Analysis of Types of Questions Embedded in Science Lessons of Japan and the United States

April Daphne Floresca Hiwatig[1], Manabu Sumida[2], Hayashi Nakayama[3]
Graduate Student[1], Associate Professor[2], Professor[3]
Ehime University[1,2], University of Miyazaki[3]

Abstract

The purpose of this study was to analyze teachers' questions in science lessons of Japan and the United States, and compare their stereotypical types of questioning. Further, how frequent higher order thinking skills are favored over simple recall were also revealed in this study. Since the classical times until today, asking questions serves as a window of learning. However, it is very difficult to conduct research on science teachers' questions in a valid and reliable way. In this study, the national sample of science lessons in Japan and the U.S., taken from the TIMSS 1999 Video Study, were used in the analysis. 496 questions in English transcripts from four Japanese science lessons and 683 questions from four US lessons were analyzed using the *Window Model* originally developed in this study. The Window Model consists of types of questions (one pane attached to each sash), combination questions (grilles), and auxiliary questions (frame). Combination questions are represented by grilles, which support at least two panes together. Auxiliary questions can be likened to the frame attached to a sash assembly, which maintain the stability of an entire window. Window blinds diversify the window model into four variations, which take into account how much of a certain type of question is implemented in each part of a lesson cycle. According to the sets of lesson plans, similarities included the following 1) teachers from both countries asked factual questions to elicit prior knowledge and; 2) they also employed more factual questions than conceptual ones to explain concepts. Slight differences were noted on the following situations: 1) even though teachers from Japan and the U.S. used factual and convergent combination types of questions during empower stage and exploratory stage, the former country used more convergent questions and; 2) factual-combination questions were asked to Japanese students during exploratory activities. Different questioning techniques also existed in some parts of the lesson cycle of each country: 1) conceptual questions were frequently used to engage Japanese students' attention while U.S. students often answered factual questions during this part and; 2) Japanese teachers elaborated prior knowledge and newly assimilated ideas by asking factual and conceptual questions, but U.S. teachers used factual questions to review the concepts learned in the activity. One original part was observed in Japan's science lesson cycle, wherein factual questions were frequently asked to Japanese students to extend students' engagement prior to the next lesson. Supplemental questions asked throughout the course of the lessons comprised 49.7% and 51.5% of the total questions embedded in Japanese and U.S. science lessons, respectively. The findings of this study can be used for future identification and comparison of trends in effective questioning techniques in science classrooms.

Keywords: types of questions, Window Model, learning cycle, science lessons, TIMMS

Introduction

Thinking is not driven by answers but by questions (Paul & Elder, 2000). Questions define tasks in activities and delineate the flow of a lesson and the thinking of students. Some educators liken questions to air that resuscitate every living thing, and/or to fuel that makes automobiles travel long distances. However, questions that do not go beyond simple recall of facts is akin to frequent stepping on the breaks in the vehicle of learning, rather than giving students artificial cogitation--equivalent to developing higher order thinking skills through appropriate questioning techniques (Paul & Elder, 2000). As a result, students tend to look beyond the walls of the classroom, and let their imagination wander off by looking at the scenery outside the windows.

According to the publication *Better Thinking and Learning* of Maryland State Department of Education (McTighe, 1991), teachers who ask "higher-order" questions promote learning because these types of questions require students to perform beyond simply recalling facts. A meta-analysis of l4 experiments by Redfield & Rousseau (1981) concluded that the predominant use of higher-level questions during instruction yielded positive gains on tests comprising both factual recall and application of thinking skills. In spite of the obvious educational advantages of emphasizing higher-order questions, research studies of classrooms conducted by Gall (1970) and Hare & Pulliam (1980) confirm that only 80% of classroom questions asked by teachers do not require more than simple factual recall. In addition, no significant difference was found between the mean post-test scores and mean gain scores of the Instruction with Creative Activities (ICA) with that of the control group implemented in chemistry classes (Ramirez & Ganaden, 2008). One underlying factor, which was not mentioned in the study, could be that the questioning techniques used in both classes might be the same.

One innovative tool that enables comparison of questioning techniques of teachers is the TIMSS 1999 Video Study publicly released less than five years ago. The use of video in teacher education program for collective video recording of lessons has now been a common practice in most countries. Moreover, videos of classroom-based teaching provide higher potential to support teacher education activities (Newton & Sorensen, 2010). Actual classroom-based teaching provide 'noise' that needs to be tackled again and again and video is one powerful way that leads to the development of skills on discerning what appears to be in plain-sight and noticing salient points. Simply put, video studies, such as the TIMSS 1999, enable educators to practice the 'discipline of noticing' (Mason, 2002) that will eventually lead to improvement in giving out questions, and thus encourage higher order thinking skills of students.

To determine if the facts mentioned by the researchers (Gall, 1970 and Hare & Pulliam, 1980) persist to be true at present educational situations in and the US, this study sought to seek answers to the following questions: 1) What are the similarities and differences of Japanese and U.S. science lesson cycles? 2) What are the similarities and differences of Japanese and U.S. teachers' questioning techniques? To answer these questions, the study developed the Window Model to analyze the types of questions embedded in the TIMSS 1999 transcripts of science lessons of Japan and the U.S.

The TIMSS 1999 Video Study Science

The TIMSS 1999 Video Study was a cross-national study of eighth-grade classroom mathematics and science teaching. The study involved videotaping more than one thousand classrooms in seven countries in two phases: the mathematics portion was completed in March 2003, and the science portion of the study followed in April 2006.

About 100 schools were randomly selected in each country. One math lesson and one science lesson was videotaped in each participating school. The five countries participating in the science portion of the study were Australia, the Czech Republic, the Netherlands, Japan, and the United States. Videotaping was distributed evenly throughout the school year so that the lessons represent the full range of eighth-grade science instruction in each country. Teacher questionnaires and worksheets and textbook pages used in the lessons supplement the videotapes.

Afterwards, data from the TIMSS 1999 Video Study were meticulously coded and analyzed by teams of bilingual coders, science specialists, international representatives, and educational researchers. Bilingual coders were, in almost all cases, born and raised in the countries whose lessons they were coding. A minimum individual reliability of 85% was attained in the coding. However, for certain codes, reliability was established by means of consensus coding. Data were carefully weighted to account for sampling design and to obtain reliable comparisons among the participating countries with significance at the .05 level.

The TIMSS 1999 Video Study Science Public Release Lessons (2007) contain 25 complete science lessons, five from each country in the study. Each of the science lessons in the CD sets includes the following:

- video of the lesson;
- video index to navigate the lesson;
- lesson graph that provides a summary of the lesson;
- lesson commentaries by the teacher of the lesson, a national educational representative, and a member of the TIMSS 1999 Video Study research team;
- relevant resources specific to the lesson (e.g., handouts, textbook pages, lesson plans, etc.) and;
- transcript of the lesson (from which the bulk of this research came).

Despite some similarities across the countries, results from the 1999 study of eighth-grade science teaching revealed that each of the countries had a distinct approach to science teaching, providing students with different opportunities to learn science and, therefore, different visions of what it means to understand science. Detailed findings of the he countries' distinct approaches varied in the organizational features, content features, and the ways in which students were involved in actively doing science work in the science lessons were published in *Teaching Science in Five Countries: Results From the TIMSS 1999 Video Study* (Roth et al., 2006). However, relevant study that dealt with the type of questioning these countries used in each part of their lesson cycles seemed unfounded.

Questioning

Many educators believe that questioning is the key aspect to teaching and learning. Teachers use questions because they:

- Can activate prior knowledge;
- Can help gauge how effectively pupils are learning;
- Can assist in forward planning;
- Can be used to involve pupils in on-going class work;
- Can give pupils opportunities to articulate their understanding;
- Can improve communication and social skills of students;
- Can stimulate the imagination into creative thinking and investigation;
- Can foster curiosity, support problem-solving and generate inquiry, and;
- Can give children the opportunity to connect what they know with what they need to examine and reflect on their own thinking.

How do teachers achieve the abovementioned potentials of questioning? Knowing the characteristics of each type of question is an important step in fueling the learning process of students.

Different types of questioning

Several models provide various types of questions. Bloom's Taxonomy of Educational Objectives (Bloom, et al., 1956; Ramirez & Ganaden, 2008) is one of the most widely used guides to discern higher order thinking skills. In effect, educators and researchers alike use the same taxonomy to classify questions. According to Bloom's taxonomy, there are at least five types of questions depending on the skill being tapped. These types of questions and skills are commonly known as knowledge, comprehension, analysis, synthesis, and evaluation. The lowest level is knowledge and the most complex is evaluation. Another classification of question is as follows:

A. Display questions, which are designed to elicit learners' prior knowledge and to check comprehension, are further classified into:

- <u>Open questions</u> which often begin with the words: What, Why, When, or Who to motivate students to speak or which are sometimes statements: "give me examples of" or "tell me about" and;
- <u>Closed questions</u> which are questions that require a yes or no answer and are useful for checking facts.

The teacher usually knows the answer to display questions.

B. Referential questions often require learners to give an opinion, explain, or clarify. They have several kinds:

- <u>Open-ended/divergent questions</u> require multiple answers and a higher level of thinking from the learners
- <u>Specific questions</u> are used to determine facts. For example "How much did you spend on that experiment?"

- Probing questions check for clarifications or further details. Probing questions give students opportunities to justify or explain their responses by dealing with the How, Why, and the Based-upon-what aspects of a concept.
- Hypothetical questions pose a theoretical situation in the future. These can be used to get others to think of new situations and to find out how people might cope with new situations. For example, "What would you do if...?"
- Reflective questions are asked to reflect back on what you think a student has said, or simply to check understanding. You can also make students reflect on their feelings toward an activity.
- Leading questions are used to gain acceptance of your view – they are not useful in providing honest opinions and views.

Educators and researchers alike use these classifications to identify the types of questions that are used in various school activities and research purposes, respectively. However, knowing which types of questions are effective for each part of a lesson should also be considered.

Effective questioning

Questioning is effective when it allows students to engage with the learning process by actively composing responses. Various researches (Borich 1996; Morgan & Saxton 1994; Wragg & Brown 2001; Muijs & Reynolds, 2001) suggest that effective questioning have the following characteristics:

- Questions are carefully planned so that they are closely linked to the objectives of the lesson.
- Open-ended questions, which stimulate and extend thinking, predominate.
- Closed questions are used to check factual understanding and recall.

However there are other factors to be considered, such as the following:

- A quality open-ended/higher order question will generate more questions.
- Questions should give opportunities for successful answers, but should also provide challenge.
- The learning of basic skills is enhanced by frequent questions following the exposition of new content that has been broken down into small steps. Each step should be followed by guided practice that provides opportunities for students to consolidate what they have learned and that allows teachers to check understanding.
- Sequences of questions are planned; questions, which demand increasingly higher-order thinking skills, should be supported by ones that require less sophisticated thinking skills.
- Students can be led to question their own learning and enter the realms of metacognition (reflecting on the learning process), with overflowing benefits.

These factors should be carefully considered in spreading out questions throughout the lesson cycle. Thus, educators use models of questioning.

Methodology, Results and Findings

The section below discusses how the classifications of questions and the Window Model were developed. After which, the results and findings of the research are thoroughly discussed.

Different models of questioning

Since it is very difficult to conduct research on science teachers' types of questions in a valid and reliable way, some educators liken asking questions to air that resuscitates every living thing; it is also akin to a fuel that makes automobiles travel long distances.

To address the factors highlighted as salient points of effective questioning, this study developed the classifications of questions, as shown on Table 2. This table shows extended classifications based on the types of questions discussed by Lindley (1993) and Erickson (2007).

Table 1. Classifications of Questions Used in the Window Model

Group	Types	Description
Factual	Factual	Solicits straight-forward answers; taps lowest level of cognitive (knowledge level); states things that were observed (quantitative and qualitative)
Conceptual	Convergent	Students are allowed to make inferences and interpolations; taps abilities related to comprehension, application, and analysis
	Divergent	Requires students to analyze, synthesize, or evaluate ideas or a knowledge base, and make extrapolations
	Evaluative	Makes students arrive at synthesized information or conclusions through sophisticated levels of cognition
	Combination	Combination of any of the above-mentioned types of questions
Supplemental	Auxiliary	Provides a sense of clarification, assurance, and/or affirmation through scaffolding in question form

To provide a mental model of these types of questions, this study also developed the Window Model, which will be discussed in the section that follows.

The Window Model

The Window Model is originally developed in this study to compare the types of questions Japan and the U.S.' teachers use in each part of their lessons. The national sample of science lessons in Japan and the U.S., taken from the TIMSS 1999 Video Study, were used in the analysis. 496 questions in English transcripts from four Japanese science lessons and 683 questions from four US lessons were analyzed using the *Window Model*. The Window Model (figure 1) has four main parts: 1) pane attached to each sash in which each pane corresponds to one of the four main types of questions; 2) grilles that represent combination questions; 3) frame that represents auxiliary questions and most importantly; 4) window blinds, which diversify the window model into four variations (Tables 3.1 and 3.2), and take into account how much of a certain type of question is implemented in each part of a lesson cycle.

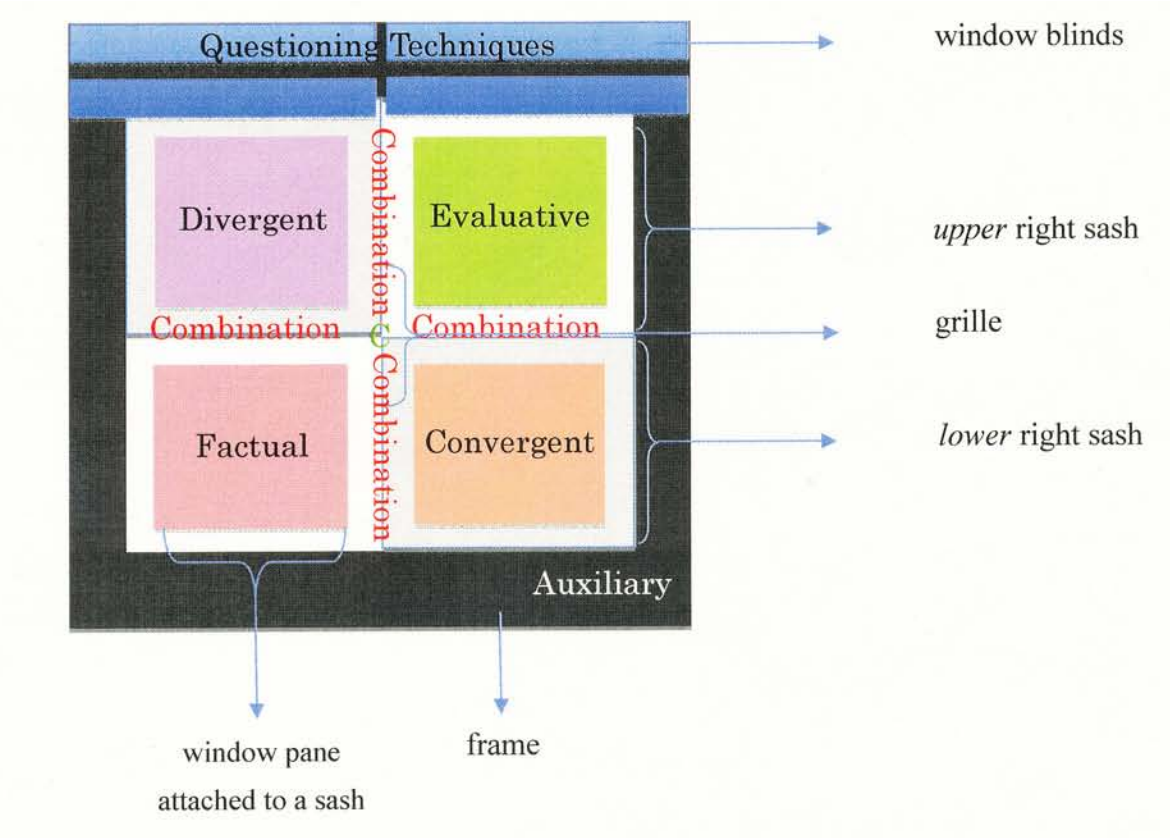


Figure1. The Window Model

The lower sash assembly has two panes, the factual and the convergent panes, while the upper sash assembly has the divergent and the evaluative panes. The cross at the center or the grilles, represents the combination questions. For instance, factual-convergent, factual-divergent, and convergent-divergent questions can exist, respectively.

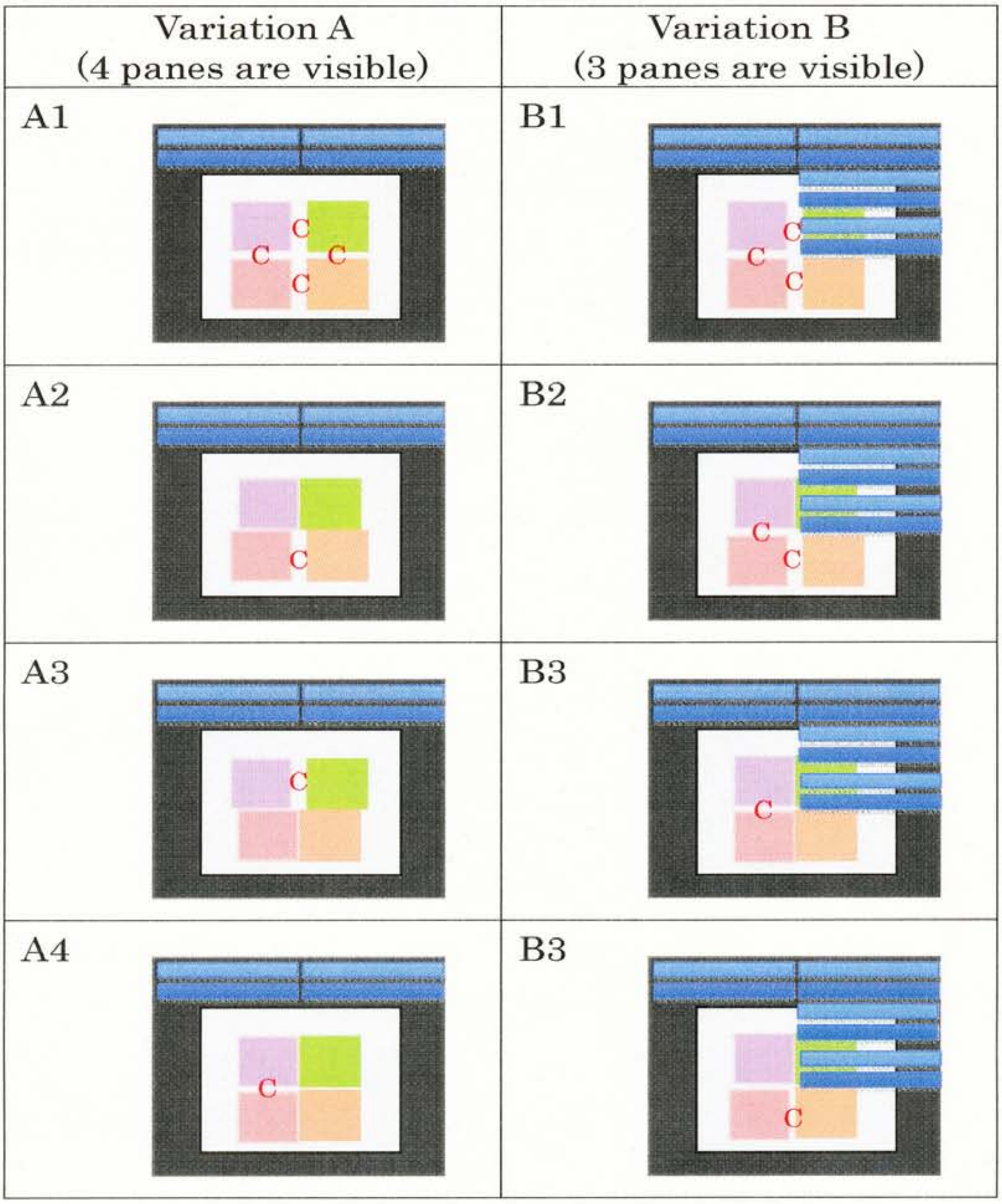
Which pane is made visible to the students is made possible by raising and/or lowering the window blinds. Thus, one lesson may employ several panes, i.e. types of questions, to delineate the flow of activities and lesson.

The frame, which represents the auxiliary questions that provides a sense of clarification, assurance, and/or affirmation through scaffolding in question form, is attached to the upper and lower sashes. This assembly indicates that auxiliary questions are important to reinforce further the power of the four main types of questions.

The number of panes and grilles revealed by lowering or raising the window blinds produce four possible variations of the window model. However, the sample questions analyzed in this study reveal several of the variations predicted by the window model.

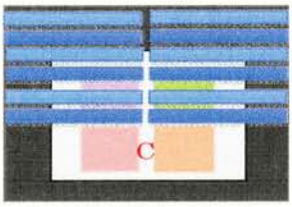
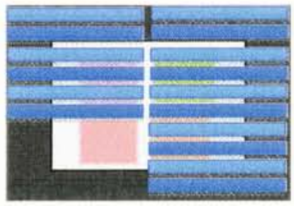
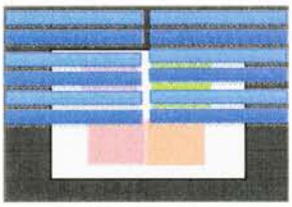
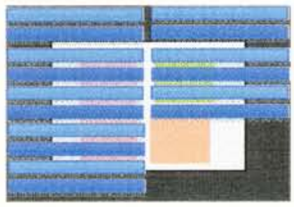
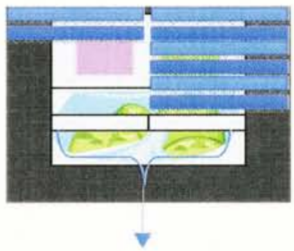
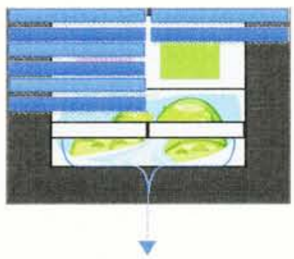
Variation A has four sub-variations. Variation A shows that all four panes are visible. However, the presence or absence of combination questions changes the appearance of each pair of windowpanes of the upper and the lower sashes, respectively.

Table 2.1 Variations A and B of the Window Model



Variation B, which showcases three visible panes, reveals four sub-variations. Likewise, the presence and/or absence of combination questions allow shift of windowpanes in each sash. Other arrangements include FED (factual-evaluative-divergent) and CED (convergent-evaluative-divergent) panes with and without combinations.

Table 2.2 Variations C and D of the Window Model

Variation C (2 panes are visible)	Variation D (1 pane is visible)
C1 	D1 
C2 	D2 
	D3  Swiveled lower sash assembly
	D4  Swiveled lower sash assembly

Variation C or the two-pane-visible variation has two sub-variations. The sub-variations exist because of the usage or absence of factual-convergent combination type of questions. If the need arises, this variation can also be applied to divergent-evaluative (DE), factual-divergent (FD), and convergent-evaluative (CE) questions, which may vary by the presence or absence of combination questions. Presence of convergent-divergent (CD) and factual-evaluative (FE) combination questions is not predicted in this model because both types of questions show opposite directions of thinking.

Variation D indicates the visibility of one type of question. Factual and convergent questions can be made visible through varying the coverage of the window blinds. The lower sash, which carries factual and convergent questions, can be swiveled to hide it in view. Thus, seeing only the sub-variations of the upper sash can be made possible.

Several of these were frequently observed in each part of the science lesson cycles of Japan and the U.S., which was provided by the script of the public release of the TIMSS 1999 video study.

What are the similarities and differences of Japanese and U.S. science lesson cycles?

Science lesson cycles of Japan are characterized by an *8E learning cycle* while U.S. science lessons revealed a *7E cycle*. In general, science lesson cycles of Japan and the U.S. have the following similar parts: 1) elicit: eliciting prior knowledge; 2) engage: engaging students' attention through statement of the problem; 3) empower: empowering prior knowledge through group collaboration and presentation of past and related experiments; 4) explore: exploratory activities (demonstrations, learning stations, experiments); 5) explain: explaining newly assimilated ideas through discussion; 6) elaborate: elaborating prior knowledge by linking it to newly assimilated ideas through textbook clarification, note-taking, and giving out conclusions, and; 7) evaluate: teachers implement the evaluation part by asking questions throughout the lesson. The 8th "E," which was only observed in Japanese science lessons, pertains to extend: extending engagement by presenting related concepts to be tackled during succeeding lessons. However, activities in the U.S. and vary in some ways so types of questions asked to students also differ in several aspects. Table 3 provides a brief summary of the parts of Japanese and U.S. science lesson cycles, activities, and types of questions teacher in each part.

The empower part of Japanese lesson cycle is implemented at least twice in a lesson. One comes after the engagement of students' attention and the other is employed prior to class discussion.

U.S. science lessons did not implement extension of lessons. On the other hand, Japanese science lessons frequently connected conclusions to next lessons concepts.

The findings published in *Teaching Science in Five Countries: Results From the TIMSS 1999 Video Study* (Roth et al., 2006) revealed that science teaching in Japan focused on making connections between ideas and evidences. This was the distinctive pattern that set Japanese science lessons from lessons in other countries, except Australia. Below presents a summary of their findings.

Canonical knowledge (e.g., ideas, science facts, and concepts) and procedural and experimental knowledge were both present during public talk time in Japanese science lessons (44 and 25 percent of public talk time, respectively). There was less public talk time about canonical knowledge during science lessons. There were more public talk time spent on procedural and experimental knowledge compared to lessons in other four countries (Australia, Netherlands, Czech Republic, and the U.S.)

The conceptual focus of Japanese lessons was reflected in the large percentage of the lessons that were organized primarily to make connections among evidences, ideas, and experiences, rather than presenting definitions and facts (72%). Observations that the Japanese practice of supporting main ideas in the lesson with evidence, often from multiple sources of evidences, were also found to be consistent with the inductive, inquiry approach and focus on in-depth, evidence treatment of few ideas. It suffices to say that the content of Japanese science lessons was organized to support the making of connections between ideas and evidence, and was presented coherently with strong conceptual connections.

On the other hand, TIMSS' findings (Roth et al., 2006) revealed that science teaching in the U.S focused on variety of activities. U.S. science lessons also stood out from other countries in the relatively infrequent use of multiple instances for evidences. 17% of U.S. science lessons were judged to have a high density of canonical ideas. Teachers of 66 percent of U.S. science lessons were organized content primarily around facts and definitions rather than making connections among ideas, patterns, and experiences. These facts and definitions were organized as discrete, unconnected bits of knowledge (30 percent of lessons). Further, several indicators suggest that science content was less central in U.S. lessons compared to other countries. In sum, while a variety of sources of evidences were presented in the lessons, these various pieces of content were not woven together to create coherent lessons that connected ideas and evidences.

Questions define tasks in activities and delineate the flow of a lesson and the thinking of students. How do the data on science teaching published by TIMSS compare with the similarities and differences of Japanese and U.S. teachers questioning techniques?

What are the similarities and differences of Japanese and U.S. teachers' questioning techniques?

It is inevitable that teachers from different countries have different approaches to teaching. Consequently, parts of their lesson cycles may have differences, as well as similarities. Furthermore, these activities are defined by the types of questions asked by teachers to engage and check students' understanding throughout the duration of each lesson. More importantly, these teaching and questioning "teach-niques" evolve gradually. Stigler and Hiebert (1999) point out that this happens because teaching is a cultural activity. Another explanation could be that because a specific Language-Culture (LC) community provides an intrinsic setting for science education, which in turn brings about the effects of LC on science education, namely: its rationale, content, and style of teaching (Sumida, in press). Thus, teachers who were once students tend to use the same strategies that were used on them in the past to develop understanding of their students at present. Teaching is like a habit that is implicitly being passed on from one generation to the other. This habit tends to be the norm. Once another culture is introduced, that is the only time that teachers become aware of the differences. These statements may lead us to the assumption that the questioning techniques 10 years ago will be quite the same as present.

Another aspect that can be considered is that rules, procedures, and arrangements that constitute institutions can include not only formal systemic structures (e.g. curriculum) but also informal elements that are sometimes thought of as cultural, such as schemas and routines in classrooms (Cave, 2011).

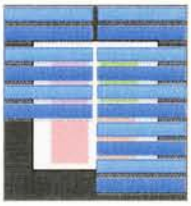
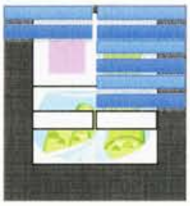
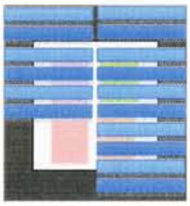
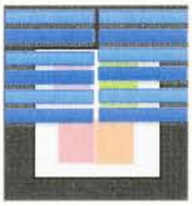
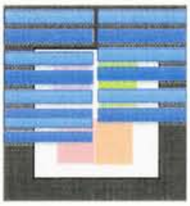
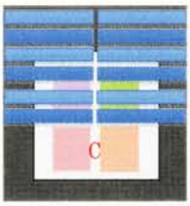
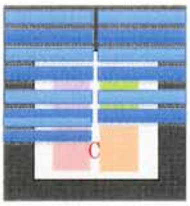
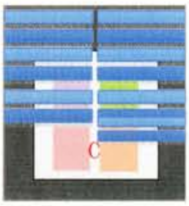
This study will try to open doors for future identification of trends in questioning techniques.

Table 3. Summary of Japan's 8E Cycle and U.S.' 7E Cycle and Type of Questions Frequently Asked in Each Part

<table>
<tr><th colspan="4">Japanese Science Lessons</th></tr>
<tr><th>Encompassing Part; Type of Q</th><th>Individual Parts</th><th>Activities</th><th>Type of questions</th></tr>
<tr><td rowspan="7">Evaluate;
Auxiliary
Questions</td><td>Elicit</td><td>Review</td><td>Factual</td></tr>
<tr><td>Engage</td><td>Motivate</td><td>Divergent;</td></tr>
<tr><td>Empower</td><td>Form Group (Hearts-on and Minds-on)</td><td>Convergent > Factual</td></tr>
<tr><td>Explore</td><td>Demonstrate
Move-type Activity
Experiment</td><td>Convergent > Factual;
FC Combination</td></tr>
<tr><td>Explain</td><td>Discussion
(Hearts-on and Minds-on)</td><td>Factual > Convergent;
FC Combination</td></tr>
<tr><td>Elaborate</td><td>Read Textbook
Note taking
Conclude</td><td>Factual; Convergent;
Evaluative; FC Combination</td></tr>
<tr><td>Extend</td><td>Link Conclusion to Succeeding Lesson</td><td>Factual</td></tr>
<tr><th colspan="4">United States Science Lessons</th></tr>
<tr><th>Encompassing Part; Type of Q</th><th>Individual Parts</th><th>Activities</th><th>Types of Questions</th></tr>
<tr><td rowspan="6">Evaluate;
Auxiliary
Questions</td><td>Elicit</td><td>Review</td><td>Factual</td></tr>
<tr><td>Engage</td><td>Motivate</td><td>Factual</td></tr>
<tr><td>Empower</td><td>Form Group
(Brainstorming of facts learned during past years)</td><td>Factual > Convergent</td></tr>
<tr><td>Explore</td><td>Demonstrate
Move-type Activity
Multimedia clips
Book activity</td><td>Factual > Convergent;
FC Combination</td></tr>
<tr><td>Explain</td><td>Discussion</td><td>Factual > Convergent;
Combination</td></tr>
<tr><td>Elaborate</td><td>Read Textbook
Review concepts</td><td>Factual</td></tr>
</table>

Tables 4.1 and 4.2 show a summary of the similarities and differences of types of questions of Japanese and U.S. science lessons with regard to variation of windows in each part of their lesson cycles.

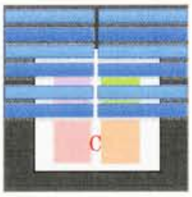
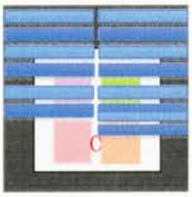
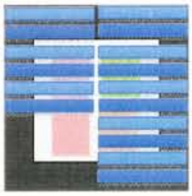
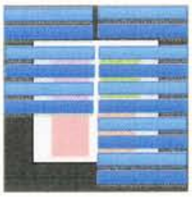
Table 4.1. Similarities and Differences of Variation of Windows in Each Part of Lesson Cycle (Elicit to Explore)

Part of Lesson Cycle	Commonalities of Variation of Window	Japan	U.S.
Elicit	D1  Factual pane is visible		
Engage	Variation D One pane is visible	D3  Divergent questions	D1  Factual questions
Empower	C2  Two panes are visible	C2  Factual < Convergent	C2  Factual > Convergent
Explore	C1  Two panes are visible; with combination	C1  Factual < Convergent; with FC combination	C1  Factual > Convergent; with FC combination

According to the sets of lesson plans, teachers from both countries asked factual questions to elicit prior knowledge. However, U.S. teachers tend to take longer time to review concepts (more than three minutes). Thus, science lessons from both countries are characterized by variation D1.

Divergent questions, which are also classified under the conceptual group, were frequently used to engage Japanese students' attention; U.S. students often answered factual questions during this part. Science lessons from both countries employed variation D. During this part, Japanese and U.S. teachers used D3 and D1 variations, respectively.

Table 4.2 Similarities and Differences of Variation of Windows in Each Part of Lesson Cycle (Explain to Extend)

Part of Lesson Cycle	Commonalities of Variation of Window	Japan	U.S.
Explain	C1  Two panes are visible; with combination	C1  Factual < Convergent; with FC combination	C1  Factual < Convergent; with FC combination
Elaborate		B3  Factual; Convergent; Evaluative; FC combination	D1  Factual pane is visible
Extend		D1  Factual pane is visible	

Even though teachers from Japan and the U.S. used factual and convergent types of questions during empower stage and exploratory stage, the former country used more convergent questions. Furthermore, factual-combination questions were asked to Japanese students during exploratory activities. In addition, Japanese students were required to go beyond answering simple recall questions.

Teachers from both countries employed more factual than conceptual questions to explain concepts.

Japanese teachers elaborated prior knowledge and newly assimilated ideas by asking factual and conceptual questions. They required students to answer simple recall questions as well as convergent, evaluative, and factual-convergent questions. U.S. teachers used factual questions to review the concepts learned in the activity.

Factual questions were frequently asked to Japanese students to extend their engagement prior to the next lesson. Supplemental questions asked throughout the course of the lessons comprised 49.7% and 51.5% of the total questions embedded in Japanese and U.S. science lessons, respectively.

Discussions

This section provides a discussion on noted advantages and disadvantages of using certain types of questions in each part of a lesson cycle. Presence and/or absence of certain learning strategies were also highlighted to account for the differences in the results on students' response to questions, despite being required to answer the same type of questions.

Implications of findings on Japanese and U.S. teachers questioning techniques embedded in science lesson cycles

Elicit (Review). According to the cognitive view of learning, prior knowledge is one of the most important elements in the learning process (Olmos & Lusung-Oyzon, 2008). Asking factual questions seems fit to elicit students' prior knowledge. Question like, "What is the main substance in here called?" (simple-recall) was asked by teachers to assess their students' understanding of previous lesson materials. This type of question also prepared students in accommodating prior knowledge to new lessons. Alexander (1996) supports this idea by stating that knowledge serves as "a scaffold that supports the construction of all future learning."

Engage (Motivate). Engagement may be characterized as the pull that brings people to a situation or topic that keeps them involved (Schwartz & Hartman, 2007). Engagement creates the mental context that prepares minds of students to learn. A good approach to engagement is to ask more conceptual questions, which develop the learners' interests so they are more likely to takes steps to learn. When teachers gave questions such as, "So today, what we'll be thinking is water. Being exposed to electricity, it can be separated into hydrogen and oxygen. So what (do you think) happens in the opposite?" Japanese students actively shared their ideas. This type of question fueled the students' curiosity; during the experiment, their enthusiasm seemed natural.

Empower (Form group). Two heads are always better than one. It is efficient to form groups and create collaborative learning environments. This offers students opportunity to develop shared understanding of concepts (Kagan, 1992; Johnson et al., 1998; Smith et al., 2005; van den Bossche et al., 2006; Lawrie et al., 2010). Further, there is strong evidence that effective collaboration promotes mutual knowledge construction through shared discourse resulting in increased performance (van den Bossche et al., 2006; Lawrie et al., 2010).

In addition, vital to any effective questioning is giving these groups the opportunity to connect what they know with what they need to examine, thus, implicitly making them reflect on their own thinking. To become effective learners, these groups need to be able to figure out what they need to learn and how to achieve their learning goals; goal setting is one of the effective ways to assist students' learning (OECD, 2010). Teachers in Japan and the U.S. both gave cues and asked questions to groups prior to activities. Cues and questions, which appear to be very similar, are techniques that teachers can use to activate students' prior knowledge (Marzano, et al., 2000). Cues are "hints" about what students are about to do or experience. Questions perform about the same function. For example, prior to conducting activities, the teachers asked students questions that elicit what they already knew about the topic. Thus, questions are less straightforward compared to cues, when it comes to eliciting prior knowledge.

However, analysis of the scripts of the lessons revealed two things about the effect of type of questions asked to students: 1) asking more factual questions than conceptual ones made students unable to answer evaluative questions (e.g. Why do you think I ask this question? What is the importance of this activity?) and; 2) asking convergent questions rather than factual ones fueled the discourse among group members and promoted more active participation among learners. In Japan, teachers also used grouping prior to discussions. Groups were asked to answer, "First, the conclusions from the results of the iodine solution. How the iodine reacted? Second, the conclusions from the results of the Benedict's solution. Can you present them?" The conclusion of each group was presented in the board. This activity facilitated the class' conclusion. The teacher was successful in making the class generate the lesson's conclusion by themselves.

<u>Explore (Activities).</u> A famous quote on learning, "We learn…70 percent of what we discuss with others and 80 percent of what we experience" relatively tells us how important it is to set group discussions and conduct activities. The percentages in the quote have no scientific accuracy, and don't really mean much, but even the famous Greek philosopher Aristotle agreed that, "What we have to learn to do, we learn by doing." John Locke also argued in his, "Theory on Education" that skills and knowledge are acquired by practice and example instead of charging children's memories with rules and principals.

However, asking students to complete a series of book activities, without conducting science experiments, proved to be inefficient. Based on the script of the lessons, teachers who used these types of activities repetitively guided students using scaffolding questions to give cues and hints to help them follow directions and even answer factual questions. Students' responses were, "I don't get 'shade regions of precipitation'" or "I'm really not sure about these, uh, models we have to put down" or "I don't quite understand them." Also, it seemed that the students were used to answering factual (simple-recall) questions. When the teacher asked, "What's the dew point? So what does that tell you about humidity?" the student answered, "It's gonna rain." The teacher reiterated the question again and told the student, "Okay? Do you get it now, (student's name)? No humidity because you can tell the humidity by the dew point. How are you doing?"

Explain. Science teachers, like scientists, frequently use analogies to explain concepts to students (James & Scharmann, 2007; Glynn, 2008). Analogies serve as initial models, or simple representations, of science concepts. Teachers frequently preface their explanations with expressions, such as, "It's just like," "Similarly," and "Likewise." These expressions all mean, "Let me give you a simple analogy."

Analogies can foster understanding, but they can also lead to misconceptions. As cited by Glynn (2008), Duit, Roth, Komorek, and Wilbers (2001) state: *A growing body of research shows that analogies may be powerful tools for guiding students from their pre-instructional conceptions towards science concepts. But it has also become apparent that analogies may deeply mislead students' learning processes. Conceptual change, to put it into other words, may be both supported and hampered by the same analogy. (p. 283)*

One teacher from the U.S. used an analogy activity. She told a story about her college years: "Can somebody tell me about the story again. Where did I first go? (To your Resident Assistant or RA) I went to my RA, then where did I go? (To your RV, a type of car) Then I got the RV, but before I took the trip I had to get? (Fuel) Okay, then after I got the fuel, where did I go? (Los Angeles or LA) And then where did I go? (Las Vegas or LV)."

During the discussion part, she asked factual questions to let the students recall the concepts included in the analogy. Although one student remarked the repetitive questions as, "This is quite pointless," the class gave correct answers to these simple-recall questions. One student blurted out, "Ah, the cardiovascular (activity)" to which the teacher responded, "Genius class. All right. All right" The activity aimed to help the students memorize the sequence of blood flow inside the heart.

Another lesson from the U.S. went through this kind of succession: Elicit→Engage→Explain. The teacher also asked factual questions but students exhibited difficulty in making inferences when activities were not conducted. The rest of the period was used up using auxiliary questions. However, the time was consumed and the discussion was not completed.

Similar type of questions were used by teachers in that same country but the succession of parts of the lesson and the absence of activity contributed to the inability of students to give appropriate responses.

Elaborate (Note taking; form conclusion). Studies have shown that note taking is a worthwhile learning strategy (Di Vesta & Gray, 1972; Olmos & Lusung-Oyzon, 2008). Note taking is perhaps more aptly appreciated by the advocates of the Information Processing Theory. In this theory, three operations, namely: encoding, storage, and retrieval are viewed to be essential. These operations are also at the core of note taking (Olmos & Lusung-Oyzon, 2008). A physical encoding takes place on paper when a student is engaged in note taking. Note taking increases the limited capacity of the working memory and prevent decay of received information. The recall task is less burdensome with good notes.

Studies attest to students being poor note takers because they tend to miss out half of the critical points of a given lesson (Baker & Lombardi, 1985; Olmos & Lusung-Oyzon, 2008). Using text outline in books, similar to outline notes of lecturers, provided considerable assistance to Japanese students because it covered information highlights of the experiment. Highlighting important information to consider in the book, after the experiment and discussion, created the right environment for note taking. In addition, Asking conceptual questions, such as: "So by the copper wire being separated, what does it mean?" to connect data gathered through experiment with the information on the book, facilitated rapid identification of the main points of the lesson. More importantly, it lessened the cognitive load on the note takers and allowed them to focus more on encoding and understanding the connection among prior knowledge, information learned through experiments and discussion, and the points outlined in the book.

Thus, when teachers asked students, "So how do you summarize these three sentences to arrive at a conclusion?" they were able to formulate their own conclusion. Teachers, themselves, formed conclusions when convergent and evaluative questions were not utilized.

<u>Extend (Link conclusions to succeeding lesson).</u> This is the original part of a Japanese science lesson cycle. The content of Japanese science lesson cycles was organized to support the making of connections between ideas and evidence, and was presented coherently with strong conceptual connections (Roth et al., 2006).

More importantly, connecting conclusions to succeeding lessons was also observed in Japanese science lessons. Teachers who asked factual questions, for instance: "How did we express iron as a symbol? Okay, we'll be using these substances in our next meeting" created an opportunity to challenge students to call on prior knowledge and embark them from memorizing information to meaningful learning. Thus, the journey of connecting learning events rather than remembering bits and pieces continues (Christen & Murphy, 1991).

<u>Evaluate</u> (Auxiliary questions). Auxiliary questions fall under the group, "supplemental questions," which comprised 49.7% and 51.5% of the total questions embedded in Japanese and U.S. science lessons. This type of question provided students clarification, assurance, and/or affirmation through scaffolding in question form.

'Scaffolding' comes from the works of Wood, Bruner and Ross (1976). The term was developed as a metaphor to describe the kind of assistance offered by teachers to support learning of students. In the process of scaffolding, the teacher helps the student master a concept that students are initially unable to grasp by themselves (Lipscomb, Swanson & West, 2004).

Although scaffolding may take the form of a teacher thinking aloud, use of a mnemonic device, guided practice, and tutoring peers during group activities, the study focused on questioning as a scaffolding technique. Samples of these are: “Are you guys ready to heat?” “Can we start now?” “Do you know hot to get it off?” “Do you understand?” “When we looked at it…everyone look, all right? There is, right? From the beginning to the end, there is always starch in these.” When teachers wanted to make their students ponder on a response, “It may have?” Note that the latter example of auxiliary question was a repetition. “Scaffolding is actually a bridge used to build upon what students already know to arrive at something they do not know. If scaffolding is properly administered, it will act as an enabler, not as a disabler” (Benson, 1997).

Conclusions and Implications

Questioning is the window of learning. It can motivate students to perform tasks and help them continue their journey toward discovering awe-inspiring connections among science concepts. However, questions that lead to high density of canonical knowledge proved to be inefficient in getting appropriate responses from students.

Being adept in information regarding types of questions is a basic thing. But being able to use each type to the fullest, by considering the task or activity in each lesson cycle and the succession of these parts, is essential. Effective questioning not only generates appropriate answers from students, more importantly, it provides answers to broad calls of educators to facilitate students’ higher order thinking skills.

The Window Model, which bears classifications of questions, serves as a mental model of the questioning techniques of teachers. In this study, the Window Model facilitated the analyses of three important things: 1) bulk of conceptual questions that may lead to development of higher order thinking skills; 2) types of questions that fit each part of a lesson cycle and; 3) questioning techniques depend on succession of parts of a lesson cycle (different responses from students may be generated despite usage of similar type of questions). The findings of this study can help educators and researchers in analyzing trends in questionings of a country and compare it to other countries. For students, teachers who ask effective questions will help them to regain attention, motivation, and inclination to learning, instead of making them habitual onlookers of objects and sceneries that lie beyond the windows of their classrooms.

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