Enhancing STEM Pre-Service Teachers' Knowledge

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Abstract
Malaysian Ministry of Education (MOE) has emphasized STEM education as one of the main components in Malaysian Education Blueprint 2013-2025. However, although there are many initiative and policies produced by the government, the target of 60:40 still has not been achieved. The issue of declining students enrol in Science stream has become major issues to the nation. MOE has stressed in STEM initiative program to refine teacher skills and abilities in teaching Science and Mathematics. Due to that, the ability of Science and Mathematics teachers especially among pre-service teacher was under the spotlight in recent debates and reforms about improving Science and Mathematics lesson. Thus, this study aim to determine the level of pre-service teacher content knowledge, pedagogical knowledge and pedagogical content knowledge before and after participates in Guided Intervention for Future STEM Teachers (GIFST) Program. This study also intended to identify is that any significant difference of pre-service knowledge before and after joined the program. A total of 91 Science and Mathematics pre-service teacher participated as sample for this study. Based on the result, it was found that there is a significant difference in pre-service teachers' knowledge before and after participated in the program. It also proved that this program provides positive benefit to Science and Mathematics pre-service teacher especially in content knowledge and pedagogical content knowledge.
Keywords: STEM Education, Pre-Service Teacher, Content Knowledge, Pedagogical Knowledge, Pedagogical Content Knowledge

Introduction
        The importance of Science, Technology, Engineering and Mathematics (STEM) education has always been a priority in Malaysia. Since 1970, the government has targeted in the first National Science and Technology Enrolment Policy of 60:40 which aims that 60 percent of students would be enrolled in Science stream and remaining 40 percent in art stream. In 1991, Malaysia has launched Vision 2020 with the goal to establish an innovative

and scientific society. In addition, the Ministry of Education (MOE) has accelerated STEM initiative in Malaysian Education Blueprint 2013-2025. The aim of this substantial idea is to prepare students with the skills to meet the Science and Technology challenges and also to ensure that Malaysia has a sufficient number of qualified STEM graduates in MOE future. MOE has been very serious about STEM education where for in first time, the Malaysian government officially used the K-12 STEM notion in education planning. The document is just a general planning for all fields and not just for the STEM field but STEM is clearly going to be the basis for the new national curriculum.

Despite the government's commitment to align all the initiatives in past decades, there are still challenges to achieve the target. This shown by the indication number of students who have chosen STEM fields has continued to decline in recent years (Halim & Subahan, 2016). Based on the record of 2016, only 42% of middle school students in Malaysia chose to do Science, including technical and vocational programs at high school (MOE, 2016). This current trend of students' preference provides a warning signal to the development of the nation in the future. According to The National Council for Scientific Research and Development, Malaysia needs a workforce of 493,830 people in STEM related industries by 2020 to support the current government initiatives. This means that the rate of increase of STEM should be about 31% per year (MOE, 2013). However, the current situation in STEM education is not parallel with the demand of government. MOE has stressed that one of the factor underlying the declining enrolment and quality of student outcomes in STEM is inconsistent quality of teaching and learning. The key player to ensure that the STEM education has effectively delivered to the students is teacher. Due to that, MOE also has targeted that to enhance STEM teachers' skills and abilities especially in content knowledge and pedagogical knowledge.

The lack of interest in Science and Mathematics class is one of the most obvious causes for concern in the debate STEM education. It has been seen time and again that pupils lose their enthusiasm for Science and Mathematics once they reach upper secondary level. Character and teachers approach able to enhance students' interest towards these subjects. Teacher personality was found play significant factors that could influence students' perception towards subject (Kubiatko, Torkar & Rovnanova, 2017).

In recent times, debate about students' engagement and perception towards Science and Mathematics subject has been increasingly concerned with the quality of teaching that is provided in classroom. According to Acharya (2017), teachers play an important role as key and provider of sound environment for improvement of pass rate respectively. The way of teacher connect the previous concept with the content structure of the lesson would contribute to the students anxiety and feeling in STEM related subject. Since STEM related subjects consist scientific and abstractly concepts, the teacher should have a robust content knowledge (CK) and dynamic pedagogical knowledge (PK) when delivering STEM related subjects. According to Halim, Abdullah & Meerah (2014), it appears that as overall the teachers and students have not addressed their needs. Low-achieving students do not view 'knowledge of concept representation' as important for effective teaching. They valued the fact that teachers should be alerted to their needs, such as being sensitive to students' reactions and preparing additional learning materials. This study has revealed that pedagogical content knowledge (PCK) of science teachers should be different for high and low-achieving students and knowledge of students' understanding plays a critical role in shaping teachers pedagogical content knowledge.

Teachers knowledge in CK, PK and PCK are essentials to ensure that STEM related subjects have efficiently conveyed to students. Ergönenç, Neumann and Fischer (2014) found that teachers' PCK was positively correlated with students' learning gains. Teachers with a higher PCK pose more questions on a cognitive level, which can be, or in fact are, answered by their students. Obviously PCK enables teachers to estimate the cognitive level their students are able to achieve. This result was well in line with our expectations as obviously teachers that know much about students' misconceptions and difficulties in subject content are able to consider these factors while posing questions during a lesson. Concern about future of STEM education, all STEM educators should be strengthening with CK, PK and PCK especially pre-service teacher. Pre-service teacher should been provide with opportunities to apply the theoretical knowledge they gain in the methodology course, contributes to the development of their PCK. These potential Teacher need to understand the content they want to teach but they also need to understand how to unpack and present the content so that students can learn with understanding (Atay, Kaslioglu, & Kurt, 2010).

Considering this emerging concern, the Science and Technology Department, Faculty of Education, UiTM has conducted Guided Intervention for Future STEM Teachers (GIFST) Program. Guided Intervention for Future STEM Teachers (GIFST) Program is intervention program for STEM preservice teacher initiated by Science and Mathematics Department, Faculty of Education, Universiti Teknologi MARA. This program emphasizes on constructing and handling hands-on and outdoor activities for STEM lesson. This 'out of norm classroom learning' is an avenue to foster contextual and meaningful experience that could help Science and Mathematics pre-service teacher exploit the technique and approach teaching Science and Mathematics in more depth and challenging manner. The participants have experienced a three days' course and minimum three of the five times STEM activities in schools. In the three days of workshop, the participants are emphasizing on the roles of facilitators, persuasive speech, communication skills, creative and critical thinking, construct and handle STEM activities. With this in view, the prime aim of this study is to investigate the effectiveness GIFST program in improving Science and Mathematics pre-service teachers in content knowledge, pedagogical knowledge and pedagogical content knowledge. To be specific, the researchers intended to investigate the following questions

- What is the level of Science and Mathematics pre-service teacher attainment in content knowledge, pedagogical knowledge and pedagogical content knowledge?
- Is there any significant different level of pre-service teacher content knowledge, pedagogical knowledge, and pedagogical content knowledge before and after participating in GIFST?
- How does GIFST beneficial to pre-service teacher in teaching Science and Mathematics?

Methodology

This two-phase study utilised a purely quantitative approach involving a descriptive design and an experimental design. Descriptive design seeks to investigate the current condition of targeted pre-service teacher. The descriptive design was undertaken to depict a picture of pre-service teacher perception towards GIFST program and their knowledge about Science and Mathematics content knowledge, pedagogical knowledge and pedagogical content knowledge. On the other hand, a quasi-experimental design was used with the aim to establish cause effects relationships about GIFST program with improvement of pre-service teacher in Science and Mathematics content knowledge, pedagogical knowledge and

pedagogical content knowledge. In other words, this experimental design enabled the researchers to assess the effectiveness of the GIFST program in enhancing pre-service teacher development in pedagogy skills related to STEM.

In the first phase, a Diagnostic Test focuses on content knowledge, pedagogical knowledge and pedagogical content knowledge of Science and Mathematics was administered to 245 Science and Mathematics pre-service teacher, ages 20 to 24, registered in a degree program in Science and Mathematics education program at a local university. All the samples have joined intervention course for three days that focusing on pedagogy and instruction in STEM.

In the second phase, ninety-one students from Science and Mathematics program were randomly selected to participate in a One Group Pre-Post Quasi Experimental Design with the aim to explore the effects of a GIFST program in developing pre-service teacher content knowledge, pedagogical knowledge and pedagogical content knowledge in teaching STEM. In the higher education program, random task of students into different group was difficult due to the institution rules, policy and procedural. Thus, for that reason, intact block sampling method is appropriate in such educational setting to represent the population of study (Creswell, 2008). These selected 91 samples (mean=5.63, SD=0.57) could be viewed as a representative of the total population of the 245 samples (mean=5.72, SD=0.50) based on the similarity mean scores obtained between the two groups in diagnostics test before joined GIFST program.

To determine if the selected groups were normally distributed, the Shapiro-Wilk test was conducted. The analyses of the p value indicate p>0.05 depicting both sets of data groups were normally distributed. Thus, this design attempts to establish a cause effects relationship with the variables of study namely content knowledge, pedagogical knowledge and pedagogical content knowledge in STEM. After undergoing the preparatory course, this group was engaged with the intervention by conducting STEM activities in five different schools for three months. Then, a post-test regarding their skills in content knowledge, pedagogical knowledge and pedagogical content knowledge in teaching STEM are determined.

A diagnostic test comprising 22 items that focus in measuring content knowledge, pedagogical knowledge and pedagogical content knowledge in teaching STEM. For a period of three days workshop, the experimental group was subjected to the humanize STEM in teaching Science and Mathematics. These students were explicitly taught about the foundation of facilitators, application of Science and Mathematics in daily life, humanizing Science and Mathematics in our daily life and Science and Mathematics recreational.

Table 1 shows the distribution of the respondents according to program. It indicates out of 91 respondents, 60 (65.9%) respondents from Mathematics program and 31 (34.1%) respondents from Science program.

Table 1
The Distribution of the Respondents According to Program

Program	Frequency	Percentage (%)
Mathematics	60	65.9
Science	31	34.1
Total	91	100.0

Table 2 shows the distribution of the respondents by semester. It indicates out of 91 respondents, the highest respondents came from semester 8 which is 36 (39.5%) followed by Semester 7 students with 22 (24.2%), Semester 6, 24 (18.7%), and Semester 5, 16 (17.6%).

Table 2
The Distribution of the Respondents by Semester

Semester	Frequency	Percentage (%)
Semester 5	16	17.6
Semester 6	17	18.7
Semester 7	22	24.2
Semester 8	36	39.5
Total	91	100.0

Table 3 shows the distribution of the respondents by gender. It indicates out of 91 respondents, the highest numbers of respondents are female which are 51 (56.04%) and 40 (43.96%) respondents are male respondents.

Table 3
The Distribution of the Respondents by Gender

Gender	Frequency	Percent (%)
Male	14	15.4
Female	77	84.6
Total	91	100.0

This was followed by interviews with 8 selected pre-service teachers in determining the details about the beneficial of GIFST program towards developing pre-service teacher content knowledge, pedagogical knowledge and pedagogical content knowledge in teaching STEM. Data collected from both the quantitative and qualitative methodology provides a general picture the effectiveness and impactful the GIFST program in developing content knowledge, pedagogical knowledge and pedagogical content knowledge in teaching STEM among Science and Mathematics pre-service teachers.

Results of Study
Research Question 1: What is the level of Science and Mathematics pre-service teacher attainment in content knowledge, pedagogical knowledge and pedagogical content knowledge in STEM among i) students of Science program? ii) students of Mathematics program?

Table 4 provides the descriptive scores of the content knowledge, pedagogical knowledge and pedagogical content knowledge in STEM where both the Science and Mathematics pre-service teachers have participated. The means score obtained by the Science and Mathematics pre-service teachers were 22.26 (SD=2.807) and 21.18 (SD=2.234) out of a maximum score of 60 for content knowledge. In other words, the percentage score for each of these groups were 37% (27.26/60 x 100) and 35% (21.18/60 x 100) respectively.

For pedagogical knowledge (*pre-test*), it indicates that the means score obtained by the Science and Mathematics pre-service teachers were 21.32 (SD=3.447) and 21.07 (SD=3.706) out of a maximum score of 60. This shows that the percentage score for each of these groups were 36% (21.32/60 x 100) and 35% (21.07/60 x 100) respectively.

Lastly, for pedagogical content knowledge (pre-test), it is found that the means score obtained by the Science and Mathematics pre-service teachers were 39.16 (SD=8.15) and 40.47 (SD=7.923) out of a maximum score of 100. This shows that the percentage score for each of these groups were 39% and 40% respectively. These findings indicate both Science and Mathematics teacher have attained a low-level score in content knowledge, pedagogical knowledge and pedagogical content knowledge in STEM.

Table 4
Pre-service teacher Score in content knowledge, pedagogical knowledge and pedagogical content knowledge in STEM

Type of Knowledge	Program	N	Mean	Std. Deviation
Content Knowledge (CK)	Mathematics	60	21.18	2.234
	Science	31	22.26	2.807
Pedagogical Knowledge (PK)	Mathematics	60	21.07	3.706
	Science	31	21.32	3.447
Pedagogical Content Knowledge (PCK)	Mathematics	60	40.47	7.923
	Science	31	39.16	8.150

Max score: CK=60; PK=60; PCK=100

Research Question 2: Is there a significant difference in mean scores of the content knowledge, pedagogical knowledge and pedagogical content knowledge in STEM between pre-test and post-test among Science and Mathematics Pre-service Teacher?

The hypothesis to be tested is:
There is a significantly higher mean score in the post test than in the pre-test among Science and Mathematics pre-service teacher.

Table 4 shows that the mean score between pre-test and post-test scores obtained by the pre-service teacher in content knowledge (CK) are 21.72 (SD = 2.52) and 41.26 (SD = 3.24) respectively. For pedagogical knowledge (PK), Table 4 indicates that the mean score between pre-test and post-test score is 21.2 (SD=3.57) and 43.18 (SD=3.88) respectively. Lastly, the mean score between pre-test and post-test score in pedagogical content knowledge (PCK) are 39.82 (SD=8.04) and 75.14 (7.99) respectively.

To investigate if GIFST program has any significant effect on *content knowledge, pedagogical knowledge and pedagogical content knowledge in STEM among* Science and Mathematics pre-service teachers, a paired sample t-test analyses was conducted. The result (refer Table 5) shows that there is a significant difference in the three types of knowledge

(content knowledge, pedagogical knowledge, pedagogical content knowledge) with mean (t=-69.101, df=90, p-value < 0.05), (t=-132.571, df=90, p-value < 0.05) and (t=-79.343, df=90, p-value < 0.05) respectively (content knowledge, pedagogical knowledge, pedagogical content knowledge) between pre-test scores and post-test scores at the .05 level. The findings support the hypothesis that improved scores in content knowledge, pedagogical knowledge, pedagogical content knowledge in teaching STEM are achieved through participation in the three months of GIFST program among Science and Mathematics pre-service teacher.

The descriptive statistics show that the post-test scores of Science and Mathematics pre-service teachers in content knowledge are (M=41.26, SD= 3.24), pedagogical knowledge (M=43.18, SD=3.88) and pedagogical content knowledge (M=75.14, SD=7.99) comparatively higher as compared to the post-test score in content knowledge (M=21.72, SD= 2.52), pedagogical knowledge (M=21.2, SD=3.57) and pedagogical content knowledge (M=39.82, SD=8.04). There is a difference of 32%, 36% and 35% between before and after experienced the training course for three months. In other words, this signifies that the Science and Mathematics pre-service teacher who have experienced the GIFST program is significantly enhanced in terms of their knowledge in content knowledge, pedagogical knowledge and pedagogical content knowledge in STEM.

Table 4
The Descriptive Statistic of Respondent's Level of Content Knowledge, Pedagogical Knowledge, and Pedagogical Content Knowledge.

Type of Knowledge	Mean	N	Std. Deviation
Content Knowledge Before	21.72	91	2.52
Content Knowledge After	41.26	91	3.24
Pedagogical Knowledge Before	21.20	91	3.57
Pedagogical Knowledge After	43.18	91	3.88
Pedagogical Content Knowledge Before	39.82	91	8.04
Pedagogical Content Knowledge After	75.14	91	7.99

Max score: CK=60; PK=60; PCK=100

Table 5
Paired Sample t-test of Respondent's Level of Content Knowledge, Pedagogical Knowledge, and Pedagogical Content Knowledge.

Type of Knowledge	Pair Difference		t	df	Sig. (2-tailed)
	Mean	Std. Deviation			
Content Knowledge Before - Content Knowledge After	-19.54	2.75	-19.101	90	.000
Pedagogical Knowledge Before - Pedagogical Knowledge After	-21.98	3.43	-25.343	90	.000
Pedagogical Content Knowledge Before – pedagogical Content Knowledge After	-35.32	8.02	-72.571	90	.000

Research Question 3: How does GIFST program beneficial to pre-service teacher in teaching Science and Mathematics?

The following sections discuss how GIFST program beneficial to Science and Mathematics pre-service teacher in teaching Science and Mathematics. Owing to some constraints, only few aspects and respondents' result will be discussed. The interview was conducted in Bahasa Malaysia. Translation is made and written in Italic beneath the interview transcript. There are five pre-service teachers selected as respondents. The respondents are representing as *A, B, C, D* and *E*. Each respondent responses to the questions that describe their opinion and perception about the beneficial GIFST program that they have experienced.

Question 1: How has your specialist content knowledge changed?

From the interview session, most of respondent agreed that STEM training program gave beneficial in improving their expertise in the conceptual of the contents Science or Mathematics and understanding well in Science or Mathematics content (syllabus). The followings are the feedback of respondent, there are two categories that respondents noticed that develop drastically in their content knowledge, which are confident in giving explanation and instruction or command. Respondents A, B and D have agreed that their confident level and ability in explaining Science or Mathematical concept has increase after participate in the program. The followings are the feedback:

"…Saya sentiasa perlu **membuat persediaan kandungan aktiviti sebelum menjalankan aktiviti STEM** sewaktu dalam program ini. Ini menjadikan **kefahaman saya dalam konsep** yang berkaitan menjadi **lebih mendalam** dan seterusnya menjadikan saya **lebih berani sewaktu membuat penerangan berkaitan konsep Matematik** berkaitan "
*(….I always have to **prepare the activity content before carrying out the STEM activities** during this program. This have made my **understanding** of the relevant **concepts** become **more profound** and makes me **more adventurous when explaining the concepts of Mathematics related**)*

(Respondent D)

*"…*saya **semakin selesa sewaktu membuat penerangan** konsep Sains kepada pelajar-pelajar sekarang ini memandangkan saya telah terbiasa dengan kandungan dan silibus yang terlibat. Saya dapat **mengurangkan salah faham** pelajar memahami konsep Sains d"
*(…I feel **more comfortable while making an explanation** and this **could reduce** the **misconceptions** students understand the concepts of Science and Mathematics…)*

(Respondent B)

"**…..kesemua aktiviti yang** saya **lebih yakin dan pandai** menggunakan dan **mengawal intonasi suara, membuat penjelasan dengan jelas dengan penggunaan laras bahasa dan analogy yang sesuai** dalam menerangkan konsep Sains atau Matematik*"*
*(…I am **more confident** and able to **use and control voice intonation**, **making clear explanations with appropriate language** and **analogies** in explaining the concept of Science or Mathematics)*

(Respondent A)

Besides, respondents' C and E agreed that this program exposes them with the structure and syllabus content in Science and Mathematics. The followings are their feedbacks:

"….**kesemua aktiviti** yang dijalankan dalam program ini **berdasarkan silibus yang sedia ada** sekarang. Oleh itu, saya dapat mengetahui **lebih mendalam kandungan** yang terdapat dalam **silibus Sains dan Matematik**. Ini memudahkan saya untuk merancang pengajaran saya sekiranya saya telah mengajar di sekolah nanti"
(…**all the activities** carried out in this program are **based on the current syllabus**. So, I could find out more about the **content contained in the syllabus of Science and Mathematics**. This makes me easier to plan my lessons if I have been teaching in school soon)

(Respondent C)

"… kami sebagai fasilitator dilatih untuk mengendalikan aktiviti-aktiviti yang berteraskan Sains dan Matematik. Dengan penglibatan dalam program ini, **saya dapat melihat perkaitan antara sesetangah topik dalam Sains dan Matematik yang mempunyai perkaitan**. Saya juga dapat **mengetahui lebih jelas aplikasi sebenar konsep-konsep Sains dan Matematik** ini dalam kehidupan seharian"
(…we as facilitators are trained to handle activities based on Science and Mathematics. With the involvement in this program, **I could visualize the relevance of some of the topics in Science and Mathematics that connected**. I also understood more about **the actual application of Science and Mathematical concepts** in daily life)

(Respondent E)

This finding indicates that all respondents agreed that this GIFST program has empowered their conceptual understanding, the interconnection between the topics and more depth conception about the structure and application in Science and Mathematics. This finding indicates that all respondents believed that GIFST program has improved their content knowledge indirectly.

Question 2: How has this program changed your ability in teaching Science or Mathematics?

For the second question is focused on how the GIFST program influenced their teaching in Science and Mathematics. Based on the interview session, respondents B, D and E agreed that this program has developed their creativity when preparing the activities for Science and Mathematics lesson. Following are their feedbacks:

"Program ini menekankan **'hands-on activities'**. Saya banyak **terdedah dengan aktiviti yang menarik** seperti aktiviti **permainan, 'role play', pembentangan yang berkesan, siasatan** dan lain-lain lagi. Ini telah **membuka minda saya untuk merancang aktiviti** pengajaran Sains atau Matematik yang **menarik dan kreatif** pada masa akan datang"
(This program emphasizes the **hands-on activities**. I have been **exposed to interesting activities** such as **games, role play, effective presentation, inquiry** and many more. This has **opened up my mind** to plan **exciting and creative** for Science or Mathematics teaching activities in the future ')

(Respondent B)

" ….memastikan **aktiviti** pengajaran yang ingin dijalankan **berteraskan elemen VAK (visual, auditori dan kinestetik)** seperti yang ditekankan dalam program ini. Dengan **pendekatan VAK** ini, saya percaya pengajaran Sains dan Matematik akan lebih **menarik dan seronok** "
(*… to ensure that the **teaching activities** is **based on VAK (visual, auditory and kinaesthetic)** elements as emphasized in the program.* **With VAK approach**, I am believed that the teaching Science and Mathematics will be **more interesting and fun**)

(Respondent D)

"… membantu saya dalam **menyediakan aktiviti berkumpulan** yang lebih berkesan bagi kelas Sains dan Matematik"
(…***provide*** me with **more effective group activities** for Science and Mathematics classroom)

(Respondents E)

While respondents A and C found that this program has developed their ability in manage the Science and Mathematics classroom. Respondent A found his ability in control the students when doing the Science and Mathematics activities has increase.

"Program ini memberi peluang kepada kami bakal guru untuk **mengajar Sains atau Matematik secara sebenar**. Tambahan pula aktiviti-aktiviti yang **dijalankan dalam kumpulan besar mahupun kecil**. Kami **harus pandai mengawal para pelajar** ini memandangkan **aktiviti-aktiviti kebanyakkannya berbentuk 'hands-on'**. Oleh itu, kami **telah mendapat pengalaman sebenar dalam mengawal para pelajar** sewaktu menjalankan aktiviti Sains dan Matematik"
(*This program provides the opportunity to us as future teacher **to teach Science or Mathematics in actual setting**. Furthermore, activities are **carried out in large and small groups**. We **need to able to control the students since most all activities are hands-on**. Therefore, we have had **the real experience in controlling students** in carrying out Science and Mathematical activities*)

(Respondent A)

However, respondent C feel that her instruction and command while teaching or conducting Science and Mathematics activities has been improved well.
"…saya kerap mendapat peluang memimpin kumpulan besar sewaktu menjalankan aktiviti-aktiviti dalam program ini. **Pada awalnya, saya menghadapi masalah dalam memberi arahan dan penerangan aktiviti.** Namun, **selepas mengikuti beberapa kali sesi aktiviti** dalam program ini, **saya perasan penyusunan ayat saya dalam memberi arahan semakin baik** dan **para pelajar lebih memahami apa yang perlu dilakukan** dalam ……"
(…I often get the chance to lead a large group while doing activities in this program. **At first, I had trouble giving instructions and activity description**. However, **after followed several series in this program**, I noticed that **my word of instruction is much better** and **the students understand what need to do** in …)

(Respondent C)

This finding indicates that all respondents agreed that this GIFST program has endowing their instructional skill in Science and Mathematics. They believed that they are able to construct a variety of approaches that are interesting and meaningful when teaching Science and Mathematics. In fact, they are confident that they are capable to carry out these activities in a controlled and effective way.

Discussion and Conclusion

This study was aimed at generating empirical data about development of Science and Mathematics pre-service teacher in CK, PK and PCK who have participated in STEM professional development program. The findings show that STEM pre-service teacher had indicated significantly improvement in CK, PK and PCK in delivering STEM lesson. The intensive program has indicated 32%, 36% and 35% of CK, PK and PCK respectively between before and after experienced the training course. This finding supported by Halim, Abdullah and Meerah (2014); Alzgool (2019); Muhammad, Saoula, Issa & Ahmed (2019), stated that professional training provides implication to PCK of the teacher. Pre-service and in-service courses need to be given equal emphasis on the development of teachers' knowledge and social competence. In addition, teachers also need to be made aware of their beliefs and expectations on their students so that teachers would provide relevant learning experiences appropriate to the diverse needs of their students. Since, by participating in this program, the STEM pre-service teachers have faced the real setting of the school and students environment (Livy, Vale, & Herbert, 2016). This factor could contribute to the pre-service teachers experience in teaching Science and Mathematics. Both pre-service teachers were provided with opportunities that extended their PCK including foundation knowledge, transformation, connections, contingencies, breadth and depth of PCK or specialised PCK for teaching STEM related subjects (Livy, Vale, & Herbert, 2016). This implies that GIFST have provided a good platform to improve pre-service teachers' knowledge (CK, PK & PCK) and experiences in teaching Science and Mathematics. The deliberative formal and nonformal learning opportunities provided in the context of initial teacher education are crucial for the development of teachers' subject matter knowledge. In contrast, informal learning in the form of incidental learning, often referred to as teaching experience, seems to have only a weak effect on the development of teachers' subject-matter knowledge, especially in CK and PCK (Kleickmann, et al., 2013; Khalid, Islam & Ahmed, 2019)

In addition, the finding found that GIFST has strengthen pre-service teacher conceptual and content knowledge in STEM subjects. This program provides them the knowledge to integrate the STEM in teaching Science and Mathematics. With the direction of the government towards strengthen STEM education, Science and Mathematics teachers should able to relate Science and Mathematics to various disciplines prior to the STEM education. According to Pimthong and Williams (2018), most of the pre-service teachers did not explain more about the nature of the integration. In order to ensure the pre-service teachers are able to connect the nature between the STEM elements, they should be exposed with the interactice and hands-on activities like GIFST. This intensive program also contributes in enhancing the style and approach of the pre-service teachers in teaching Science and Mathematics. Since the nature of this program was hands-on activities and teacher plays a role as facilitator, it contributes a new dimension of teaching Science and Mathematics to the pre-service teacher. Nasir, Salleh, Rasid, Ismail and Abdullah (2017) found that hands-on activities carried out with cooperative learning can influence students to have positive perceptions on the Science and Mathematics subjects. The findings further affirmed and clearly demonstrated that students enjoyed learning Science and Mathematics with attractive presentation and enjoy activities prepared and as a result improved their interest and performance towards these subjects (Munawaroh, 2017). Due to that, teachers need to know to design effective learning environments for their students so that could sustain and attract their interest to the subject . In conlusion, GIFST is able to improve pre-service teachers knowledges and provide valuable experiences in teaching Science and Mathematics. Overall,

teachers have positively perceived this program to be beneficial for them to become a better STEM teachers.

References

Acharya, B. R. (2017). Factors Affecting Difficulties in Learning Mathematics by Mathematics Learners. *International Journal of Elementary Education, 6*(2), 8-15.

Alzgool, M. (2019). Nexus between Green HRM and Green Management towards Fostering Green Values. *Management Science Letters*, *9*(12), 2073-2082.

Atay, D., Kaslioglu, O., & Kurt, G. (2010). The pedagogical content knowledge development of prospective. *Procedia Social and Behavioral Sciences 2*, 1421-1425.

Ergönenç, J., Neumann, K., & Fischer, H. E. (2014). The Impact of Pedagogical Content Knowledge on Cognitive Activation and Student Learning. In H. E. Fischer, P. Labudde, K. Neumann, & J. Viiri, *Quality of Instruction in Physics – Comparing Finland, Germany and Switzerland* (pp. 145-160). Waxmann.

Halim, L., & Meerah, T. S. M. (2016). Science Education Research and Practice in Malaysia. In M.-H. Chiu (Eds.), *Science Education Research and Practice in Asia* (pp. 71-93). Singapore: Springer.

Halim, L., Abdullah, S. I., & Meerah, T. S. (2014). Students' Perceptions of Their Science Teachers' Pedagogical Content Knowledge. *Journal of Science Education and Technology, 23*(2), 227–237.

Kubiatko, M., Torkar, G., & Rovnanova, L. (2017). The Teacher as One of the Factors Influencing Students' Perception of Biology as a School Subject. *C E P S Journal* , 127-140.

Khalid, N., Islam, D. M. Z., & Ahmed, M. R. M. (2019). Sentrepreneurial Training and Organizational Performance: Implications for Future. *Humanities & Social Sciences Reviews*, *7*(2), 590-593.

Livy, S. L., Vale, C., & Herbert, S. (2016). Developing Primary Pre-service Teachers Mathematical Content Knowledge During Practicum Teaching. *Australian Journal of Teacher Education, 41*(2).

Ministry of Education of Malaysia (2013). Malaysia Education Blueprint 2013-2025 (Pre-School to Post-Secondary Education). Putrajaya: Ministry of Education.

Munawaroh. (2017). The Influence of Teaching Methods and Learning Environment to the Student's Learning Achievement of Craft and Entrepreneurship Subjects at Vocational High School. *International Journal Of Environmental & Science Education, 12*(4), 665-678.

Muhammad, K., Saoula, O., Issa, M., & Ahmed, U. (2019). Contract Management and Performance Characteristics: An Empirical and Managerial Implication for Indonesia. *Management Science Letters*, *9*(8), 1289-1298.

Nasir, N. A., Salleh, M. F., Rasid, N. S., Ismail, M. H., & Abdullah, N. (2017). Intellectual Science and Mathematics Program: Improving Students' Interest in Learning Science and Mathematics. *Advanced Science Letters, 23*(4), 3268-3272.

Pimthong, P., & Williams, J. (2018). Preservice Teachers' Understanding of STEM Education. *Kasetsart Journal of Social Sciences*, 1-7.