Impact of integrated STEM on knowledge and self-efficacy based on teachers’ experience

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Abstract: There are many research studies on education have found that students’ interest toward STEM learning has declined globally. In order to improve the trend, needs more trained teachers in STEM. Thus, this study was done to determine the level of knowledge and self-efficacy of the trained teachers towards teaching and learning based on years of teaching experience. Survey research design were used on 816 teachers from training of trainer’s program. Findings shows that teachers, knowledge, attitude and self efficacy towards teaching and learning based on STEM integration are affected by the teachers teaching experience.

1. Introduction
There are many research studies on education have found that students’ interest toward STEM learning has declined in many countries including Malaysia [1]. In addition, the last few decades demonstrate that education was focused on improving science and mathematics as isolated subject. This trend can be seen in our current teaching program in school. Thus, currents studies on STEM education reports that the awareness on STEM integration program effort worldwide is currently increasing to improve the education system and students’ interest in STEM which in line with the country needs. Besides, the awareness spurt and continues to grow because there is increasing in demand for STEM skills in order to meet economic challenges [2]. In addition, international efforts to improve STEM education may cause by the impacts on the 21st century, globally [3].

The STEM acronym is often used in reference to just one of the disciplines, commonly science [1]. Students’ interest is affected by several factors such as learning environment in schools, learning STEM related subject separately and teachers’ effort in making sure the students engage in self-regulated learning [3,4]. To nurture students’ interest in STEM related subject, such program should include technology and engineering in science and mathematics subjects in school and provide global issue project based learning [5].

Current research prove that teachers are interested in implementing STEM integration concept in their current teaching subjects but depending on the effectiveness of the teaching process in classroom [6]. Besides, disintegrating of teachers’ interest in teaching STEM in the subjects may cause by the unseen contribution that they can offer in STEM education. Here, the interest on STEM education can be nurtured by explaining and applying the importance in education system. Thus, the improvement of delivering STEM content, pedagogy, and conceptualization to teachers may encourage them to enhance the quality as STEM educators and help in providing visualization of effective STEM teaching [7].

Besides, such competition especially related to technology and science project such as robotic competition maybe an additional effort in raising students interest and teachers excitement in advance
technology related STEM program [8]. By making such program easily access may allow both teachers and students, to aim for developing technologies to enter the competition. Understanding teachers’ needs and level of thinking towards teaching based on STEM education is important to nurture the interest [9].

Malaysia is facing a lacking in students who are keen to continue their studies in STEM fields [10]. Recent studies have shown that Malaysia need 60% students to continue their studies in STEM fields in order to strengthen the socio-economic development [3]. Thus, this study aims to determine the level of knowledge, confidence, attitude and self-efficacy of the trained teachers (the STEM master trainers) towards teaching and learning based on integrated STEM according to their gender and years of teaching experience.

2. Method
The research instrument was obtained from 816 of teachers who has participated in STEM Training of Trainers (ToT) program. The respondents are among teachers teaching Science and Mathematics with 84.4% of them have more than five years teaching experiences (Table 1). According to the ratio, female teachers dominate the male by 3 to 1 ratio. Teachers with age 31 to 40 dominate by 44.9% followed by those with 40 and above (29.7%) while the rest are less than 31 years old. Table 1 below shows the respondents’ distribution by various background.

| Background           | Profile | Number (N) | Percentage (%) |
|----------------------|---------|------------|----------------|
| Gender               | Male    | 207        | 25.4           |
|                      | Female  | 609        | 74.6           |
| Teaching Experience  | < 5 years| 127        | 15.6           |
|                      | 5-10 years| 283       | 34.7           |
|                      | 11-15 years| 190      | 23.3           |
|                      | 16-20 years| 106      | 13.0           |
|                      | > 20 years| 110       | 13.5           |

This research is a survey study involving qualitative method to examine and identify the level of knowledge, belief and self-efficacy of the trained teachers who has participated in the ToT program. The instrument used is the set of questionnaires. The survey was done on two constructs (Knowledge and Self-Efficacy). To identify the reliability of the internal consistency of the instrument used, the value of the Cronbach alpha coefficient is determined. According on Table 2, all variables applied have a high internal consistency as the Cronbach alpha value exceeds 0.7 except the attitude instrument that shows the value of Cronbach alpha coefficient less than 0.6. However, this instrument is still acceptable because the number of items and Cronbach alpha values are not at a critical level of less than 0.4 (11).

| Construct                      | Number of item (N) | Alpha Cronbach (α) |
|--------------------------------|--------------------|--------------------|
| Knowledge                      | 47                 | 0.767              |
| • Knowledge on STEM Module content | 39                 | 0.981              |
| • Knowledge on STEM education integration teaching | 10                 | 0.907              |
| Self-efficacy towards STEM integration | 9                 | 0.927              |
3. Findings

3.1 Impact on teacher’s knowledge

Teachers’ knowledge on STEM was examined from two aspects, namely the knowledge on STEM module content and knowledge on teaching based on STEM education integration. Teachers’ knowledge on STEM module content is at medium high level for both gender (mean score: male: 3.47; female: 3.19) and all teaching experience levels (mean score ranged from 3.20 to 3.33) with teachers of five to ten years of teaching experience has highest knowledge in STEM module content. Male teachers with more than 20 years of teaching experience and female teachers of five to ten years of teaching experience scored the best in knowledge of STEM module content. The findings above is affected by score in item in the instrument as majority of the participants scored medium high level in most of the item in content knowledge instrument. Besides, teachers’ approval rates on the minimum module content are at low moderate level with the percentage rate of consent is 22.8% to 30.6% involving content related to ‘engineering design process,’ How Piezoelectric energy is produced ‘,’ Types of space-based communication system ‘,’ Ethernet ‘and’ Microcontroller concept ‘. Other contents in the instrument show a medium high level and no module content items show a high level. Comparing both gender, the mean score of the knowledge on STEM module content of male teachers was higher than that of female teachers. Female teachers also show lower level of STEM module content knowledge as their teaching experience increases while male teachers showed an inconsistent mean score of content knowledge.

For the second aspect, teachers’ knowledge on teaching in STEM education integration is also at medium high level for both gender (mean score: 3.65) and all teaching experience (mean score ranged from 3.52 to 3.67) with those with teaching experience of less than 5 years scored the highest. Teachers with more than 20 years of teaching experience has the highest mean score for male and less than five years of experience for female. It is found that the mean score of knowledge on teaching STEM education of male teachers is higher than that of female teachers. Yet the mean score of female teacher knowledge with less than 5 years of teaching experience over male teachers. However, female teachers show lower mean knowledge scores while male teachers show inconsistent mean score of knowledge as teaching experience increases. Teachers show the level of their knowledge on teaching of STEM education integration in high medium level because all the mean score of the item in the instrument is at high medium level. Minimum teacher approval rates are at the percentage level of 35.9 percent consent that involves their ability to apply engineering design process in teaching activities involve science and mathematical.

Table 3. Descriptive statistics of teachers’ knowledge level towards the according to gender and teaching experience.

| Aspect                             | Gender | Teaching experience | Mean     | Standard deviation | N  | Level       |
|------------------------------------|--------|---------------------|----------|--------------------|----|-------------|
| Knowledge on teaching STEM education integration | Male    | < 5 years           | 3.6398   | 0.6818             | 29 | Medium high |
|                                    |        | 5-10 years          | 3.6708   | 0.5294             | 65 | Medium high |
|                                    |        | 11-15 years         | 3.6508   | 0.5039             | 59 | Medium high |
|                                    |        | 16-20 years         | 3.5719   | 0.6920             | 32 | Medium high |
|                                    |        | 20 years >          | 3.7136   | 0.4950             | 22 | Medium high |
|                                    | Total  |                    | 3.6500   | 0.5660             | 207| Medium high |
|                                    | Female  | < 5 years           | 3.6898   | 0.4634             | 98 | Medium high |
|                                    |        | 5-10 years          | 3.6606   | 0.4592             | 218| Medium high |
|                                    |        | 11-15 years         | 3.5958   | 0.5274             | 131| Medium high |
|                                    |        | 16-20 years         | 3.5500   | 0.5643             | 74 | Medium high |
|                                    |        | 20 years >          | 3.4716   | 0.4953             | 88 | Medium high |
|                                    | Total  |                    | 3.6106   | 0.4975             | 609| Medium high |
There was a significant gender effect on the level of knowledge at $P < 0.05$ with a small effect size ($\text{partial \ it \ squared} = 0.0361$). According to the mean of the expected margins, the knowledge on STEM module content of male teacher is higher than that of female.

**Table 4.** Multivariate analysis of teacher knowledge.

| Effect                  | Wilk’s Lambda value | F     | DF1 | DF2 | P         | Partial eta squared |
|-------------------------|---------------------|-------|-----|-----|-----------|---------------------|
| Gender                  | 0.0361              | 15.0920 | 2   | 805 | 0.0000    | 0.0361              |
| Experience              | 0.0134              | 1.3635 | 8   | 1612| 0.2079    | 0.0067              |
| Gender*Experience       | 0.0079              | 0.7957 | 8   | 1612| 0.6064    | 0.0039              |

3.2 Impact on teachers self efficacy

The self efficacy of teachers towards teaching and learning based on STEM integration is at medium level either by gender or teaching experience. Male teachers’ self efficacy towards teaching and learning STEM education overcame the female teachers. However, the average male teacher efficacy score is inconsistent as their teaching experience increases while female teachers showed a decrease in self efficacy as their teaching experience increased. Teachers’ consent rates for minimum efficacy are at 63% and mean score 3.4436 which involves teachers’ confidence in their ability to carry out teaching activities involving engineering design processes.

**Table 5.** Descriptive statistics of teachers' self-efficacy level by gender and teaching experience.

| Gender | Teaching experience | Mean   | Standard deviation | N    | Level       |
|--------|---------------------|--------|--------------------|------|-------------|
| Male   | < 5 years           | 3.7739 | 0.4929             | 29   | Medium high |
|        | 5-10 years          | 3.8879 | 0.4933             | 65   | Medium high |
|        | 11-15 years         | 3.6949 | 0.4850             | 59   | Medium high |
|        | 16-20 years         | 3.8446 | 0.6005             | 32   | Medium high |
|        | 20 years >          | 3.8586 | 0.4380             | 22   | Medium high |
|        | Total               | 3.8071 | 0.5050             | 207  | Medium high |
| Female | < 5 years           | 3.7632 | 0.4523             | 98   | Medium high |
|        | 5-10 years          | 3.6844 | 0.4721             | 218  | Medium high |
|        | 11-15 years         | 3.6194 | 0.5794             | 131  | Medium high |
|        | 16-20 years         | 3.5978 | 0.6319             | 74   | Medium high |
|        | 20 years >          | 3.5396 | 0.5236             | 88   | Medium high |
|        | Total               | 3.6516 | 0.5253             | 609  | Medium high |

There is a significant difference in the mean score of efficacy towards teaching and learning based on integration of STEM education between gender ($p < 0.05$) with a small size effect ($\text{partial \ it \ squared} = 0.0174$). The mean margin of expectations of the efficacy of integration of STEM education by male teachers is higher than female teachers. There are five efficacy items on the construct i.e. those with confidence in applying and designing activities related to STEM and engineering design process shows the difference in mean score between male and female teachers. However, the efficacy of both gender are at high medium level.
Table 6. Impact test between teacher efficacy subject.

| Effect          | Total squared | DF | Mean squared | F       | Sig.   | Partial eta squared |
|-----------------|---------------|----|--------------|---------|--------|---------------------|
| Gender          | 3.8369        | 1  | 3.8369       | 14.3126 | 0.0002 | 0.0174              |
| Experience      | 1.7022        | 4  | 0.4255       | 1.5874  | 0.1756 | 0.0078              |
| Gender* Experience | 1.4967     | 4  | 0.3742       | 1.3958  | 0.2336 | 0.0069              |

4. Conclusion
Teachers’ knowledge and self efficacy towards STEM education integration are affected by gender and teaching experience. In order to aid them in convey the interest in STEM subjects, we have to build their knowledge and self-efficacy in teaching science, mathematics and technology related subjects from an integrated STEM approach. Besides, teachers’ knowledge in teaching STEM related subject as integrated subject is important as students may feel disinterested in learning science and mathematics without connected to real world issues [3]. Teachers knowledge in STEM integrated education may increase students’ interest and potential to learn STEM [6]. This factor is also important as knowledge on STEM pedagogy may help teachers to design skills to make students understand the STEM integration concept [11].

It is also important for teachers as educators to belief and confident in teaching based on STEM integration but they think that there are not prepared to deliver STEM content in the classroom [9, 12]. Preparing teachers with STEM content, pedagogy, and concept is important in STEM education [8]. But still further research and discussion is needed to develop more effective methods that can be implemented to teachers to apply STEM integration in schools besides understanding teachers’ level of thinking towards teaching based on STEM education [13].

This implies that in order to develop students who are interested in STEM related subjects, teachers may need to nurture students’ interest by applying project based learning in existing science and mathematics subjects in schools. To achieve this, teachers need to have positive attitude towards applying STEM in teaching and learning. Teachers who are responsive and supportive in STEM education may increase students’ interest in learning in schools, thus, they are motivated in engaging in a self-regulated learning [4].

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