCK be affected? And how should they respond?

This study was based on the self-discrepancy theory (Higgins, 1987; 1989; Higgins, et al., 1985). The self-discrepancy theory indicated that actual-ideal discrepancy was generally associated with dejection-related emotions and symptoms. However actual-ought discrepancy was generally associated with agitation-related emotions and symptoms. The aim of this study was to develope cognitive structure tool to realize STEM field teachers whose self concept and views of STEM Teacher.

RESEARCH PROCEDURE

The study had eight STEM field teachers. All participants were recruited to accomplish the "Views of STEM Teacher Questionnaire " and interview. This measure asked participants to list up to 10 traits or attributes associated with different self-concepts of STEM Teacher. The questionnaire had four dimensions: "Actual self(A)", "Ideal STEM teacher(I)", "Ought STEM teacher (O)"and " Significant others' views of the self(C) "(figure 1). Actual self: To write the attributes you think you actually are. "Ideal STEM teacher": asked subjects to describe your image for ideal STEM teacher. "Ought STEM teacher ": asked subjects to answer what attributes are a STEM teacher should have at least. The part of " significant others' views of the self " asked subjects to list the attributes of the work companion who believed you should or ought to be.

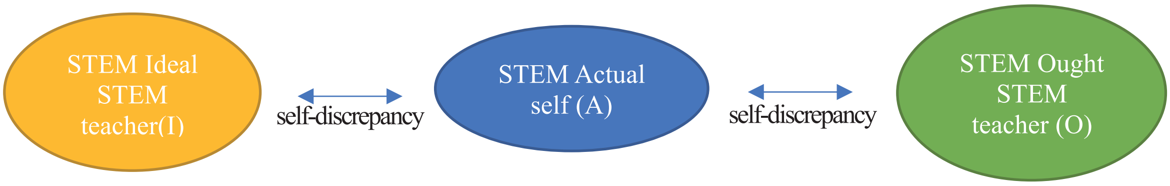

Figure 1. Self-discrepancy theory

FINDINGS

Thereafter, we compared the attributes in each self-concept and in the other dimensions to determine which attributes matched or mismatched. To subtract the total number of matches from the total number of mismatches. Thus, self-concept discrepancy scores could theoretically range from +10 to -10. The range of our study was +7 to -1. To test the reliability of this scoring procedure, two raters independents scored 20 randomly selected self-concept pairs. The interrater correlation was .86.

SUMMARY AND DISCUSSION

The data reavealed that the participant had more interdisciplinary experience had less self-discrepancy. Some attributes pairs were nonmatched, the meaning of attribute have partial overlap. So, we suggest to develope "STEM Field Chinese Semantic Space Construction".It can also be provided to community workers or general teachers to realize the mental representation of words in STEM field. On the other hand, some participants felt shy to describe themselves or who couldn't figure out enough adjective. We consider to modify "Views of STEM Teacher Questionnaire " question type to multiple choice can be improved. This project will enable researchers in the STEM field to have a deeper understanding of the current situation of STEM teachers in Taiwan. Through the STEM self-discrepancy theory cognitive structure tool, we can gain a better understanding of teachers or careers which have not yet entered the STEM field.

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Oral Session 5	Day3 (June20th) 13：00～14：30
Room7	C7-2

【Category】 7: Science Education for Policies and Others

=Chairperson=

Prof. Hiroki Fujii	Okayama University

=Presentation Program=

1	117-7-2-20-1（FY62-LUMC-OF021） Chatree Faikhamta（Kasetsart University） Tharuesean Prasoplarb, Kornkanok Lertdechapat, Samia Khan, R. Ahmad Zaky El Islami, Nguyen Van Bien, Le Hai My Ngan, Song Xue, Vipawadee Kwangmek *SCIENCE AND ENGINEERING PRACTICES IN SCIENCE CURRICULA: A COMPARATIVE ANALYSIS OF THAI, VIETNAMESE, INDONESIAN AND SCOTTISH CURRICULA*
2	118-7-2-20-2（FY5E-MNM2-VD021） Young-Shin Park（Chosun University） Gyu-Jin Hwang *The Development of the Global Energy STEAM program for Cultivating democratic citizen’s literacy and its implication in science education*
3	119-7-2-20-3（FY6W-KDQ5-T9021） Yue-jiong Su（Taiyuan No.61 Middle School） Guo-feng Zhang, Wen-hua Zhang, Zu-hao Wang *Research on the mechanism of integrating PCK knowledge between high school chemistry novice teachers and experiential teachers*

SCIENCE AND ENGINEERING PRACTICES IN SCIENCE CURRICULA: A COMPARATIVE ANALYSIS OF THAI, VIETNAMESE, INDONESIAN AND SCOTTISH CURRICULA

Chatree Faikhamta[1], Tharuesean Prasoplarb[1], Kornkanok Lertdechapat[1], Samia Khan[2], R. Ahmad Zaky El Islami[3], Nguyen Van Bien[4], Le Hai My Ngan[4], Song Xue[4], Vipawadee Kwangmek[1]

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4. *Hanoi National University of Education, Hanoi, Vietnam*

ABSTRACT

Science and engineering practices (SEPs) are one of the key learning goals of Science, Technology, Engineering, and Mathematics (STEM) education. There are few studies that compare similar SEPs in the science curricula of different countries. This study aims to compare SEPs in the science curricula of four countries (Indonesia, Scotland, Thailand, and Vietnam) in order to ascertain common knowledge and skills. Content analysis was used to analyse learning outcomes for grades seven to nine. The results showed that 1) desired learning outcomes in all four countries were consistent with science practices rather than with engineering practices and that they did not cover a number of SEPs. "Constructing scientific explanations" was found to have the highest frequency of the SEPs addressed in the curricula of the four countries, while "asking questions and defining problems" had the lowest overall average frequency. "Developing a model" was found more frequently in the Thai curriculum than in the Indonesian, Scottish, or Vietnamese curricula. The results of this study suggest that curriculum developers interested in broadening practices associated with science might revisit learning outcomes for the science curriculum in the areas of modelling and asking questions. Further research into the science curriculum could compare science or mathematics learning outcomes with the core disciplinary ideas, crosscutting concepts and the nature of each discipline, that are foundational in STEM education. Moreover, it would be worthwhile to investigate curriculum implementation of these practices by assessing teachers' instruction and students' STEM literacy.

INTRODUCTION

In response to the need for more curricular research in the area of STEM education, the present comparative study attempts to highlight the similarities and differences between countries regarding their Science and Engineering Practices (SEPs) suggested by US NGSS (Lead States, 2013). The main objective of this study was to compare the SEPs in the science curricula of four countries; Indonesia, Scotland, Thailand, and Vietnam. The four countries included in this study represent two distinct regions and historically divergent cultures: Scotland and Southeast Asia. Both also reflect the richness of a rapidly transforming educational system linked to new emerging economic power. These differences and similarities make it interesting to evaluate the links, spatial patterns, and differences within and across curricula.

RESEARCH METHODOLOGY

Following an interpretive paradigm (Cresswell and Miller, 2000), this research represents a comparative case study of science curricula. For the sake of comparison, the SEPs addressed in NGSS standards were used to inform the development of an initial practice framework. We aimed to build a nuanced understanding of the individual curricula in terms of their SEP practices. Care was taken to present the basis for SEP inclusion from a country-context perspective and not to present these practices as deviating from a supposed standard measure (e.g. the NGSS). Since learning outcomes in some countries are divided into a series of very short sentences or bulleted phrases, details of each curriculum were broken down into sub-SEPs, so that the learning outcomes could be classified and identified more clearly via content analysis.

CONCLUSION AND DISCUSSIONS

Our quantitative analysis revealed that Thailand and Vietnam had a greater number of total sub-SEPs than either Indonesia or Scotland in their science curriculum. Since Thailand, Vietnam, and Indonesia had newly revised their curriculum at the time of this analysis. The aims strongly emphasized students' authentic problem-solving and 21st century skills, and this emphasis may have resulted in many SEPs being included in the curriculum. Compared with Southeast Asian countries, the Scottish curriculum did not have as many SEP learning outcomes. The SEP, 'constructing scientific explanations and designing engineering solutions' was the most common SEP and was among the top three in all countries' 7-9 science curricula. In the Thai curriculum, the SEP was ranked first (32%), followed by the Vietnam curriculum, where it was ranked second (25%) as it was in the Scottish curriculum (23%); whereas it ranked third in the Indonesian curriculum (9%). Another SEP that all four countries emphasised was the third: 'planning and carrying out investigations'. Since all the countries have developed their curriculum based on the STEM approach, the engineering design process has been addressed as one of the key ideas. Teaching science is more integrated and engineering solutions inherently appeared to address real-world problems (NRC, 2014). Besides, Biology had Rich-SEPs in all four countries, while Physics and Chemistry had Rich-SEPs in three countries, excluding Scotland and Indonesia, respectively Even though space science was a topic in all of the countries in terms of SEPs, it had the most Some-SEPs, evident across three of the countries, with the exception of Vietnam, which but No-SEPs in this strand. Earth Science was similar, with all countries having Some-SEPs except Scotland, which had Rich SEPs. Only two strands, in two countries, showed No-SEPs; these were Astronomy in Vietnam's curriculum and Technology in Scotland's curriculum.

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The Development of the Global Energy STEAM program for Cultivating democratic citizen's literacy and its implication in science education

Young Shin Park[1] Gyu-Jin Hwang[2]

1.2. Chosun University, Korea

ABSTRACT

We analyzed how much democratic citizen literacy is included in the energy topic from K to 12 of science textbooks. The future democratic citizen literacy analyzing frame was developed on the basis of theories from literature reviews and practices expert meetings and it was finalized with the 8 categories; critical thinking, communication and collaboration, information management, sympathy, social responsibility, STS, self-direction, and decision making. The 'energy part' from the existing elementary, middle and high school science textbooks were analyzed to show how much democratic citizen literacy is included, and the results showed that the societal consensus was quite low, although critical thinking, communication and collaboration, and information management were dominantly included. In addition, decision-making, self-direction, the understandings of the relationship among STS, and social responsibility were shown, so the frequency was significantly low. The results imply that we can analyze and include if necessary the component of each democratic citizen literacy which is essential competency for the 21st century. The authors developed the energy themed general books for the citizen as well as students at schools in the 6 topics of energy (nuclear, wind, thermal, solar, hydrogen, and biomass energy) important in Korea with the aim of cultivating democratic citizen literacy. The results implied that the textbook writers and science curriculum policy makers need to consider including the part of cultivating democratic citizen literacy so that we can equip citizen as well as students with competencies to be 'act' as citizen scientists.

Keywords: *citizen literacy, STEAM, global energy, science education*

DEMOCRATIC CITIZEN LITERACY

The democratic civic competence that can be addressed in science focuses on the need for democratic citizens to be able to exercise their decision-making power through reflective thinking about the problems that arise in the future society. Also, we need to know that future social problems are deeply related to science and technology and we could withdraw the necessary competencies to carry out problem-solving processes based on scientific knowledge and scientific thinking.

We need standards for fostering democratic citizen literacy that must be achieved through the science curriculum. For scientific literacy in the 21st century, we plan to develop frame to analyze the energy topics from textbooks and develop new programs to enhance energy awareness with the focus of citizen literacy.

Table 1. Democratic citizen literacy frame

CATEGORY	DEFINITION	COMPONENT
Critical thinking **CT**	Logically explain the given problem and information and judge from various perspectives	Logical decision/divergent thinking
Communication & collaboration **CC**	Process of reaching a compromise when exchanging opinions with colleagues and others during scientific exploration and problem solving	Cooperative learning/discussion
Information management **IM**	Process of reaching a compromise when exchanging opinions with colleagues and others during scientific exploration and problem solving;	Data collection/data analysis/data representation

Sympathy **S**	There is an emotional part that we can share together and increase our empathy for it.	Emotional empathy/ethics
Social accountability **SA**	Feeling and expressing social responsibility closely with students' lives	Responsibility/accountability
Science, technology & society **STS**	Explain explicitly the link between technological development and social change.	Science and technology influence on society and its vice versa
Self-direction **SD**	Plan, execute and evaluate what you can do on your own personal level to solve the problem	Self-directed planning, implementing, and evaluating
Decision-making competency **DM**	To enhance decision making, various alternatives are presented and include discussion and discussion activities to compare them. Need to come up with an exact solution.	Exploring alternatives/decision making

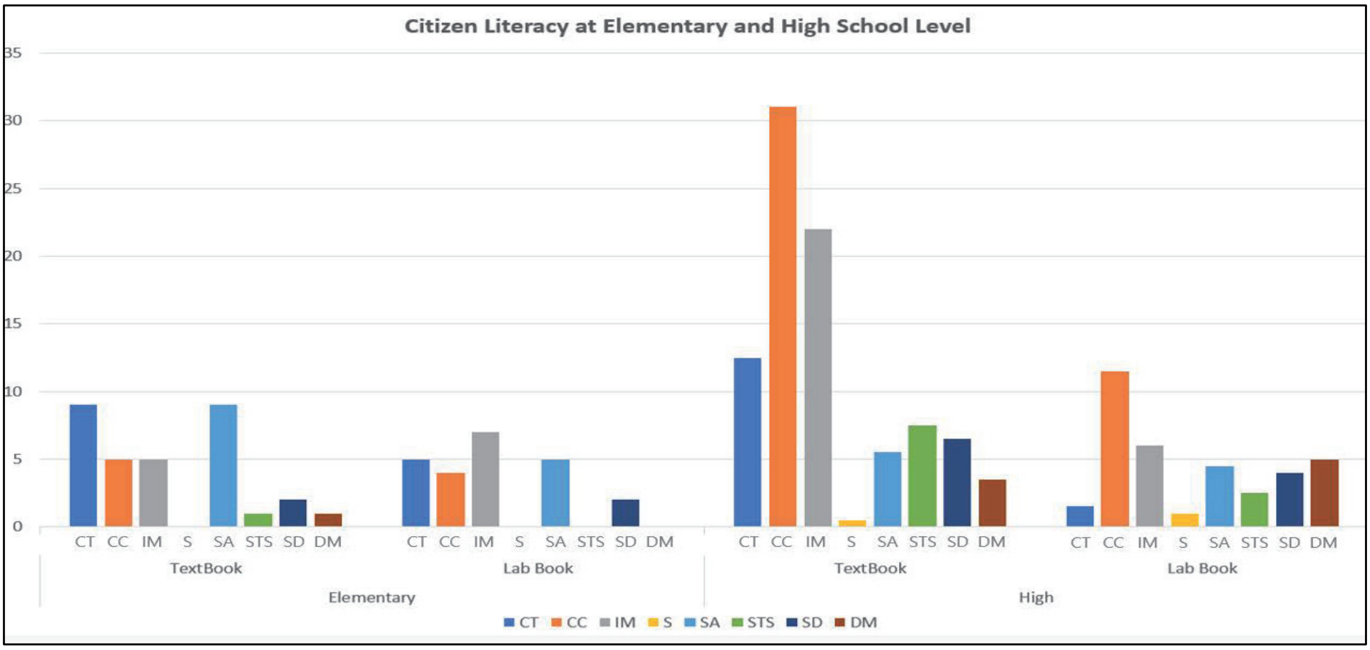

Figure 1. Citizen literacy pattern of one national textbook at elementary level (energy topics)

We developed new STEAM book with energy topics for citizen literacy on the basis of guideline which can lead teachers/educators to form understandings of citizen literacy with the global issues. We developed 6 energy issues for citizen literacy and each energy topic consists of the following 6 chapters.

Chapter	Content	Citizen Literacy
1.motivation (nuclear, I really wonder what that is)	Students can be motivated by cartoon showing what nuclear is on TV.	Critical thinking Social accountability
2. the trend of nuclear energy nationally and internationally	Students can learn concepts about nuclear energy.	STS Critical thinking
3. two faces of nuclear energy	There are issues in society, good or bad about nuclear energy so students experience those two aspects	Sympathy STS
4. what is my opinion?	Students in groups face real issues which they need to make decision for their society	IM CC/SA/DM/CC
5. My emotional travel with nuclear energy	Students become to know where they can be most exposed to radiation. The answer is smoking person.	SA Sympathy
6. If I were Einstein? Marie Curie? What I could do?	Students can experience scientists' attitude about their work. What would I do if I were scientist in the history? I could change the society in the history?	Sympathy SA

These new reading materials demonstrate we can include the components of citizen literacy in science, energy topics, which students as well as citizen must be equipped with for the next century.

Research on the mechanism of integrating PCK knowledge between high school chemistry novice teachers and experiential teachers

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ABSTRACT
Subject pedagogical knowledge (PCK) is a kind of knowledge that can represent the development and construction of teachers in long-term practice to transform subject content and pedagogy into a form that students can understand. It is an important standard to distinguish novice teachers from experienced teachers. However, there are few empirical studies on PCK representing teachers in China. It is not common to use PCK as a measure of teacher professional development. This study takes "Iron and Its Compounds", Chapter 3 of Chemistry Compulsory I in PEP as an example, and adopts Park's Pentagon model to analyze the PCK integration mechanism of novice teachers in open class and experienced teachers in regular class. The conclusion is as follows: novice teachers lack knowledge about students, and the ability to guide students to generate knowledge in the experiment needs to be improved; The evaluation method of scientific learning of experience-based teachers is simple; The formation mechanism of the teaching strategy knowledge of the two teachers is different, and it is found that the novice teacher can reach the level of the experience teacher in a short time by attending the open class. It is expected to provide reference for the empirical research on PCK in China.

Keywords: *PCK, Integration mechanism, Novice teacher, Experiential teacher*

Research method

The research methods adopted in this study mainly include literature research, classroom observation and semi-structured interview.

Research tool

Draw the qualitative coding table

According to the division of PCK components by Park(2008) and combined with the corresponding textbook and standard content of different lessons, each component was subdivided according to the level, and the respective qualitative coding tables of the two lessons were drawn.

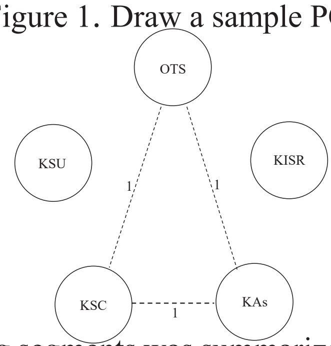
Transcription and coding of video

This study to teacher's classroom video transcribed in the first place, then divide the teaching segments, divided in each teaching section when PCK points of the components as far as possible to 1, and then USES the PCK five components of their unique combination of letters and Arabic numerals in the classroom teacher's behavior coding, first letter on behalf of PCK five components, Arabic numerals represent the dimensions under each component and are arranged in sequence. For example, "O1", "O2" and "O3" respectively represent the three dimensions under OTS. In order to reduce the influence of individual subjectivity of the researcher, in the process of coding, in addition to the author's own coding, this study also invited two other pre-service teachers who were also conducting PCK analysis to participate in the coding. Finally, the points after the three people's coding were respectively summarized to take the average value.

Determination of evaluation tools

In this study, Park's (2008) Pentagon model was used as a tool to measure PCK components among different teachers. Before delving into the definitive description of PCK, the author uses the Pentagon model, the PCK map, as the analytical device, which represents the connecting components between the components of PCK. PCK maps are drawn for each teaching segment according to the coding table, and each teaching segment must have at least one identified connection between any two components in a special way. For example, if OTS, KSC, and KAS are present in a particular PCK fragment, then a connection is recorded between any two of the three connections shown in Figure 1. For the sake of analysis, we assume that each connection has a strength of 1.

Figure 1. Draw a sample PCK map



Then, the PCK map of all teaching segments was summarized, and the connection strength between each component was added up, and finally the connection strength between each component and other components was added up to obtain the PCK map of two teachers under a specific topic, as shown in Table 1.

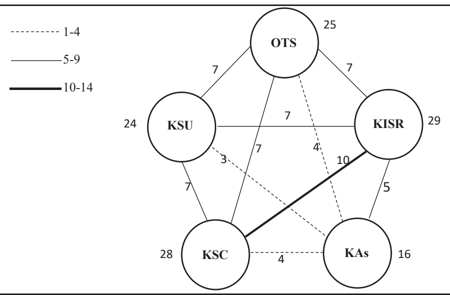
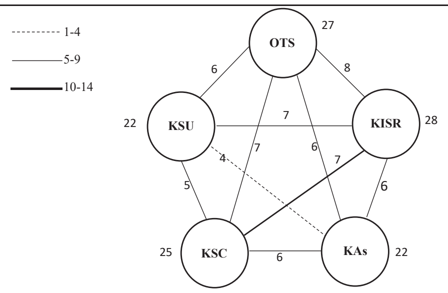
<table>
<tr><td>H Teacher 's PCK map under the topic "Iron and its compounds"</td><td>L Teacher's PCK map under the project "Study of Inorganic Properties with Valence 2-D Digraphs Using Ferric and Ferric Salts as Examples"</td></tr>
<tr><td>
</td><td>
</td></tr>
</table>

Table 1. PCK maps for teacher H and teacher L

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Poster Session

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C-2	Kazushige Mizobe, Koki Hirakawa, Tetsuya Iwamoto *Children's Awareness for ''Soil'' focusing on Linguistic Expressions based on Various Senses before Observation and Experiment*
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C-2	Chao-Fang Yang, Yu-Ling Lu *Learn science in first- or third-person perspectives? Effects on students' growth on scientific knowledge and argumentation skills*
C-3	Thanyarat Suwannatrai, Theerapong Sangpradit *Exploring Scientific Argumentation Skills in Socio-Scientific Issues of 8th Grade Students*

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Poster Session

C-3	Tharuesean Prasoplarb, Chatree Faikhamta *Argumentation Practice as Embedded in Thailand’s Science Teacher Guidebooks for the Junior High School Level*
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Dairy Farming Education: Fostering Competencies for Sustainable Development Goals among Young Children

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Introduction

Education for Sustainable Development Goals (SDGs) includes "Education for Sustainable Development (ESD)" and "Global Citizenship Education (GCED)" (Okitsu, 2019). While competencies for ESD include critical thinking, the ability to predict and plan the future, and communication skills (National Institute for Educational Policy Research, 2012), those for GCED include conflict resolution skills, perspective-taking skills, and dialogue (Kobayashi, 2018). Dairy farming education has the potential to foster these competencies among children (Japan Dairy Council, 2019).

The purpose of study

This study aims to clarify **what kind of competencies for SDGs are fostered** among children with dairy farming education.

Conclusion

- The children showed **perspective taking** skills.
- The children showed **conflict resolution** skills.
- The children demonstrated **communication** skills.

Methods

Methods	Protocol analysis
Targets	80 young children 2–3 years old
Years	2019 December

Program activities

① Feeding cows.

② Contact with cows.

Results

Program activities	Utterance or Action	Interpretation	Skill
①	“ This cow is already full ”	The word is cow-conscious, indicating the child thought from the cow's perspective.	Perspective taking skills.
	The children overcame their fear of cows with the help of dairy farmers and teachers.	It can be interpreted that the conflict of a child who is scared but wants to approach a cow has been resolved.	Conflict resolution skills.
②	“ I was licked ”	While using these words, the child and the calf communicated.	Communication skills.
	“ Come on! Come on! Come on! ”		

Discussion

The above results indicate that dairy farming education can foster competencies for SDGs among children.

These conclusions have limitations in that they are based only on children. Therefore, there is a need to expand the survey target to elementary and junior high school students.

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Children's Awareness for "Soil" focusing on Linguistic Expressions based on Various Senses before Observation and Experiment

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Koki Hirakawa (Furuichi Elementary School, Osaka, Japan)
Tetsuya Iwamoto (Ajihara Elementary School, Osaka, Japan)

Introduction Recently, our research group has been engaged in basic research on science learning that emphasizes the utilization of various senses. For example, reports on water (Iwamoto et al. 2017, Satake et al. 2020), light (Iwamoto et al. 2019a), sound (Iwamoto et al. 2018, 2019b), magnets (Iwamoto et al. 2019c) and plants (Sakata et al. 2020, Iwamoto et al. 2020a 2020b) can be mentioned. We have also reported on stones and soil (Satake et al. 2019, Iwamoto et al. 2021, Hirakawa et al. 2021). However, no research has been conducted on how students have the image of the subject before learning to exercise the senses. It is expected that the recall of memory by various senses will differ depending on the subject.

Purpose The purpose of this study was to clarify how the various senses are used to grasp the natural object (soil) before the experiment / observation conducted by using the various senses. From the results, it is expected to clarify the basis of the prediction and the reason for the order of the senses that work during experiment / observation in the future research.

Method The survey was conducted in October 2020 on 4th grade elementary school children (30 students). We classified the linguistic notations based on various senses (visual, auditory, and tactile) about the image of the difference between soil, sand, mud, and clay before the experiment / observation, and compared the numbers.

Result In the classification of all expressions (448), there are visual 202 (color: 122, large and small: 80), tactile sense 210 (hardness: 45 weight: 78, surface: 36, dampness: 36, others 15), and auditory (sound) 36(Table.1). So it turned out that two senses were concentrated. In "Soil (34)", "Visual: Color" mainly includes brown (21) and dark brown (8), and "Sand (32)" has ocher (10) and skin color (10). There were gray (6) and Nezumi (rat) color (6) in "Clay (25)". In "Mud (31)", there were many dark browns (19). Therefore it was found that the color change was clear depending on the type. In the tactile sense (weight: 78), about 20 words were evenly expressed in all types, but in the tactile sense (hardness: 45), variations were observed. In the sense of touch (surface: 36), there were many "Sara-Sara" in "Sand (26)" and in the sense of touch (moisture: 36), there were many "Doro-Doro" in "Mud (24)".

Discussion When students image "soil", many notations were made for the two senses, so it is thought that there is much understanding as a multi-modality effect for the two senses. Although the visual sense was concentrated on the colors, there are many similarities in the way they are perceived, and it is thought that there is little discomfort. It has become clear that the tactile sense is perceived from various viewpoints such as hardness, weight, and dampness, and it is considered that the difference in the tactile sense causes a difference in the prediction and the procedure of experiment / observation.

Table.1

Sense		Number
Visual	color	122
	large/small	88
Auditory	sound	36
Tactile	hardness	210
	weight	78
	surface	36
	dampness	36
	others	15

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Reconnect self, others and nature

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Abstract

Modern lifestyle that is based on ideologies such as consumerism, individualism and materialism has led to overconsumption, mass extinction and climate change in the world and threatens the wellbeing of every member on this planet. We conducted a hermenrutic phenomenological study of a female British teacher-researcher, Diana (psuedonym), who develop a mindfulness program for cultivating a sustainble lifestyle among her school community for the past 11 years. We concluded that embracing polysemia and respecting the existence of every human being, animal, plant, and mineral of the whole ecosystem is vital for meaningful transformations at individual and societal level.

Overcoming the Ignorance of Dualism

The problems of the modern education system come from an overemphasis on attainment and dualistic thinking (e.g. self Vs others, human beings Vs animals). However, mindfulness offers relief to this drivenness by bringing people back to here-and-now and nurtures a nondiscriminant worldview. Diana's authentic inquiry aims to enhance her community's self-awareness, empathy, and environmental awareness through practicing mindfulness in daily life activities, such as eating, walking, sitting, breathing,.

Mindful Consumption

Diana's mindfulness program is based on the Plum Village's Five Mindfulness Practice (i.e., reverence for life, true love, true happiness, loving speech & deep listening, nourishment & healing)

- ***Taking care of self*** - 3 to 5 mins breathing exercise, food contemplation, contemplate "what am I made of"
- ***Taking care of others*** - buddy system, active listening, conflict role play
- ***Taking care of nature*** - Making promises to nature, hugging trees, walking in nature

Interbeing

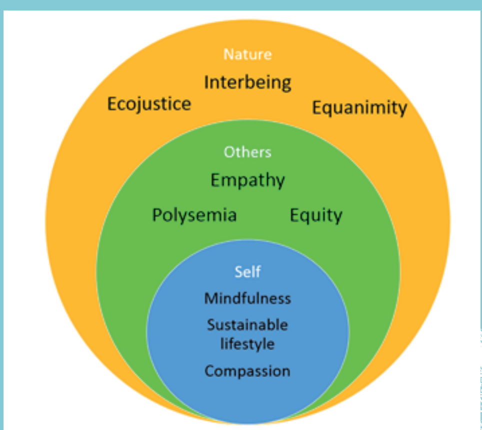
Diana used place-based learning (e.g. visiting the school garden with her students, hugging trees, playing with little animals) to nurture the insight of ***interbeing***, that is, our existence and wellbeing are not separated from everything in the environment among young children. Such insight allows her students to understand that causing harm to others is the same as causing harm to themselves. Moreover, her students formed a close emotional bond with other species, which nurtures the seeds of joy, empathy, and compassion within them.

Building a Sangha

Our ego-centric lifestyle assumes that human beings are separate from each other and that we have to compete against each other to get to the top of the food chain. Diana took several steps to reconnect with her community to overcome loneliness and selfishness:

- ***Mindfulness Professional Learning Community (2017 to 2019)*** - weekly practice, sharing lesson plans, organizing workshops and courses for other teachers, retreats
- ***Mindfulness for families (2018 to 2020)*** - self-care, care for family, care for community

Authentic Inquiry for Sustainable Lifestyle



A more polysemic, conscious, & compassionate future

Diana's story is an example of authentic inquiry, in which she constantly applied what she had learned to her teaching practices in an emergent and contingent way. Based on her lived experiences, there a few insights for science educators to implement an impactful education for sustainable development:

- Nurture the understanding of interbeing since early age through mindfulness practice
- Begin from being present and aware of oneself, then share compassion with others
- Include the voice of every member of our ecosystem (human beings, animals, plants, minerals)
- Meaningful social transformation comes from changing individuals' worldview and lifestyle

Learn science in first- or third-person perspectives? Effects on students' growth on scientific knowledge and argumentation skills

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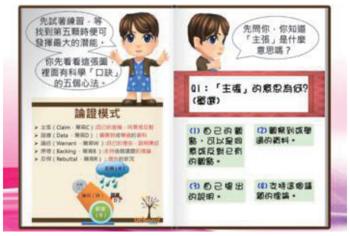
INTRODUCTION

Emerging media are increasingly used in science learning, yet the effect of first- or third-person perspectives that student used in learning has not been well explored. Florella et al. (2017) pointed out the importance of this issue and further studied college students' learning in assembling circuit. They found the effect of perspective does exist. However, not enough studies addressed the perspective effect on younger students and on learning broader scientific literacy.

METHODOLOGY

This study divided 84 six-grade students, ages 11–12, into two experimental groups: (1) the first-person perspective learning group (F-PP), who learned with a first-person game, and (2) the third-person perspective learning group (T-PP), who learned with a third-person e-book. The learning materials were developed for this study and controlled to having equivalent contents. To monitor students' learning growth, two tests were used—scientific concept test and the scientific argumentation skills test. T-test and ANCOVA were used to examine the comparative effectiveness after 15 classes (each of 40 minutes).

the first-person perspective learning



the third-person perspective learning

RESULTS

Results showed that: a) F-PP and T-PP both significantly improved students' scientific knowledge and argumentation skills; b) F-PP and T-PP were equally well in helping students learn scientific knowledge; and c) F-PP led to significantly better learning of argumentation skills.

CONCLUSIONS

The study empirically supports that, when giving students first-person learning experiences which is more learner-centred, more student power enhances motivation and engagement, and thus facilitates learning (Cochran et al, 2017).

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Exploring Scientific Argumentation Skills in Socio-Scientific Issues of 8th Grade Students

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Introduction

In today's society, there are a number of problems that arise as a result of advances in science and technology, including Socio-scientific issues. Causing conflicts of people who do not have the same opinion (Toulmin, 2003). When students are in the society of science, scientific argumentation skills are required because scientific argumentation is important for students to express their opinions, make decisions and solve problems in daily life (Driver, 2000).

Therefore, teachers should provide instruction that promotes the scientific argumentation skills for students and explore scientific argumentation skills as a basis for the development of learning management that promotes the skills of scientific arguments in class continue.

purpose of research

This research aims to explore scientific argumentation skills in Socio-scientific issues of eighth grade students at a secondary school in Samutprakarn province.

Research procedures and methods

01 Participants

200 eight grade students in a secondary school in Samutprakarn province.

02 Instruments

The scientific argumentation skills test in Socio-Scientific Issues. The test was an open-ended question with 2 scenarios. The first scenario provided information about use of fossil fuels and renewable energy, the second scenario provided information about food containing preservatives. Each scenario, had 4 questions according to 4 components of scientific argumentation skills: claims and warrants, counterargument, supportive arguments and evidence (Lin & Mintzes, 2010) .

03 Data analysis

1. Analyzed learner responses individually and them according to the quality level in each component of scientific argument skills by finding the average percentage and comparing with the criteria.

Low	Middle	High
0.00-0.99	1.00-1.99	2.00

2. Content analysis for a detailed overview of each answer to support students' scientific argument skills.

Results

The results of the survey on scientific argumentation skills in Socio-scientific issues of eighth grade students by using a scientific argumentation skills test showed in Figure 1.

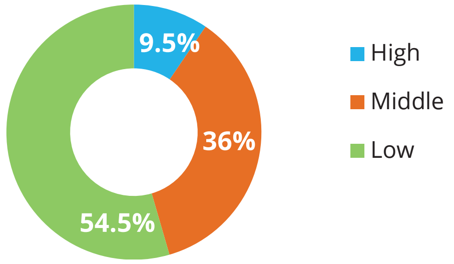

Figure 1. The percentage of student in each level of scientific argumentation skills.

The scientific argumentation skills of eighth grade students, classified by components of scientific argumentation skills showed in Figure 2.

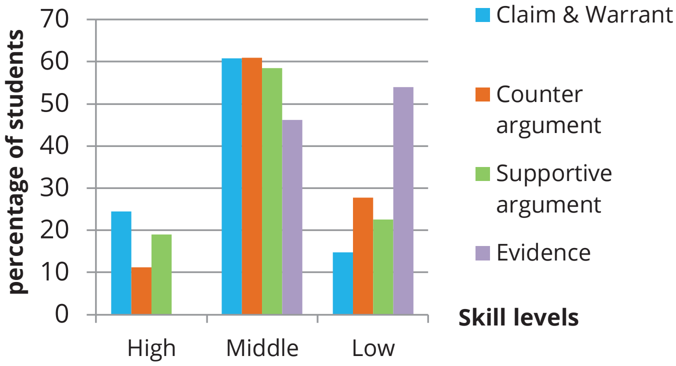

Figure 2. The percentage of student in each level of scientific argumentation skills, classified by components of scientific argumentation skills.

The results meant that the students were able to state their claims but they can not provide enough reasons to support and the students were unable to construct an argument and scientific explanation from the evidence. Moreover, the students were unable to find evidence to support their credible reasoning.

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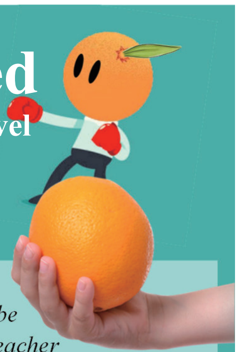
Argumentation Practice as Embedded

in Thailand's Science Teacher Guidebooks for the Junior High School Level



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ABSTRACT

Argumentation Practice (AP) is one of the most important goals of learning science. It is expected to be addressed in science curricula, teachers' manuals and teaching practices in the classroom. The Science Teacher Guidebook (STG) became one of the guides for supporting teachers in designing activities and challenging students to practice argumentation. However, the introduction of an epistemic understanding of the practice would shift science teachers' focus to valuing the purpose, function, and context of AP in this integrated learning era. Therefore, this study aims to examine how AP is embedded in the 2021 version of the guidebook from the Institute for the Promotion of Teaching Science and Technology (IPST) in Thailand. All guided questions from 21 units of learning covering grades seven to nine were analyzed by inductive content analysis through the synthesis framework of the Epistemics of Argumentation Practice (EOAP) embedded with three aspects : the nature of practices (NOP), the context of practices (COP), and the teaching of practices (TOP). The results indicated that quality-guided questions would lead to AP through the context established in the list of guided questions between each lesson. The guiding questions for classroom discussion after each activity led to more engaged AP with the purpose of argumentation as verification and persuasion. This research concludes that the EOAP framework is a powerful tool for teachers to use with guided questions from STGs to develop students' AP and other practices for further study.

INTRODUCTION

Argumentation Practice (AP) is the one of crucial science practice which engage in ways of reasoning and communicating (Osborne, 2014) while further as the critiquing (Kite et al., 2020). Understanding of epistemic would enhance learner about how science knowledge is constructed and why to revised them over time (McNeill et al., 2104) with to realize the purposes and values of learning science (Knight and McNeill, 2012). To support teacher to design learning activity with argumentation requires teacher's understanding about nature and context of argumentation, that becomes a key challenge to enact science practice into the classroom (Sengul et al., 2020). Those requirements lead this study to investigate and to revise Thailand's STG for grade 7 to 9 through the framework of EOAP to empower teacher's teaching AP in Thailand's science classroom.

RESEARCH QUESTION

How do Thailand's Science Teacher Guidebooks for grade 7 to 9 present the Epistemics of Argumentation Practice aspects with respect to instruction-embeddedness

METHODOLOGY

This study employed a qualitative research design that utilized a structured and content analysis of six Thailand's Science Teacher Guidebooks which is included 21 units of teaching. This aspects of argumentation practice in the literature was synthesized as a framework EOAP to indicate and generate code on each instruction. Data were analysed using the inductive process, finding the patterns, and synthesizing as a theme of finding.

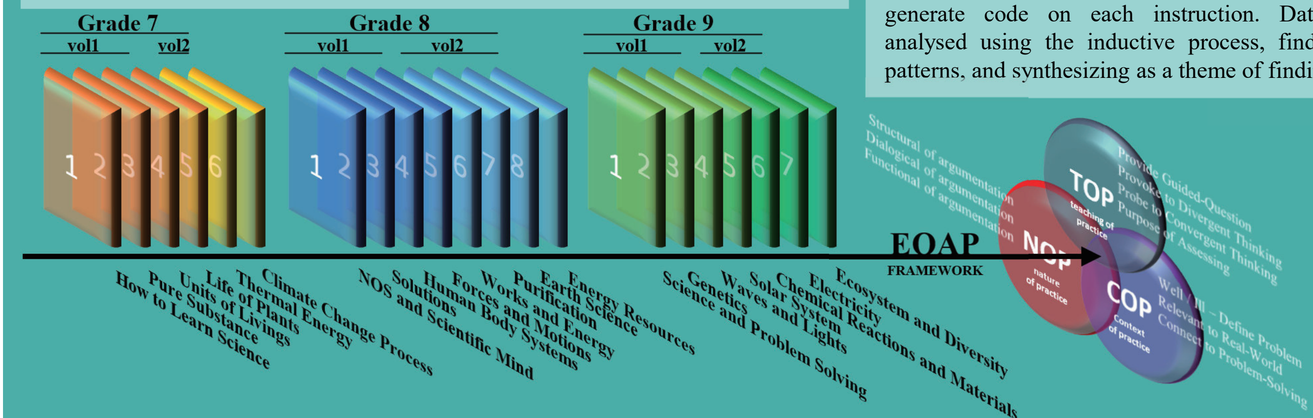

Figure 1 The Learning Units through EOAP Framework

FINDINGS

Theme 1: The intro unit required more strategies/guided of sensemaking through AP

The introduction unit 'How to Learn Science', 'NOS & Scientific Mind', and 'Science and Problem Solving' of grade 7, 8, and 9 respectively are the room for learners to understand the purposes and values of learning science with content-free. Argumentation practice would shift or experience learners about practicing science further the sensemaking on the next unit. While mostly codes on the introduction unit limited as the 'open-end question' 'read and discuss', but would be more completed by verification / persuasion on each other claims or ideas.

Theme 2: Topic-review question connected science classroom and authentic context

At the end of each topic in guidebooks, the question list elaborated both nature and context of argumentation practice but it depends on teacher's instruction to engage learner's claims or solutions with the data from experiment or explicit evidence from their previous studies. Those session were analyzed for both functions in the same time; first, the question list would be used as the formative assessment on learner's argumentation; second, the question list would allow learner to shift their own learning science in the classroom to practicing science on the context.

CONCLUSION/DISCUSSIONS

Teacher Guidebooks become the one important tools for teacher to design an instruction or an activity on reforming education as focusing on teaching practice. With this research EOAP framework, the future study would elaborate on the rest science practices that are distinct and unique to complete the integrated science with other disciplines. Further, PCK for teaching argumentation practice is the key to support teacher from pre - paring the argumentation issue to the assessment learner's argumentation

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CLIMATE CHANGE EDUCATION: A BIBLIOMETRIC ANALYSIS

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ABSTRACT

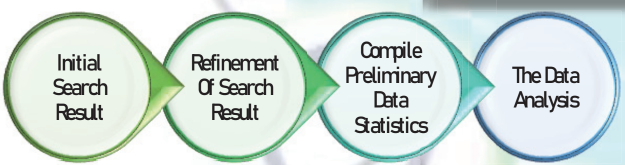
Climate change education is a topic of concern for current research. The concept of climate change education is often related to skills, knowledge and competencies. Currently, the including of climate change education concept in the context of Education Sustainable Developments is still needed, especially in the field of geoscience education. This article aims to provide a review of the bibliometric literature on climate change education. Articles were searched with the Publish or Perish (PoP) software with the google scholar database from 2019-2021. A total of 40 out of 100 articles were analyzed in this study. Selected articles are then managed using the Zotero software. The managed articles are then classified and visualized using VOSviewer software. In general, this study provides a comprehensive reference for further research on climate change education.

Keywords: *climate change education, climate literacy, education sustainable development*

1. BACKGROUND

Climate change is a phenomenon that is of great concern to industry and developing countries. This phenomenon will have a negative impact on the planet, people and natural resources. The majority of scientists in the world believe that global climate change is caused by human activities and they are commited to reducing the rate of increase in the global average temperature by no more than 1.5 C from 1990 (IPCC, 2018). In addition, climate change also greatly affects the economic stability, safety, and sustainability of an environment. Therefore, one of the mitigations that can be done is to integrate climate change education at all levels of education. Educated people are more aware of the risks posed by climate change and better equipped to make informed decisions about responses at local, national and international scales. While climate change education is important at all levels, from primary school to university (UN CC: Learn, 2013), it is the higher education sector that is most in need of developing a systemic approach (Leal Filho, 2010; Leal Filho et al., 2018). This shows that education about climate change is one of the topics of concern by some education experts. Several researchers have also studied geoscience education as a means to develop students' climate literacy (Clary & Wandersee, 2014; Cook, Bedford, & Mandia, 2014; Dewaters, Andersen, Calderwood, & Powers, 2014; Uz et al., 2014) . Currently, education for climate change is still not a priority, although the Paris Agreement encourages countries to increase education, training, public awareness, public participation in information about climate change. The Paris Agreement also encourages the creation of educational programs that can ensure graduates have an understanding of the challenges and impacts posed by climate change. In addition, they are also required to have skills on climate change mitigation. Considering the reasons, this article aims to fill the research gap by providing an extensive bibliometric analysis of the literature in relation to climate change education.

2. METHOD



3. RESULTS AND DISCUSSION

The results of the bibliometric analysis of 'climate change education' can be visualized in 3 parts, namely data visualization network (Figure 1), overlay visualization (Figure 2), and density visualization (Figure 3). The results of the analysis show that research on climate change education related to environmental competence and eco-enxiety is still very limited (as shown in Figure 1). In addition, the results of the overlay analysis shown in Figure 2 also show that research on climate change education related to environmental competency is still relatively new. This provides evidence that currently research on climate change education related to environmental competence still needs to be researched. This assumption is supported by a visualization of density which shows that research linking climate change education and environmental education is still very limited. The results of this analysis provide an opportunity for researchers to conduct further research on the relationship between climate change education and the environment.

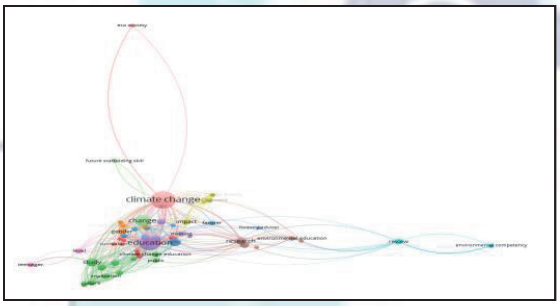


Figure 1. Network visualization on the GS database

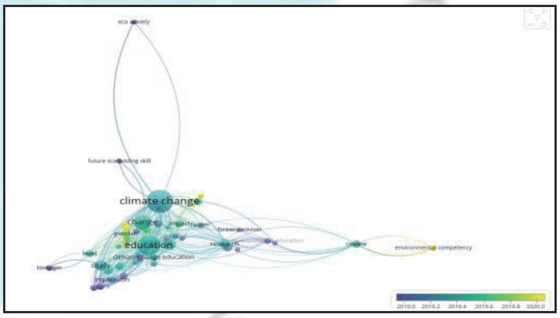


Figure 2. Visualization of overlays on the GS data base

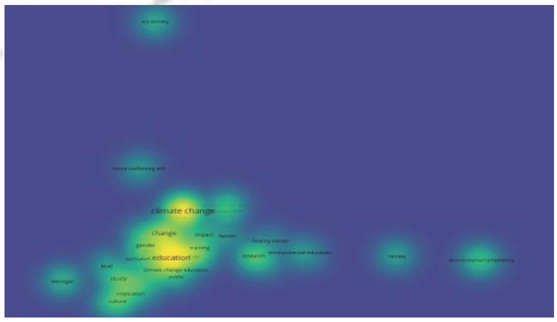


Figure 3. Visualization of density on the GS database

4. CONCLUSION

These results indicated that research on the relationship between climate change education and the environment is still rarely done. In addition, studies on climate change education which are associated with eco anxiety are also very limited. Therefore, the results of this bibliometric analysis provide information that research on climate change education and environmental education is a very important to be studied.

A Systematic Review of Teacher Competency Trends in Teachers' Education

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Abstract

The purpose of this study is to study the research trends on teacher education competency from 169 articles in the Journal of Teacher Education. We discovered trends of author and country contributions, participants, strategies, and teachers' competencies through the identification, critical evaluation, and summarizing of findings. The results show that the highest contributions of articles came from the United States, which focuses on improving teachers' learning and preparation in developing teaching strategy competencies. The findings also indicate the importance of teachers' preparation process; we suggest that future studies should focus on in-depth preparation of teachers' knowledge and skills, such as classroom practice transformation, improved learning achievement, pedagogical content knowledge, content knowledge, communication skills, social communication skills and instructional design skills, and outcomes that fit 21st-century teaching.

Keywords: Systematic review, research trends, teachers' competencies, teacher education

Introduction

Currently, the trend of research in teacher education has been emphasized by focusing on improving the skills to fit with 21st-century skills development which enhancing the identity and ability of teachers such as teacher's education and preparation (Bocala, 2015). Besides that, teachers' quality and how teachers work in the application of teaching have been highly recognized as critical essentials in teacher education. Recently studied by Chong & Cheah (2009) has shown that teachers' quality and teachers' work could be known by teachers' skills and knowledge which identified by the components and core values of the curriculum through developing values, skills, and knowledge. However, Medeiros et al (2018) described that teachers' skills and knowledge could be shown by the abilities and problem-solving skill which implemented by the pedagogical intervention, evaluation of students' performance or feedback and observation of classroom activities. To access the limitation and discussion of research, this study was to focus on the trends of competencies and the strategies for achieving the competencies of teacher education from the Journal of Teacher Education in the period of 2015–2020.

Methods

This study was to investigate the authors' and countries' contributions, participants, the trend of teachers' competencies, and teachers' strategies for the competency of teacher education by focusing on the thematic analysis and narrative summary (Dixon-Woods et al., 2005). We focused on the keywords of teachers' competencies from 169 articles. Then, we identified, critically evaluated, and summarized recent studies of teachers' competencies and strategies into 90 articles. However, we adopted and modified the work of Polanin et al (2017) to searching and screening the current trend issues on the competencies of teacher education, deciding the eligibility criteria of authors' and countries' contributions clearly reported in the articles on teacher education in the title or the abstract, and selecting the findings of the literature review process by using inclusion and exclusion criteria.

Acknowledgements

We would like to thank the Royal Golden Jubilee Ph.D. program (PHD/0149/2561).

Results

Table 1. Authors and countries' contributions in the year of 2015–2020

Countries	No.
USA	208
Germany	10
Belgium	8
Israel	8
Holland	6
Singapore	5
Australia	5
Canada	3
UK	3
Columbia	2
Turkey	2
Norway	2
China	2
Sweden	1
Spain	1

Fig 1. The details of the participants in the JTE during 2015–2020

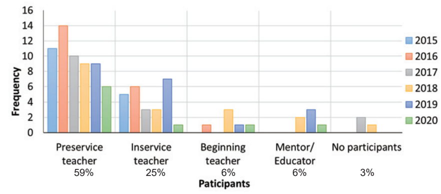
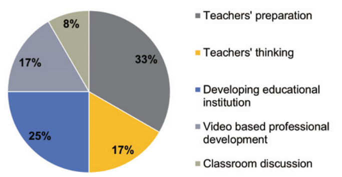


Table 2. Trend of teachers' competencies from 2015 to 2020

Competency	Number of articles
Teachers' learning	17
Teachers' beliefs	10
Classroom practice transformation	9
Collaborative/cooperative teachers' learning	9
Improved learning achievement	9
Pedagogical content knowledge	9
Content knowledge	9
Teaching experiences	9
Teacher identity	7
Communication skills and social communication skills	6
Professional practice	6
Instructional design skills and outcomes	6
Critical teacher discussions	5
Field experiences	5
Instructional teaching	5
Others	16

Fig 2. The spread of teachers' strategies during 2015 - 2020



Discussion & Conclusion

The results indicated that most authors and countries are coming from the United States (208 authors) by focusing on investigative preservice teachers/ novice teachers' preparations, experiences, and outcomes (58 %) (e.g. Coogle et al., 2020) and indicated that teachers have little experience in practice for teaching in the classroom by focusing on developing educational institutions and communication (25%).

Other findings established to improve the competencies of teachers' attitudes such as teachers' learning, teachers' beliefs, and teachers' knowledge: classroom practice transformation, improved learning achievement, pedagogical content knowledge, and content knowledge (López (2017) and teachers' skills (communication skills and social communication skills and instructional design skills and outcomes) (e.g. Coogle et al., 2020), and teachers' attitudes such as teacher identity and professional practice (e.g. López, 2017).

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Recognition of primary school teachers about distance learning in science education due to the pandemic situation in Korea

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Introduction

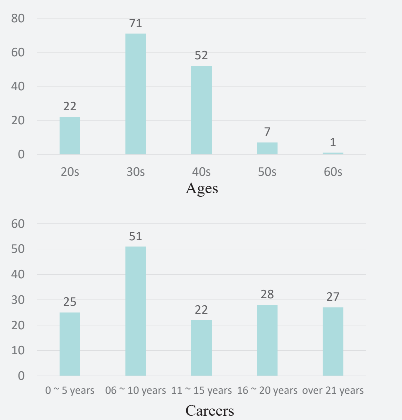
- The crisis of social, economic, and public health caused by COVID-19 is continuing on a global scale. Not ending with a short-term social disconnect, the COVID-19 pandemic is not only threatening many lives and causing economic difficulties but also drastically changing the educational environment.
- According to UNESCO, schools in at least 165 countries were closed during the pandemic, and more than 500 million students suspended their study. After schools closed, many governments switched to distance education.
- Though in some tertiary institutions in Korea, the infrastructure for distance learning has been established and learning classes are currently being conducted, in the case of elementary institutions, sudden change of distance learning caused a great of confusion in schools. In Korea, basic investigation for difficulties in schools has not yet been conducted.
- In this study, we will research the perception of primary school teachers who have experienced distance learning due to the COVID-19 through a questionnaire and a focus interview to determine the future direction of distance learning on science education.

Method

❖ Timelines about schools due to the COVID-19 in 2020

Date	Content	Note
20, Jan	The1st patient due to the COVID-19 in Korea	
19, Feb	The 1st death due to the COVID-19 in Korea	
23, Feb	The Ministry of Education announced to delay the begining of school in one week	The normal date of the begining of school is the 2nd March in Korea
28, Feb	2nd delay in three weeks	
17, March	3rd delay in another two weeks	
31, March	The Ministry of Education announced to start distance learning in schools	
9, April	To Start distance learning	
4, May	The Ministry of Education announced to start classroom learning from the13th May	
11, May	To delay classroom learning to the 20th May	
20, May	To stop classroom learning	
	Less summer vacation in August	
25, Aug	To order the distance learning in schools except 12th students for SAT test	
3, Dec	SAT test	2 weeks late comparing to the normal date

❖ Participants of Questionnaires (N=153)

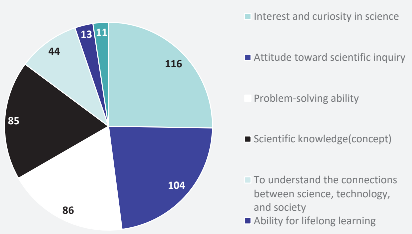


❖ Participants of Focus Interview (N=9)

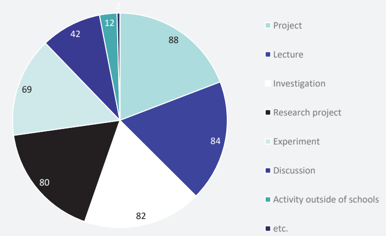
No.	Gender	Ages	Careers in teaching	Roles in 2020 and 2021	Area
1	Female	40s	17	Science teacher	Small Town
2	Male	30s	8	Homeroom teacher of 5th grade	City
3	Male	30s	8	Homeroom teacher of 5th grade	City
4	Female	30s	11	Homeroom teacher of 5th and 6th grade	City
5	Female	40s	10	Homeroom teacher of 6th grade	City
6	Female	20s	7	Homeroom teacher of 5th grade	City
7	Male	30s	10	Homeroom teacher of 3rd and 5th grade	City
8	Female	30s	9	Science teacher	City
9	Female	30s	16	Homeroom teacher of 3rd grade	City

Result

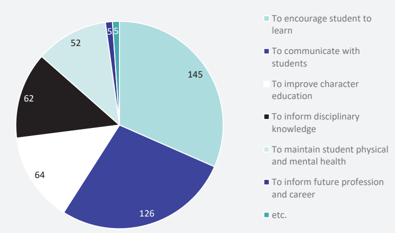
Question 1. What is important in science class with the distance learning?



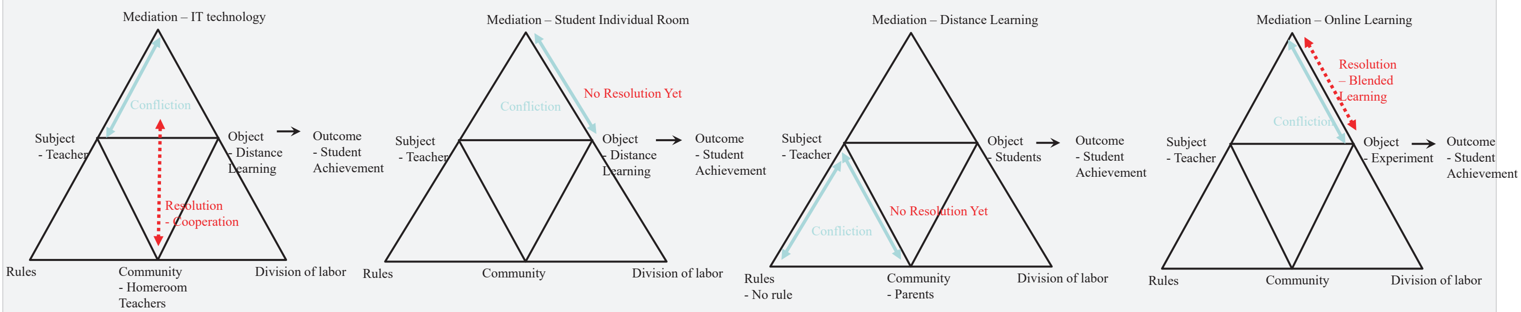
Question 2. What teaching method is proper to achieve aims of education in the pandemic situation?



Question 3. Which role of teacher7s is important in the pandemic situation?



Focus Interview. What difficulties or conflictions were in online classroom with distance learning?
How did teachers resolve the difficulties related to online classroom with distance learning?



Conclusion

1. Primary school teachers thought that their roles were to encourage students to learn and to communicate with them rather than to inform disciplinary knowledge in pandemic situation. However, lecture was still a favorite teaching method among primary school teachers.
2. Distance learning enhanced the cooperation between homeroom teachers to resolve the problems which were caused by their poor skills in IT technologies.
3. Technical difficulties including absence of student own room, which caused confliction against distance learning, was not resolved.
4. Confliction between teachers and parents due to more contacts among in pandemic situation were not resolved.
5. Primary school teachers tried blended-learning to help students conduct experiments instead of online learning.

Science gifted students' perception of Scientists' Social Responsibility

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Pusan National University

Introduction

- Today, the development of science and technology has become a threat to the ecosystem including humans, while improving the quality of life. This is because there has been an 'ethical gap' in which ethical discussions cannot keep up with the rapid development of science and technology.
- Accordingly, the 'responsibility ethics' proposed as a new future ethic saw that the present-generation human beings should have not only ex-post responsibilities as agents of actions, but also pre-emptive responsibilities and obligations for life and the future.
- Most of the students showed a high level of understanding of scientific knowledge and methods, but their perception of the relationship between science and society and the responsibility of scientists as subjects of scientific activities was very low(Kim, 2012).
- In addition, there is no systematic discussion of responsibility in society as a whole(Song, 2011).
- Therefore, based on an understanding of the role of scientists in society, education about who scientists are, what they do, and their responsibilities is necessary for future citizens and scientists.

Research purpose

This study aimed to analyze science gifted students' perception of scientists' social responsibility and to discuss the necessity of responsible ethics in science education.

Rationale

perceptions of scientists

- Traditionally, the meaning of a scientist has been perceived as a person who discovers answers by exploring nature, asking questions, and exploring scientific knowledge.
- However, today scientist is a person with the qualities for a role as a member of society, and it is presented as an image of a scientist by considering psychological aspects such as unique thoughts and emotions together (Resnil, 1998).
- Most research on scientist images typically draws stereotyped images, such as gray hair, lab coats, glasses, and men (Martin et al, 1977; Sim, & Yoon, 2013). In scientists images, cognitive rather than emotional and ethical aspects predominate, and students tend to perceive them as mechanical, neutral, and insensitive attributes.
- Scientific activity in modern society cannot be properly recognized without an understanding of scientists and their social functions and roles. Therefore, in the field of science education, it is necessary to provide education about who scientists are, what they do, and what responsibilities and obligation they have.

Social Responsibility of Scientists

- As the ripple effects and side effects of the development of science and technology appeared together, the discussion of the role and social responsibility of scientists emerged as a very important issue.
- Since the 1970s, as the relationship between science, technology, and society has become more important, interest in science and technology ethics is growing. In other words, unlike the general public, scientists are responsible for using their expertise in a desirable way.
- Nevertheless, in South Korea, the degree of ethics education in science is very low, and there is insufficient discussion or research on the qualifications of scientists and social responsibility (Song, 2001).
- Scientists are researchers and professionals, and as members of society, their roles naturally come with duties and responsibilities. Responsibility stems from the impact of science and technology on society.
- As part of their responsibilities, scientists must provide the public with accurate information and knowledge about science and technology, and have a good understanding of the nature of science, its impact on life and society, and society's impact on science(Saenko et al, 2019).

Responsibility Ethics of Hans Jonas

- Responsibility in traditional ethics has been limited to areas directly affected by human actions, but advances in modern science and technology have affected not only human interactions, but also the environment and future generations that are the result of actions
- In response, Jonas argued that responsibility should be presented as a future ethic and that the scope of ethical considerations should be extended to humans, nature and future generations.
- The scientific research process itself was viewed as an object of moral judgment because it involves the diverse values of individuals and groups. Therefore, it argues that both scientists and those who use them should be held accountable, proposing three attributes of responsibility.
- First, the 'totality' of responsibility emphasized the need to be enduring and forward-looking with the same responsibilities as parents. The second is to focus on 'sustainability' and to pursue advances in science and technology within the limits of what the natural environment can accommodate. The third is 'permanence', which emphasizes the importance of taking preventive measures, focusing on the negative impacts that scientific and technological measures can have, with a focus on ex post responsibility rather than ex-post responsibility(Jonas, 1979) .

Method

- **Data collection**
- The main data source of the study was fourty-three elementary science gifted students' writing about their opinion on the responsibility of scientist based on the historical factor of poison gas development during World WarⅡ.
- **Science Writing Topics**
- Depending on how a scientist's expertise is used, it can benefit or harm humanity. What responsibility does a scientist who uses his or her scientific expertise have to society and humanity? Describe and be specific about the responsibility of a scientist to society and humanity.
- **Participants**

object	Boy	Girl	total
Elementary science gifted student	21[48.8%)	22(51.2%)	43 (100.0%)

Development Of Evaluation items → Gifted sutdent Selection 2nd screening → Analysis framework development → Scientific writing analysis

- **Framework(Jonas, 1979)**

The analysis framework was analyzed according to the three aspects of responsible ethics;

1. Sustainability (promoting technological advancement within the scope of the current natual environment),
2. Permanence (considering prevention against possible risk of technological advancement), and
3. Totality (perceiving that technological advancement should be helpful for future generation), suggested by Jonas's theory of responsibility.

Conclusion and Discussion

- As a result of the study, 27 (48.2%) students perceived the permanence perspective, 17 (30.36%) students perceived sustainability, and 12 (21%) students perceived responsibility for totality.
- In conclusion, most of the gifted students have the concept of permanence whereas the number of the students who perceive totality as main responsible ethics was lowest.
- This study implies that responsible ethics education should be systematically conducted so that science-gifted students who is future scientist and engineers have comprehensive responsibility for the the scientific and technological development.
- In addition, responsible ethics needs to be treated as an important science literacy not only for future scientists, but also for future citizens.

Member Group Session

Day3 (June20th) 15：00～16：00

EXPLORING SCIENCE TEACHER EDUCATION FOR CLIMATE CHANGE EDUCATION: CHALLENGES IN ASIAN COUNTRIES

【Session Keywords】*Science Teacher Education, Climate Change Education, Asia*

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Batchuluun Yembuu	Mongolian National University of Education, Mongolia
Zhou Juan	Asia-Pacific Education for Sustainable Development Institute, China
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East-Asian Association for Science Education
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2021
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EXPLORING SCIENCE TEACHER EDUCATION FOR CLIMATE CHANGE EDUCATION: CHALLENGES IN ASIAN COUNTRIES

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ABSTRACT
In general, science teacher education for climate change education (CCE) has not progressed much compared to school science for CCE. It is limited to the development of courses, and educational strategies and systematic educational programs have made little progress. Directing science teacher education for CCE is an urgent and challenging task. In this group session, we will explore the direction of science teacher education for CCE in Asian countries. The basis for this attempt are research reports on the following themes:1) Awareness of climate change among Indonesian students in schools; 2) the understanding and attitudes of prospective science teachers in Indonesia, Japan, and Mongolia on climate change and CCE; and 3) the CCE teacher education curriculum developed in Mongolia. Additionally, we intend to introduce a new project to tackle this challenge in collaboration with Asian countries. The objectives of this project are to create a framework for the science teacher education program for CCE in Asia, develop a dissemination guide for the framework, and promote mainstreaming CCE in teacher education institutions and schools.

Keywords: *Science Teacher Education, Climate Change Education, Asia*

INTRODUCTION

Education for Sustainable Development (ESD), stipulated in the Sustainable Development Goals (SDGs) - target 4.7, is a new area of education that pursues and advocates for the sustainability of life and society on earth. Climate change rests at the heart of ESD themes and thus, is inextricably linked to almost all ESD themes, for example, renewable energy, biodiversity, disaster risk reduction, sustainable consumption and production, poverty, peace, and international understanding. Consequently, UNESCO and UNFCCC (2016) have urgently called for action regarding climate empowerment, emphasizing that an appropriate educational process of planning, implementation, and monitoring/evaluation/reporting is essential to encourage people to take concrete actions against climate change. In addition, UNESCO (2017) has proposed learning objectives for achieving SDGs. Therefore, it is imperative to consider the school level (or the level of a learner's development) and the subject and learning areas in which we will implement practices in line with the learning objectives of SDG 13 - "Climate action: Take urgent action to combat climate change and its impacts."

Globally, advanced efforts in climate change education (CCE) have been developed by UNESCO Associated Schools. One of these is a worldwide school network project entitled "Getting Climate-Ready." This effort introduced whole-school approaches to climate action, with specific school reforms proposed across four areas: school governance, teaching and learning, facilities and operations, and community partnership (for example, UNESCO, 2016; Sustainability and Education Policy Network, 2018). The outcomes of this project involve identifying good practices and accumulating cases throughout each country. Furthermore, another UNESCO CCE project "Sandwatch: Adapting to climate change and educating for sustainable development" (Cambers & Diamond, 2010) has provided a framework for children, youth, and adults, with the help of teachers and local communities, to work together to critically evaluate the problems and conflicts facing their beach environments and to develop sustainable approaches to address these issues.

Regarding science education, there are many discussions concerning CCE teaching and learning via school science (for example, Torkar, 2013). The introduction of CCE learning contents into curricula standards at the national and state levels is also progressing (for example, NGSS Lead States, 2013). Furthermore, there is an accumulation of research and practice in science teacher education for CCE (for example, Hestness et al., 2014). In these efforts, teacher education for CCE is often aimed at the development of teaching materials and classes. Notably, the development of systematic educational programs for CCE has made little progress, particularly in Asia.

Directing science teacher education for CCE is an urgent and challenging task. In this group session, we shall explore the direction of science teacher education for CCE in Asian countries, with reference to cases in Indonesia, Japan, and Mongolia.

INDONESIAN STUDENTS' UNDERSTANDING OF CLIMATE CHANGE: A FEEDBACK ON TEACHER EDUCATION

In the past, the issue of climate change has been addressed in science lessons as a part of the bigger topic of environmental issues. Lessons on environmental issues usually cover pollution, biodiversity loss, deforestation, and climate change. In daily life and media, people often relate extreme weather with climate change. To identify students' understanding of climate change, a questionnaire survey was conducted with elementary (grades 4-6), junior high (grades 7-9), and senior high school (grades 10-12) students in Bandung, Indonesia. The survey is still running, but some initial findings are shown here.

First, more than 50% students at all school levels have a good understanding of climate change and the greenhouse effect. Majority of them believe that carbon dioxide is responsible for climate change issues (75% of elementary, 80% of junior high, and 90% of senior high school students). Second, there are relatively similar answers on the major impacts of climate change: land drought, field burn, and extreme hot weather (elementary school students); field burn, land drought, and extreme hot weather (junior high school students); and biodiversity loss, extreme hot weather, and poor quality of farming products (senior high school students). Third, almost all students at all school levels say that they are worried or very worried about climate change caused by global warming. Elementary school students worry the most about the current generation of Indonesian people, while junior and senior high school students worry most about the next generations. Lastly, more than 75% students at all school levels say that urgent action is needed to stop climate change. Most are willing to participate in efforts to stop climate change. Reducing electricity consumption and limiting the use of private cars are the two main actions that they think should be practiced.

To further promote students' understanding and awareness of climate change, there is an initiative to present climate change as a special topic in the school curriculum. In the draft of the upcoming science curriculum at the national level, climate change is offered as an integrated issue within science subjects. To ensure that climate change is taught more in schools, it should be officially included in the school curriculum issued by the government.

Conventionally, climate change is a topic of science lessons because it is considered a natural phenomenon that requires an understanding of science concepts. Consequently, science teachers must engage on this topic to their students. However, in science teacher education, climate change is rarely offered as a course or as a topic within courses, such as environment, ecology, or earth and space science, which are closely related to the understanding of climate change. Science teacher education should aim at not only developing teachers' understanding of climate change but also building their capacity to create better lessons, and, therefore, a change in teaching orientation in teacher education institutions is required. Managing such changes can be very challenging for teacher educators because it requires teachers to acquire both their competencies for CCE and belief in the necessity of climate change action to save the earth.

UNDERSTANDING AND ATTITUDES OF PROSPECTIVE SCIENCE TEACHERS ON CLIMATE CHANGE AND CLIMATE CHANGE EDUCATION: A COMPARATIVE STUDY OF INDONESIA, JAPAN, AND MONGOLIA

This study aims to clarify the understanding and attitudes of prospective science teachers in Indonesia, Japan, and Mongolia on climate change and CCE through a questionnaire survey. The questionnaire items on climate change comprise 22 items falling in the cognitive, socio-emotional, and behavioral domains, with reference to the learning objectives of SDG 13 “Climate Action” (UNESCO, 2017); 4 items regarding climate change image and interest; and 3 items regarding CCE in school practice. Answers to multiple-choice questions are aggregated simply, whereas those to open-ended questions are categorized using the KJ method. Next, answers to the multiple-choice questions falling in the cognitive, socio-emotional, and behavioral domains are scored and totalized. The questionnaire survey was conducted from December 2019 to January 2020, with 146, 158, and 390 valid responses from Indonesia, Japan, and Mongolia, respectively.

In the cognitive domain, a high total score and many questions with a significantly higher percentage of correct answers were observed among Japanese prospective science teachers. This suggest that they have a better understanding of climate change than their Indonesian and Mongolian counterparts. In the socio-emotional and behavioral domains, a high total score and many questions with a significantly high percentage of positive responses was observed among Indonesian prospective science teachers. For example, for the question “Which is/are closer to your thoughts on approaching climate change due to global warming?”, 48.6 % of them answered “Even if I change my lifestyle, I should counteract climate change due to global warming.” In comparison, only 17.8% and 22.3% of Japanese and Mongolian respondents answered the same, respectively. Thus, Indonesian prospective science teachers seemingly consider the problem of climate change as a result of the global warming to be urgent, and argue in favor of appropriate remedial actions.

Regarding climate change image and interest, only 61.1% Japanese prospective science teachers gave a positive response to the question, “Do you think that it is possible to improve global warming?”, compared with 100% of Indonesian and 96.9% of Mongolian respondents. Therefore, Japanese prospective science teachers have a pessimistic view of climate change due to global warming. Regarding school practice for CCE, approximately 98% of prospective science teachers in all three countries gave a positive response to the question, “Do you think that climate change education is important?”. In addition, 92.1% of Japanese, 98.6% of Indonesian, and 96.6% of Mongolian prospective science teachers gave a positive response to the question, “Do you want to conduct school classes on climate change?”. To respond to prospective science teachers’ awareness and motivation, improvements in the curriculum and classes of CCE in teacher training are urgently required.

TEACHER EDUCATION FOR CLIMATE CHANGE EDUCATION IN MONGOLIA: INITIATIVES AND CHALLENGES

CCE is an integral element of quality education as well as to the efforts to achieve the SDGs supported by the integration of ESD. CCE fosters an understanding of the complexities and interconnection of various challenges posed by climate change. Furthermore, CCE plays a central role in helping the public, especially the next generation, to understand and relate to the issues, make changes in their lifestyle to reduce greenhouse gas emissions, and adapt to changing local conditions. CCE is needed at all levels, especially at the general education level. Furthermore, instilling awareness and understanding of climate change at a young age is ultimately the best way to change their behaviors and attitudes. CCE should be a lifelong process that starts at an early age and continues through different stages of education to promote behavioral change and enhance the resilience of communities.

Therefore, teacher education for CCE is crucial. This is, especially important for a country like Mongolia, given that it is highly vulnerable to climate change due to its geographic location, sensitive ecosystems, socio-economic conditions, and other stressors, including land degradation, desertification, and food insecurity. Aridity in the country is not the only relevant factor influencing climate change. People’s low awareness of climate change adaptation and mitigation is a decisive factor influencing the combat against climate change in Mongolia.

In this study, we will present the current situation in pre-service teacher education for CCE in Mongolia based on the results, challenges, and lessons learned, as well as further intentions from the implementation of the climate change adaptation curriculum developed by the Department of Geography, Mongolian National University of Education. The curriculum aims to enhance pre-service teachers' knowledge, skills, and attitudes toward climate change, and the values necessary to shape a sustainable future. Its teaching and learning methodology focuses on learner-centered, problem-oriented, and inquiry-based approaches to develop the teachers independence and creativity as CCE practitioners.

CLOSING

In general, science teacher education for CCE has not progressed much compared to school science for CCE; it is limited to the development of courses. Educational strategies and systematic educational programs have made little progress.

There are several obstacles that need to be addressed. The following points noted in teacher education for ESD (Wolff et al, 2017; Stevenson et al, 2015) also apply to teacher education for CCE. First, because the universities operate autonomously, a standard set of guidelines and recommendations on ESD does not exist. Second, teacher education mainly constitutes mandatory attendance courses; the practical issue of calibrating courses from other degrees with the teacher education schedule is unresolved. Third, ESD often depends on teacher educators' interests and therefore, is frequently uneven. Fourth, typically, there are only a limited number of compulsory courses on ESD, with marginally more electives.

We argue that directing science teacher education for CCE is an urgent and challenging task. Based on our experiences in teacher education for ESD, we have launched a new project to tackle this challenge in collaboration with Asian countries. This project focuses on cross-country exchanges of expertise and collaboration between teacher education institutions and schools. The fruitful results of these endeavors will create a framework for the science teacher education program for CCE in Asia, develop a dissemination guide for the framework, and promote mainstreaming CCE in teacher education institutions and schools.

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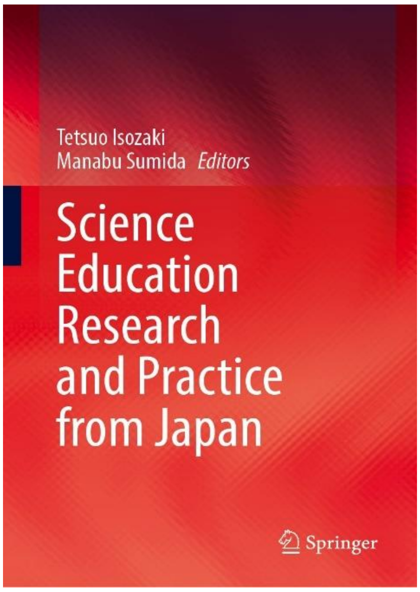
Book Review

SCIENCE EDUCATION RESEARCH AND PRACTICE FROM JAPAN



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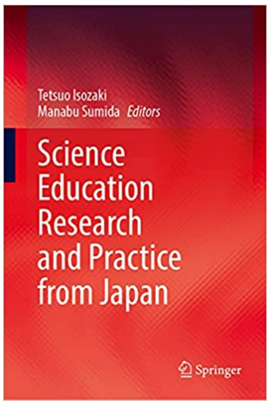
SCIENCE EDUCATION RESEARCH AND PRACTICE FROM JAPAN



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ABSTRACT of Book
This book is a collection of full-fledged research papers, predominantly written by Japanese science education researchers. It is expected to be valuable not only for Japanese readers, but also younger researchers interested in science (rika) education in Japan. This book addresses research topics related to temporary issues across the world, such as socio-cultural issues and teacher education programmes. It is unique in that its authors include Professor Masakata Ogawa (The 1st President of East-Asian Association for Science Education)'s disciples and others who have a fruitful research connection with him. We are publishing this book for his retirement Memorial. We believe that numerous prominent science education researchers will benefit from reading this book in Asia, as well as in Europe, America, and Africa. The authors have attempted to use various methods to solve their research questions, such as historical, empirical, theoretical, and narrative methods. This book helps researchers, particularly younger science education researchers, understand how to design and implement authentic research. For policymakers and curriculum developers, this book will serve in designing science curricula that refer to the philosophy and ideas of rika.
Keywords: *science (Rika) education, Japanese science education researchers*

TRANSFORMING SCIENCE EDUCATION FROM JAPAN

A unique aspect of Japanese history is the period of state-mandated national isolation that has extended for over 200 years. The long-reaching effects of this isolation have become particularly evident in the Japanese education settings (Sumida, Saruta, Inada, & Lin, 2016). For example, it is very difficult to encounter non-Japanese teachers even in English classes, apart from Assistant Language Teachers. Despite the decades-long leading performance of Japanese students in the Programme for International Student Assessment (PISA) and Trends in International Mathematics and Science Study (TIMSS), Japanese scholars are not very active in international societies and conferences of science education research. It is a pity that the country's success in science education has not received much attention from the international academic community, mainly due to lack of English publications and paucity of non-Japanese science education researchers. This book attempts to connect Japan to the rest of the world and offers valuable insights on cross-cultural research and practices in science education.

The key concept of *rika* in Japanese science education (Ogawa, 2015) was re-contextualised in the late nineteenth century (Isozaki, 2014), resulting in its distinctive and unique characteristics that differ markedly from science education in the West. For readers interested in this topic, such as curriculum developers, policy makers, and researchers and practitioners, this book will provide historical background and discuss the practical settings essential to Japanese science education. It will explain why Japanese science education is unique and why studying it can enrich and expand global science education research.

The chapter titles and the authors are as follows:

The target readership of this book includes science educators, curriculum developers, science teachers, and masters as well as doctoral students. It can also be used as reference material in courses at various levels (e.g., master's course, EdD, and PhD course) and in academic research such as teachers' action research. This book addresses the challenges science education researchers face in disseminating research findings and encourages maintaining the strength of science education in Japan. It also presents a unique opportunity to initiate change and/or develop science education research *from* Japan. This is one of the reasons why we highlight 'Japan', 'Japanese' and 'Japanised' in this book.

'The festschrift's authors have articulated research methods and results, from which readers can gleam subtle essential truths about Japanese Rika research'.

(from 'Epilogue' by Glen Aikenhead, Professor Emeritus, University of Saskatchewan)

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Junior Session

Day3 (June20th) 09：30～10：20

Takanori KOIZUMI FUZOKU SHIZUOKA Junior High School
What is repelling the water?

Haruki UNNO FUZOKU SHIZUOKA Junior High School
Water Rocket

Yuta MORIKAWA KITAUE Junior High School
Development of hydroelectric generators with minimal impact on the natural environment

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Akito OGAI HIKUMA Junior High School
Familiar Birds ～Around My House～

Yunon KANAI FUZOKU SHIZUOKA Junior High School
Which Parts of Body Sensers do Active Towards Sunlight?
-The case of T. GRANULATUS=

Rei SHIOZAWA SHIZUOKA SEIKO GAKUIN Junior High School
Use Raspberry Pi to make life easier

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