Influence of Teaching Option and Teaching Experience on Science Teachers' Pedagogical Content Knowledge of Environmental Education

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ABSTRACT

Environmental Education is usually taught across the curriculum in most of the countries. This teaching approach had been a challenge for the teachers to implement especially in the Malaysian curriculum context. Thus, science teachers require Pedagogical Content Knowledge of Environmental Education (PCK-EE) to implement Environmental Education across curriculum. The purpose of this study was to explore the influence of teaching option and teaching experience on science teachers' PCK-EE. Five components of PCK-EE were investigated in this study, which were: a) knowledge of curriculum, b) knowledge of content, c) knowledge of student, d) knowledge of teaching strategies, and e) knowledge of evaluation. 347 secondary science teachers from the state of Selangor participated in this survey study. The questionnaire used had 60 items. The findings revealed teaching option have significant influence on science teachers' knowledge of content (p=.000), knowledge of student (p=.000) and knowledge of teaching strategies (p=.016). In the case of teaching experience, it was found that there is a low correlation on two components of PCK-EE i.e. knowledge of content (r=.174) and knowledge of evaluation (r=.170). Implication of this study leads to the suggestion of the enhancement of teachers' education program especially at pre-service level. This is because pre-service training is found out to be the factor that determines teachers' future teaching option.

INTRODUCTION

Environmental Education is the agenda of sustainable development that is expected to foster development of the concept of environment, sensitivity towards the environment, and eventually enhancing the values which stimulate individual and society participation to care for the environment (Cutter 2002). Based on the timeline of the Decade of Education for Sustainable Development (DESD) plan, implementation of Environmental Education is now in the third phase; the identification of the impact and results of the implementation of Environmental Education. Therefore, few studies have been conducted to see how well the environmental literacy had shifted among the students and teachers after almost three decades Environmental Education in Malaysia implemented across curriculum.

Norlila (2007), Mageswary et al. (2006), and Santha (2008) conducted studies to measure Malaysian students' knowledge about the environment. Result of the studies showed that the level of attitudes and behavior towards the environment among students were at the moderate and low level. It also appears that the level of teachers' knowledge concerning the environment is between moderate and low level (Che Kalbi, 1999; Rohiza, 2004; Khor, 2006; & Mohammad Zohir, 2008). Those teachers who are knowledgeable about the environment were said to be actually acquired some specific knowledge of environmental issues only (Rohiza, 2004). Nevertheless, Khor (2006) argues that the teachers' knowledge on environmental issues is satisfactory, but not for the knowledge of environmental and sustainability concepts. Thus, Tal and Argaman (2005), Choi and Cho (2009) and Alvarado (2011) concluded that Malaysian teachers have low level of PCK-EE.

This problem is worrying as one of the features needed to develop effective teaching and learning of Environmental Education is the quality of the PCK-EE of the teachers (Khairuddin 2004; Kisoglu 2010). Though an advanced technology has been used at the present time for dissemination of educational materials, the aspects of pedagogy and knowledge of teachers are still remain as a priority as it was thought to be a valuable investment for providing significant returns to education (Shaffe 2004) and subsequently for environmental sustainability. Tthe quality of PCK among teachers are based on various factors, among others are their teaching option (Subahan 1998; Sarkim 2004) and teaching experience of teachers (Nilsson 2008; Isamudin 2008; Tengku Zawawi 2005; van Driel et al. 1997; Coble and Azordegan 2004; Hammond et al. 2005).

Usually, the determination of teachers' teaching option in school depends on the key areas they had during pre-service training in teaching institutions. But in reality the teaching option is made based on the determination to meet the requirements of teaching vacancies (Mohamad Rahmat 1995) as well as other factors such as balancing the number of teachers based on gender, attitudes, responsibilities and existing problems (Wang & Azizah 2005). This situation presents a great challenge to non-option teachers. Compared to an option teachers, the non-option teachers have a tendency to experience difficulties during teaching process as their teaching tend to be based on a teaching the theory only (Subahan 1998). Teaching across curriculum as expected used for Environmental Education would serve more challenge to these teachers because there are no specific option teachers to teach Environmental Education. However, based on the concept of science education described by White (2000) and the Curriculum Development Centre, Malaysian Ministry of Education (2005), science is one of the most relevant curriculums to be as the medium for the implementation of Environmental Education.

In terms of teaching experience, de Jong (2009) found that PCK authentic changes occur when the teaching experience is required to make a reflection on the previous lesson. Moreover, van Driel et al. (1997) reckon mostly experienced teachers were capable to transform their knowledge of general pedagogy into the knowledge of content and knowledge of teaching strategies. However, Tengku Zawawi et al. (2009) criticized this opinion as he asserted that experienced teachers may have good knowledge about the learning difficulties of students, but this does not mean that they are able to plan lessons well.

Based on the above arguments, the question arose is whether the two factors of PCK developments also influenced the development of the PCK-EE of science teachers. The current teaching of EE uses across curriculum approach that entails either for teachers to deliver the content of Environmental Education to students independently or integrate them in any phase areas of the teaching and learning process (Nilsson 2008). However, factors such as teaching option and teaching experience may be an impediment for effective implementation. Thus, the aim of the study is to answer three questions:

i. What is the level of PCK-EE that science teachers have?

ii. Is there a significant difference between the level of PCK-EE among Biology, Chemistry, Physics and Core Science teachers?

iii. Is there a relationship between the level of PCK-EE with science teachers' teaching experience?

METHODOLOGY

This survey study was conducted among 347 science teachers from the state of Selangor, in Malaysia. 29.5% of the total respondents are Biology teachers, 13.8% are Physics teachers, 26.2% are Chemistry teachers and 30.5% are Core Science teachers. In addition, respondents are also selected from a different range of teaching experience, which is 54.8% of them had teaching experience less than five years, 17.6% have teaching experience between six and ten years, 14.4% experienced teaching between 11 to 15 years, and the balance of 13.3 % had taught for more than 15 years.

Quantitative data was collected using a 60 item questionnaire. The items were developed based on five components of PCK-EE which were adapted from the Science PCK research instrument developed by Tuan et al. (2000). The five components of PCK-EE were: i) knowledge of curriculum, ii) knowledge of content, iii) knowledge of students, iv) knowledge of teaching strategies, and v) knowledge of evaluation. As for knowledge of curriculum and knowledge of content (in this case on environmental issues), respondents were tested through multiple choice questions. While respondent's knowledge of students, teaching strategies and evaluation are gauged through 5 point Likert items which ranging from 1 = never, 2 = very rare; 3 = sometimes, 4 = often and 5 = very often.

To determine the science teachers' level of PCK-EE for each component, a descriptive analysis based on the mean and standard deviation values were used. To compare the level of PCK-EE among science teachers with different teaching options, the one-way ANOVA test was used, while the relationship between PCK-EE with experience in teaching is determined by Spearman rho correlation test.

Table 1

Component of PCK-EE	n item	Reliability coefficient value
Knowledge of curriculum	6	0.54
Knowledge of content	27	0.91
Knowledge of students	6	0.91
Knowledge of teaching strategies	14	0.94
Knowledge of evaluation	7	0.90

Table 1 shows the reliability coefficient value for each construct of which all constructs except for the construct for , knowledge of curriculum is high (0.90). However, validity test from the experts decided that all six items in this component should be maintained.

FINDINGS

Overall, Table 2 shows the results of descriptive analysis to determine the level of PCK-EE according to each construct. For the knowledge of curriculum and knowledge of content components, the mean value was based on the total scores of correct answer given by the respondents. In term of the component for knowledge of curriculum, six items were put forward. Based on the mean value, the average number of correct answer given by respondents for this component was 2.92 (SD=1.16).This value signified that the knowledge of science teachers on Environmental Education curriculum was at a moderate level. The component for knowledge of content consists of 27 items with the mean value of correct answers being 13.39 (SD=3.18). The result from the mean value signified that respondents' mastery on knowledge of content is also at moderate level.

Table 2

Components of PCK-EE	n item	Mean	Std. Deviation
Knowledge of curriculum	6	2.92	1.16
Knowledge of content	27	13.39	3.18
Knowledge of students	6	2.64	0.81
Knowledge of teaching strategies	14	2.21	0.77
Knowledge of evaluation	7	2.65	0.90

As shown in Table 2, the mean value for knowledge of students and knowledge of evaluation components were almost comparable, which were 2.64 (SD = 0.81) and 2.65 (SD = 0.90) respectively. This value do not differ much from the mean value for knowledge of teaching strategies which is lower at 2.21 (SD = 0.77).These mean values indicate that respondents' level of PCK-EE on knowledge of students and evaluation was at moderate level, while the level on knowledge of teaching strategies was low.

Comparison of PCK-EE between science teachers of different teaching options

The finding on the comparison of PCK-EE between science teachers' teaching option is shown in Figure 1 and Table 3. Overall, the comparison of mean values shows identical level of five components of PCK-EE among respondents from every teaching option. However, graph in Figure 1 illustrates that the mean value for each component of PCK-EE for the Physics teachers is quite clearly lower than the teachers from other teaching options. Biology teachers clearly obtained highest mean value for knowledge of content. While based on inferential analysis, the p value obtained for the component of knowledge of curriculum and knowledge of evaluation exceeds 0.05 (F (3, 343) = 1.73, p = 0.162 and F (3, 343) = 2:08, p = 0.102) respectively. This finding indicates that there is no significant difference of mean for knowledge of curriculum and knowledge of evaluation among the four groups of teaching option studied. In addition, the p value for the knowledge of content (F (3, 343) = 6:54, p = 0.000), knowledge of students (F (3, 343) = 10:40, p = 0.000) and knowledge of teaching strategies (F (3, 343) = 3:48, p = 0016) are less than the significant value 0.05 (5%). That means there are significant differences between mean value for those three components of PCK-EE among Biology, Chemistry, Physics and Core Science teachers. Consequently a PostHoc Tukey test was carried out to identify the differences.

Based on the Tukey Post-Hoc test analysis, it was identified that differences mainly occur between Biology and Physics teachers. As for knowledge of content, there were significantly different mean between Biology and Physics teachers (p = 0.000), Biology and Chemistry teachers (p = 0.035), and Physics and Core Science teachers (p = 0.032). Whereas for the knowledge of students, Post-Hoc tests revealed significant mean differences between Biology and Physics teachers, Chemistry and Physics teachers, and Biology and Core Science teachers. Significant value of each pairs were p = 0.000. Comparison of differences between groups for knowledge about teaching strategies showed significant values only for the Biological Physics group (p = 0.000).

The Biology teachers perform better in the construct related to knowledge of content compared to the other group of teachers because as shown from the analysis of curriculum specification of each subject it was found that Biology is a subject that is most relevant to apply Environmental Education in its teaching. Almost all the environmental knowledge themes listed by Hungerford et al. (1994) are applied in the Biology curriculum, particularly in the last two chapters in the Biology Form Four syllabus namely "Ecosystem Dynamics" and "Endangered Ecosystems'. Almost all of environmental theme has been infused into several subtopics, namely: a) the abiotic and biotic components of ecosystems, ii) Colonization and succession in the ecosystem, iii) the population ecology, iv) biodiversity, v) appreciation of the biodiversity, vi) human activities that endanger the ecosystem, vii) the greenhouse effect and ozone layer depletion, and viii) the development of activities and ecosystem management. Apart from the two main chapters mentioned, there are also several other chapters in the Biology curriculum that is appropriate to apply knowledge about the environment indirectly. For example, through the chapter of ‘Nutrition’, knowledge about food resources can be delivered to students while knowledge of the human population can be applied through chapter ‘Fertilization and growth’.

Similarly, the Core Science curriculum also has a specific chapter that can apply knowledge about the environment. In the Form 5 syllabus, there are chapters that convey environmental knowledge directly to students. The chapter is ‘Preservation and Conservation of the Environment’. Through this chapter, several environmental themes are conveyed to students through the subtopics i) the balance in nature, ii) environmental pollution, iii) the preservation and conservation of the environment and pollution control, iv) the importance of proper management of natural resources in maintaining balance in nature, and v) practicing responsible attitudes to preserve and conserve the environment. Meanwhile, in other chapters, such as ‘Nuclear Energy’ and ‘Chemicals in Industry’, there is a subtopic related to environmental nature that can be applied as a platform to discuss with students about the need for proper handling of radioactive substances, and the effects of industrial wastes disposal on the environment.

On the other hand, based on the description of the Physics syllabus, it was found that this subject is a subject that can apply the least of environmental knowledge in its curriculum. Only a few subtopics were identified to be relevant for Environmental Education. In fact, the subtopics identified were only from the Form 4 syllabus. For example it was about the need for energy that applied through the subtopics ‘Understanding work, energy, power and efficiency’ from the topic ‘Force and motion’.

For the knowledge of students, it was found that significant differences exist between Biology and Physics teachers, and also between Biology and Chemistry teachers. Knowledge of students related to EE would probably similar to the knowledge of students in learning biology since the environmental themes and issues are in synergy with Biology compared to the learning and teaching of Physics and Chemistry. Thus, Physics and Chemistry teachers would less understanding of knowledge of students that would help learning and teaching of EE. Finally, the Core Science involves combination of all three science components but at surface level.

Whils, the knowledge needed by teachers on students’ existing knowledge, learning styles, learning difficulties, students’ capabilities and strengths, and student’ achievement in environmental education learning could be assumed to be very similar to that required for teaching Biology and Core Science subjects. Thus, this gives an advantage to these two group of teachers to know their students for teaching and learning in Environmental Education. But, for the Physics and Chemistry teachers, they must explore the knowledge of students more widely in order to integrate environmental knowledge which are different from the core subjects they are teaching.

For the knowledge of teaching strategies, significant differences were found between Biology and Physics teachers. Biology teachers have a higher level of knowledge of environmental education teaching strategies. According to Raczynki and Munoz-Stuardo (2007), teachers teaching strategy involves among others choosing languages relevant to the subject content. Thus, somehow it give an advantage to Biology teachesr to implement Environmental Education rather than other subject specific teachers.

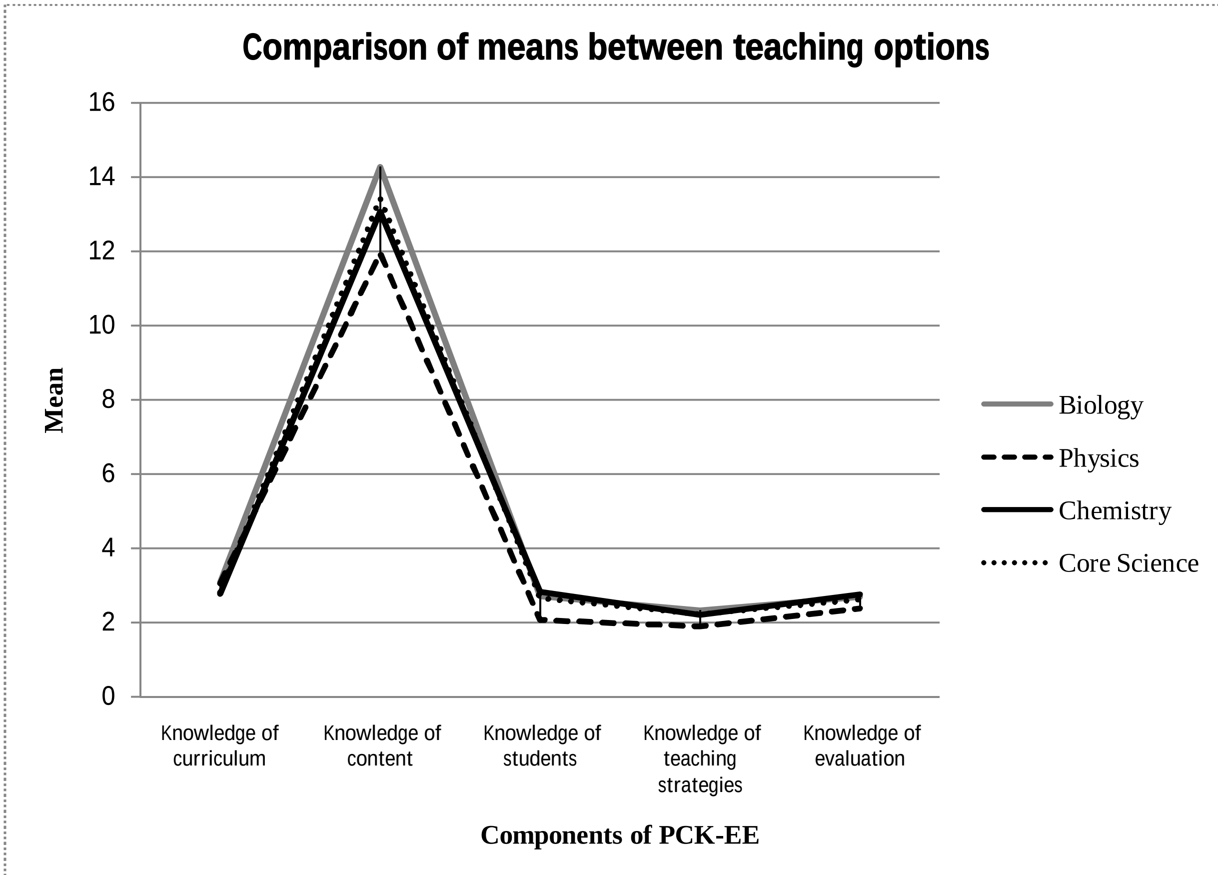
Comparison of means between teaching options
16
14
12
10
8
6
4
2
0
Mean
Knowledge of curriculum
Knowledge of content
Knowledge of students
Knowledge of teaching strategies
Knowledge of evaluation
Components of PCK-EE
Biology
Physics
Chemistry
Core Science

FIGURE 1

TABLE 3

Component of PCK	No. of items	Mean and Standard Deviation (SD)				F	Sig.	Tukey HSD Result	
		Biology	Physics	Chemistry	Core Science			Difference between groups	Sig.
Knowledge of curriculum	6	3.09 (1.18)	3.06 (1.21)	2.78 (0.98)	2.81 (1.24)	1.73	.162	-	
Knowledge of content	27	14.28 (1.16)	11.96 (3.43)	13.07 (3.35)	13.44 (2.81)	6.54	.000*	Physics- Biology	.000*
								Physics – Core science	.032*
								Chemistry - Biology	.035*
Knowledge of student	6	2.71 (0.79)	2.08 (0.93)	2.83 (0.52)	2.66 (0.87)	10.40	.000*	Physics – Biology	.000*
								Physics – Chemistry	.000*
								Physics – Core Science	.000*
Knowledge of teaching strategies	14	2.33 (0.78)	1.90 (0.68)	2.21 (0.64)	2.22 (0.87)	3.48	.016*	Physics - Biology	.008*
Knowledge of evaluation	7	2.70 (0.93)	2.38 (1.00)	2.76 (0.86)	2.62 (0.83)	2.08	.102	-	

* The mean difference is significant at the .05 level.

The relationship between PCK-EE with science teachers' teaching experience

Figure 2 and Table 4 shows the descriptive and inferential analysis of the relationship between PCK-EE with science teachers' teaching experience. As seen in Table 4, comparison of the mean value for five components of PCK-EE studied did not show a clear trend with teachers' teaching experience. It was also supported by the graph in Figure 2. The lines which indicate mean values of the six to ten years experience group cannot be seen in the graph as their mean values for every component was almost similar to the mean value recorded by the group of more than 15 years experienced teachers. Both of these groups also showed quite clear higher mean values of PCK-EE compared to the other two groups (below 6 years and between 11 to 15 years). For the lowest mean value, the most inexperienced teachers were not necessarily having the lowest level of knowledge than other teachers. For example, as for knowledge of teaching strategies component, the lowest mean value recorded by the group of teachers who have teaching experience between 11 to 15 years.

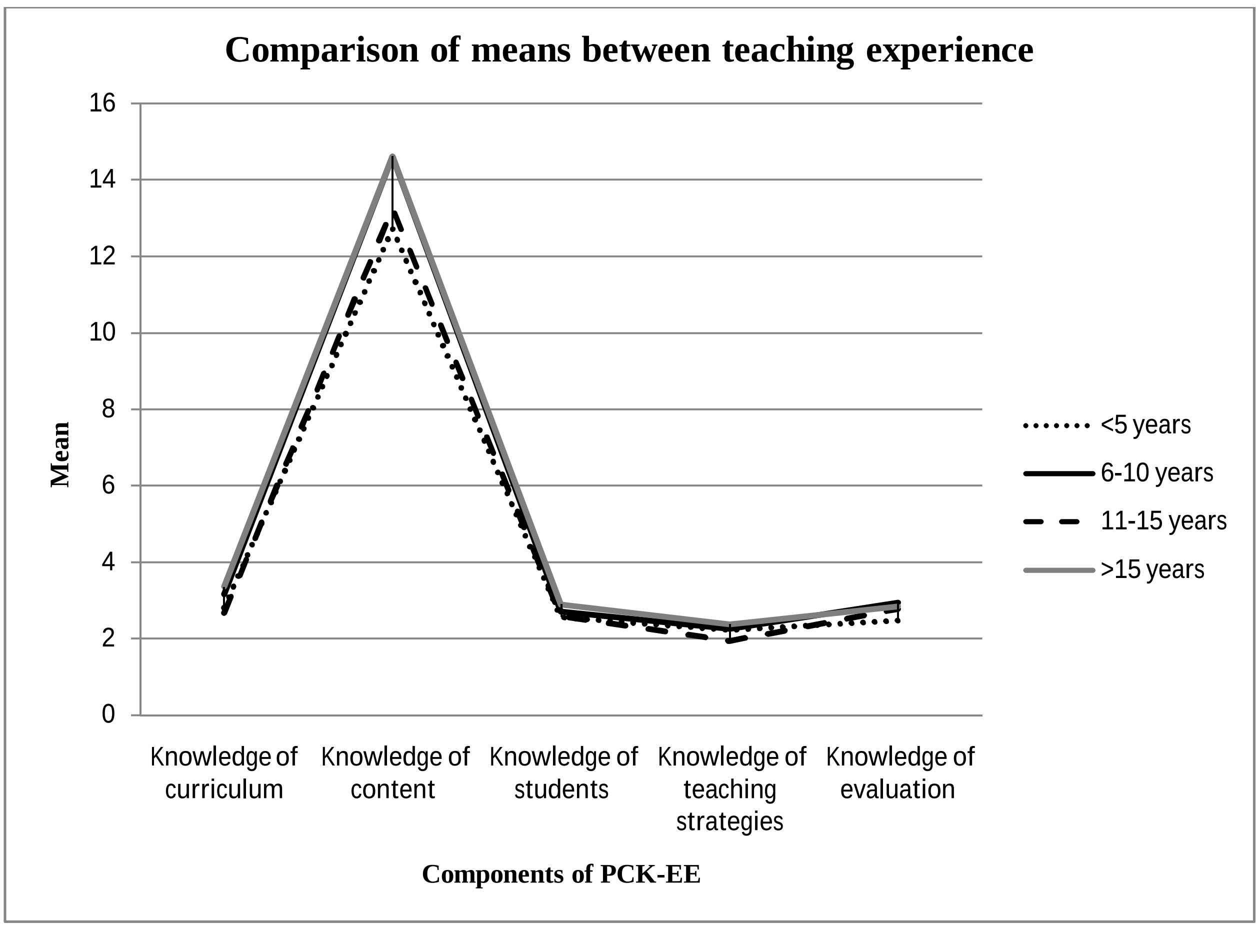

FIGURE 2

Table 4

Component of PCK	No. of items	Mean and Standard Deviation (SD)				Spearman rho correlation value (r)
		≤ 5 years	6 – 10 years	11 – 15 years	>15 years	
Knowledge of curriculum	6	2.80 (1.31)	3.16 (0.66)	2.68 (1.19)	3.35 (0.74)	.091
Knowledge of content	27	12.73 (3.48)	14.61 (2.50)	13.26 (2.44)	14.61 (2.57)	.174**
Knowledge of student	6	2.56 (0.89)	2.71 (0.59)	2.60 (0.93)	2.89 (0.49)	.075
Knowledge of teaching strategies,	14	2.22 (0.83)	2.26 (0.60)	1.94 (0.68)	2.37 (0.80)	-.016
Knowledge of evaluation	7	2.47 (0.90)	2.95 (0.78)	2.77 (0.88)	2.84 (0.90)	.170**

** The correlation is significant at the 0.01(2-tailed) level.

From the inferential analysis, Spearman rho correlation value shows only two components of PCK-EE have significant relationship ($r < 0.01$) with the teaching experience. The two components were knowledge of content and knowledge of evaluation. For the knowledge of content, $r = 0.174$, $n = 347$, $p = 0.001$, while for knowledge of evaluation, $r = 0.170$, $n = 347$, $p = 0.001$. However, both of the findings revealed that the strength of the relationships is very low.

This finding has rejected the notion argued by van Driel et al. (1997), Coble and Azordegan (2004), Hammond et al. (2005), and Yusminah and Effandi (2010), who claimed that more experienced teachers have higher levels of PCK than less experienced teachers. However, the finding of this study supports Grosmann et al. (1989) and Tengku Zawawi et al. (2009) view that the teaching experience of a teacher cannot guarantee the development and stability of PCK. Teaching experience is not the only factors that influence teachers PCK but it may influence just some of the components (Grosmann et al., 1989). In Kamtet et al. (2010) view, teachers who have longer teaching experience may have broader knowledge of content because there is a high probability that they had taught students from various levels. Indirectly, these teachers need to acquire the greater scope of knowledge of content especially which involve for each level of the students being taught.

Regarding the knowledge of evaluation component, Brickhouse and Bodner (1992) explained that less experienced teachers have lower levels of knowledge of evaluation because they are often confused between their personal views on the teaching and learning evaluation concept with the realities in the classroom. In contrast, experienced teachers was said to be capable to solve the problem as the practical experience will provide them with the necessary understanding of the considerations on how to choose the method of teaching and learning evaluation in real classroom situations (Nilsson 2008 & Noor Shah, 2009).

A way to resolve this problem, is that it is suggested that the improvement should be made on the structural of teaching training programs for every option of science teachers. Emphasis should be placed on each component as the mastery of PCK-EE among science teacher as a whole have not reached the desired level. However, on the basis of the findings, it is seen that the knowledge of environmental education teaching strategies need to be stressed on. Science teachers should be taught how to develop the skills of selecting appropriate teaching strategies which will enable to generate students' understanding and interacting science knowledge with the integrated knowledge (Mishra & Koehler, 2006). Therefore, it is suggested that teacher training programs ought to use the approach or teaching strategies that are proposed to the teachers. That way, teachers will get an idea of how teaching strategies can be applied in their teaching. PCK-EE can be exposed to science teachers through the restructuring of science education training curriculum, namely putting emphasis on the ways of evaluating student teachers ability to integrate environmental knowledge during their macro/micro teaching and teaching practice. Similar emphasis should be done on experienced teachers since this study showed that PCK-EE does not automatically acquired through experience. Hence, professional development program for Environmental Education for experienced teachers is needed.

CONCLUSION

PCK-EE is an area of study that gets less attention among researcher and academia. In this study, the PCK-EE investigated was based on five components, which were: knowledge of curriculum, knowledge of content, knowledge of students, knowledge of teaching strategies, and knowledge of evaluation.. The study found that the overall level of PCK-EE among science teachers is moderate. The level of the various types of knowledge is found to be different between teachers of different science teaching options, and have a weak relationship with teaching experience. Therefore, systematic efforts should be made by strengthening the current pre-service and in-service teacher training programs where PCK-EE is acquired explicitly the teaching of EE that is currently being practiced, i.e. teaching EE across curriculum, might be shortchanged since teachers tend to teach and focus on topics that will be tested in the examination. Perhaps the teaching of EE should be as a subject matter and being tested. Thus, it is suggested that a Delphi study should be carried out with various stakeholders regarding the teaching of EE explicitly.

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