JOURNAL OF BALTIC SCIENCE EDUCATION
ISSN 1648-3898

BITARA-STEM™ TRAINING OF TRAINERS' PROGRAMME: IMPACT ON TRAINERS' KNOWLEDGE, BELIEFS, ATTITUDES AND EFFICACY TOWARDS INTEGRATED STEM TEACHING

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Abstract. *The Bitara-STEM™ Training of Trainer Programme is a short-term professional development programme aimed to increase STEM teachers or facilitators' abilities to teach integrated STEM education and to increase their efficacy, beliefs and attitudes of integrated STEM teaching. The programme involves 35 facilitators, representing a broad spectrum of STEM fields. Pre- and post-test results of the participants' beliefs, attitudes, perceived efficacy and content knowledge in the context of integrated STEM teaching revealed significant changes. The findings also revealed (i) knowledge of integrated STEM teaching to be related to facilitators' efficacy for teaching integrated STEM and (ii) facilitators' attitudes to be related to beliefs of integrated STEM teaching. The outcomes of this study provide evidence that a relatively short-term professional development can have a significant impact on facilitators' beliefs, attitudes, efficacy and knowledge of integrated STEM teaching and STEM concepts.*

Key words: *attitudes, beliefs, integrated STEM teaching, STEM Education, STEM facilitators.*

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Introduction

As Malaysian economy moves from a manufacturing-based economy to information and service-based economy, the demand for a workforce well educated in science, technology, engineering and mathematic (STEM) is growing. The success of the country depends on the quality of STEM education and the quantity of students enrolled in the field. Thus to remain competitive in a growing global economy, it is imperative that we raise students' achievement and enrolment in STEM related subjects. However, recent international assessment on the Malaysian student's performance in science and mathematics shows that student performance is at low. Malaysia's performance in Trends in International Mathematics and Science Study (TIMSS) between 1999 and 2011 indicates that student performance has fallen. The results of the 2009 Programme for International Student Assessment (PISA) also showed that Malaysia ranked in the bottom third of 74 participating countries, below the international and Organisation for Economic Co-operation and Development (OECD) average. Parallel to this, according to Martin et al. (2012), a total of 18% of Malaysian children have limited prerequisite knowledge and skills in science classrooms; meanwhile, 55% of them had limited prior knowledge in science.

The number of students who chooses STEM fields also continues to decline in the recent years. In 2011, only 45% of student graduates were from the Science stream, including technical and vocational programmes (Ministry of Education Malaysia (MOE), 2013). Additionally, the percentage of secondary school students, who met the requirement to study Science after national level examination (named Lower Secondary Assessment) but chose not to do so, increased to approximately 15% (MOE, 2013). This

raises concerns about the education system's ability to produce sufficient STEM graduates for the economy. The National Council for Scientific Research and Development estimates that Malaysia will need 493,830 scientists and engineers by year 2020 (MOE, 2013). At current speed and course, however, the Ministry of Science, Technology and Innovation (MOSTI) (2012) estimate that there will be a shortfall of 236,000 professional in STEM related fields. The declining enrolment in this STEM disciplines is expected to create a shortage of scientists and engineers in the Malaysia workforce in the near future. These figures indicate the need for strong intervention to meet the targeted number of STEM related graduates and to improve future student outcomes.

Previous research showed that students' interest towards STEM related subjects is one of the main factor contributed in the declining in the number of students to choose to enroll in STEM related courses (Subotnik et al., 2010) and has been identified in influencing the decision to choose STEM related fields (Riskowski et al., 2009; Sanders, 2009). Students have lost interest in the domains of science, mathematics, engineering and technology as early as elementary school (before reaching high school) and believe that these areas are not innovative or creative (Marasco & Behjat 2013). According to MOSTI (2008), only 44.9% of Malaysians are interested in new science inventions or discoveries. These statistics make quite a compelling case that the Malaysian government needs to do more to reach out to those Malaysians who appear to be indifferent to or uninterested in STEM (MOSTI, 2008). As such, there is a great need to spark interest among students in STEM, and to develop and facilitate quality STEM experiences among them. Research shows that integrative approaches among science, mathematics, technology and engineering give positive effect on students' learning especially in increasing and improving students' interest and learning in STEM (Becker & Park, 2011). Integrated teaching and learning is when the program has an explicit assimilation of concepts from more than one discipline (Satchwell & Loepp, 2002). Integrated STEM educations programs apply equal attention to the standards and objectives of two or more of the STEM fields (Laboy-Rush, 2011). The integration of STEM in the curriculum will increase student achievement in the disciplines (McBride & Silverman, 1991). Besides, teaching STEM disciplines through integrating them would be more in line with the nature of STEM. The nature of the work of most STEM professionals blurs the lines between disciplines, thus integrated STEM education can make learning more relevant and meaningful for students (Stohlmann et al., 2013). It can improve students' attitudes toward STEM subjects, improve higher level thinking skills, and increase achievement (Stohlmann et al., 2013). STEM learning experiences prepare students for the global economy of the 21st century (Cullum et al., 2007; Hynes & Santos, 2007).

Thus, realizing the importance of STEM integration on promoting students' interest and achievement in STEM related fields, many are calling for increased emphasis on STEM integration activities among students especially in the informal settings. *Bitara-STEM™* is one of the collaborative efforts among Faculty of Education, Universiti Kebangsaan Malaysia (UKM), New York Academy of Sciences (NYAS) and New York University Polytechnic School of Engineering (NYU-Poly) to spark interest and provide fun learning experience that integrated STEM subjects. *Bitara-STEM™* programme used project-based activities divided into four separated modules namely Energy, Urban Infrastructure, Transportation, and Wireless Communication. The activities in the modules use engineering design process as a bridge to connect STEM subjects together. Through these activities, engineering design process can act as a catalyst to improve student learning and achievement in science and mathematic by providing a gateway to turn the abstract science and mathematic concepts into concrete real-life applications. At the same time, building an engineering project can also serve as a pedagogical strategy that combines problem solving, creative thinking skills and presentation skills in other STEM subjects.

The introduction of integrated STEM teaching and learning approach, where engineering design process serves as a context in the activities in *Bitara-STEM™* modules require teachers or facilitators to have a good understanding of integrated STEM instructional strategies, engineering practices and its applications. In addition, possessing the content knowledge of science, mathematics and technology is also important. However, most undergraduate teacher education programs did not expose students to integrate STEM teaching and learning and do not include engineering concepts or engineering design practices into their curriculum. Thus, it is unrealistic to expect teachers or facilitators to create integrated STEM learning activities when most of them do not have a good understanding of integrated STEM instruction, engineering practices or its applications. Thus, prior to the full implementation of the program, a group of teacher or facilitator has been trained through a professional development program called "*Bitara-STEM™ Training of Trainer Program*". The objective of the program is to enhance teachers or facilitators' competency with the STEM content knowledge, STEM integration pedagogy, engineering design and affective variables related to the implementation of integrated STEM teaching.

Affective Variables and Teacher Effectiveness

Teachers' attitudes and beliefs play an important role in teachers' effectiveness and their choice of instructional practices (Ernest, 1989; Handal & Herrington, 2003; Wilkins & Ma, 2003). According to Keys & Bryn (2001), every aspect of teaching is influenced by the complex web of attitudes and beliefs that teachers hold, including knowledge acquisition and interpretation, defining and selecting instructional tasks, interpreting course content, and choices of assessment. Currently, there is substantial evidence that teachers' performances at school are influenced by their beliefs about teaching and learning (Pajares, 1992; Richardson, 1996; Wilkins, 2004). Pajares (1992) maintains that "beliefs the teachers hold influence their perceptions and judgements, which in turn affect their behaviour in classroom" (p.307).

Jones & Carter (2007) designed Sociocultural Model of Embedded Belief Systems "as a tool for understanding the construction and development of beliefs and attitudes" of teachers. In this model, instructional practices are influenced by a complex set of belief systems, prior knowledge, epistemologies, attitudes, knowledge and skills. This model highlights the interactive nature of these components. Attitudes and beliefs were the critical components in this model. Both attitudes and beliefs are all posited to have a direct influence on teachers' instructional practices. In this model, teachers' attitudes are strongly influenced by their epistemological beliefs. Teachers' epistemologies (which include beliefs about STEM, beliefs about teaching STEM, and beliefs about learning STEM) affect the type of instructional behaviours that occur in the classroom. The relative strengths of all these components at any given time, in any given context, can shift, producing a negative or positive attitude toward implementing the instructional practice. If both attitude sets are negative, then there is no motivation to implement the instructional practice, whether or not the knowledge and skills to do so are present. Teachers with negative attitudes toward STEM tend to avoid teaching STEM (Appleton, 2003). Positive STEM educator attitudes will influence classroom strategies used to teach and contribute to the formation of positive learner attitudes (Relich, Way, & Martin, 1994; Carpenter & Lubinski, 1990).

Recent research on teacher affective variables showed, that teachers often fail to develop or implement new curriculum about teaching and learning because of their beliefs that the current educational environments are effective and efficient based on their limited experiences (Mansour, 2009). Teachers' beliefs stem from their own experiences and their educational environments (Clark & Peterson, 1986). So teacher needs to have positive attitudes or beliefs about new teaching approaches in order to succeed with the classroom practices. They also need to have various positive experiences to change their current beliefs about teaching that prevent from developing the new teaching approaches. Thus, it can be concluded that both attitudes and beliefs toward teaching are crucial components to promoting an enabling learning environment for learners, and in this context it is for the teaching and learning of integrated STEM.

Besides, attitudes and beliefs, studies have shown that teachers' content knowledge, confidence, self-efficacy, experience, and social context are linked to beliefs systems and practices. Self-efficacy, or beliefs about one's ability to successfully implement an instructional strategy, has been identified in several studies as a major component in the instructional decision-making process. Jones and Carter (2007) described self-efficacy as "beliefs about one's ability to successfully implement an instructional strategy". Tschannen-Moran & Woolfolk-Hoy (2001) defined educator efficacy as an educator's judgement of his/her capabilities to bring about desired outcomes of student engagement and learning, even among those students who may be difficult or unmotivated. Efficacy in teaching has been identified as a major variable, contributing to teacher and student success (Settlage et al., 2009) and may be a proxy for the larger issues of teacher knowledge and preparedness for teaching STEM content (Nadelson et al., 2013). Educator self-efficacy plays a critical role in effective integrated STEM education (Koirala & Bowman, 2003). Educators with a high sense of efficacy exhibit greater enthusiasms for teaching (Allinder, 1994) and have greater commitment to teaching (Coladarci, 1992). Nadelson et al. (2012) in their study of the effect of in-service teacher professional in STEM found the perceptions of efficacy for teaching STEM to be related to the comfort of teaching STEM and pedagogical discontentment with teaching STEM. Their results indicate that, as teachers learn more about science and math concepts, they feel more comfortable teaching STEM.

In the literature on teacher beliefs, knowledge is also an important component. Knowledge plays an important role in STEM integrated teaching and learning. For STEM integrated instruction to be successful in school, teachers will need a new and interdisciplinary content knowledge base (Stohlmann, Moore & Roehrig, 2012). STEM educators will be effective in the classroom if they understand their subject matter deeply and that they can explain concepts and procedures from multiple perspectives (Halim et al., 2014; Ejiwale 2012). Teachers' level of understanding and

knowledge of subject matter is linked to their ability to effectively teach the content (Nadelson et al., 2012). In order to ensure that teachers are successful, it is important that they receive support for developing their content knowledge to be able to effectively teach STEM integration (Stohlmann et al., 2013). Although expertise related to content knowledge is important for teaching integrated STEM, however content knowledge alone is not sufficient. Teachers also need to know about and become expert in pedagogical strategies that support students in integrated STEM experiences. Teaching in this environment also requires competency in pedagogy that ensures active participation in classroom activities by learners (Ejiwale, 2012). Mastery of pedagogy is necessary for enhancing STEM educators' abilities to manage their classroom efficiently. To be successful at this, STEM educators must be able to call on a repertoire of strategies and methods for illuminating STEM topics—guiding students in scientific inquiry, the design of experiments, and making sense of data. STEM educators need to hone and adapt the skills needed for effective classroom management (Ejiwale, 2012). According to John & Carter (2007), one obvious reason for the conflict between beliefs and practices is a lack of knowledge and skills needed to implement the preferred practice. Not knowing how to implement a specific teaching behaviour is an insurmountable roadblock to engaging in the strategy, regardless of strength of beliefs about its effectiveness (John & Carter, 2007). Professional development can be implemented to increase teacher subject matter knowledge through many forms, such as workshops, courses, and representations (Hewson, 2007). The potential link between teachers' knowledge of STEM subject matter and their effectiveness in teaching STEM is justification for providing professional development designed to increase content knowledge of STEM. To determine the effectiveness of meeting the goal of increased content knowledge, it is critical to assess the participating teachers' content knowledge of STEM within the domains they are learning.

As highlights in the Sociocultural Model of Embedded Belief Systems, efficacy, knowledge, attitudes and beliefs are all posited to have a direct influence on teachers' instructional practices (John & Carter, 2007). Therefore, when creating and implementing teacher professional development on integrated STEM teaching and learning, there is justification for focusing on these variables that are predicted to influence teacher instructional practices. Thus, considering the influence of these affective variables on teacher effectiveness, instructional perceptions and preparation in integrated STEM instruction, as well as the potential relationship between these variables, we designed and implemented teacher professional development programme. Our goal was to enhance the participating teachers or facilitators' attitudes, beliefs, STEM content knowledge, knowledge of integrated STEM teaching and perceptions of their effectiveness (efficacy) to teach STEM by attending to their subject matter knowledge, integrated STEM instruction preparation, and understanding of how people learn.

Research Questions

The aim of this study was to assess the impact of the professional development program on participants' knowledge, beliefs, attitudes and efficacy of integrated STEM teaching by using a one group quasi-experimental design. The participants were pre- and post-tested on a range of variables and examine the outcomes for significant changes. This study was guided by the following research questions:

1. Were there significant changes in the participants' knowledge, beliefs, attitudes and efficacy of integrated STEM teaching?
2. What was the relationship between the participants' knowledge, beliefs, attitudes and efficacy of integrated STEM teaching?
3. Were there significant changes in the participants' content knowledge of STEM modules?

Methodology of Research

Bitara-STEM™ Training of Trainer (ToT) Programme

The Bitara-STEM Training of Trainer Programme was a professional development program that provided integrated STEM teaching and learning experiences for STEM facilitators prior to the implementations of *Bitara-STEM™* activities to the secondary students. The programme was held from 18 to 21 February, 2014 in Faculty of Education, National University of Malaysia (UKM). The training provided instructional strategies to aid facilitators in implementing integrated STEM instruction and to develop deeper understanding of the subjects, increase their

understanding of the connection between the areas of STEM and to explore mechanisms for integration across STEM disciplines. Participants, involved in these project-based activities, were divided in four separated modules named Energy, Urban Infrastructure, Transportation, and Wireless Communication. The activities in the modules were using engineering (engineering design process) as a bridge to connect STEM subjects together. Participants were exposed to project-based instruction as an instructional strategy that integrates STEM contents. Unlike the normal professional development programme that is only focusing in lecturing, our programme provides participants with experience in conducting the integrated STEM instruction through combination of "hands on" and small group discussion. Besides aiming at increasing participant knowledge in conducting integrated STEM teaching and learning, the programme also sought at increasing participant efficacy, attitudes and also beliefs on the integrated STEM instruction.

Sample of Research

The *Bitara-STEM™ Training of Trainer Programmes* involved 35 post graduate students (master and *Phd* candidates) who voluntarily registered as a facilitator for the *Bitara-STEM™* programme. All the participants were involved in this study. The participants were in the fields related to STEM where 17 of them were science and mathematics teachers. 80% of the participants hold degrees in science related fields while the remaining was in engineering. As a result, this study had participants representing a broad spectrum of STEM fields. The majority of the participants (51.4%) were between 20 to 30 years old. Females made up 62.9% of the participants.

Instrument and Procedures

To determine attitudes and beliefs about the nature of and the teaching of STEM, the *Attitudes and Beliefs about the Nature of and the Teaching of Mathematics and Science* (McGinnis, Watanabe & Shama, 1997) was modified. This questionnaire was developed for the Maryland Collaboration for Teacher Preparation for elementary and middle level teachers. The questionnaire initially included 29 items to which teachers responded by selecting one of five options ranging from "1" representing "Strongly Disagree" to "5" representing "Strongly Agree". 15 items out of the 29 items were selected to develop the questionnaire used in this study. Modifications to some of the original items were made to reflect a more general focus on STEM and develop the rest of them. To assess the participants' efficacy for teaching integrated STEM, the *Science Teaching Efficacy Beliefs Instrument* (STEBI) (Riggs & Enochs, 1990) was modified. These 25 item instruments assess teachers' perception of their efficacy for teaching science. 10 items out of the 25 items were selected to develop the questionnaire used in this study. Participants rate their beliefs on five Likert scale ranging from "1" representing "Strongly Disagree" to "5" representing "Strongly Agree". Modifications were also made to the STEBI items to reflect a more general focus on STEM.

To determine the teacher knowledge of integrated STEM teaching, a five-point Likert-type scale, ranging from 1 (strongly disagree) to 3 (neutral) to 5 (strongly agree) was developed. These 11 item instruments assess teachers' knowledge of integrated STEM teaching. The instrument was used to collect data that would allow us to establish how the participants defined integrated STEM teaching and learning. While, to determine the teacher content knowledge of STEM modules, teacher responded to their familiarity of each STEM concepts introduced in the modules before and after completing the training by selecting one of five options ranging from "1" representing "Strongly Disagree" to "5" representing "Strongly Agree". Table 2 shows the examples of item of attitudes, beliefs, efficacy and knowledge of integrated STEM teaching.

Table 2. Examples of item of attitudes, beliefs, efficacy and knowledge of integrated STEM teaching.

Constructs	Example of Items
Attitudes of Integrated STEM Teaching	• The idea of teaching integrated STEM scares me. • I prefer (feel prepared) to teach integrated STEM activities emphasizing connections between the disciplines.
Beliefs of Integrated STEM Teaching	• Conducting integrated STEM activities will improve students' interest towards STEM related subjects. • Small group activity should be a regular part of the integrated STEM instruction.

Constructs	Example of Items
Integrated STEM Teaching Efficacy	• I am sure that I can develop creative ideas for changing unfavorable instructional structures. • Increased teacher effort in teaching STEM content produces little change in some students' STEM learning achievement.
Knowledge of Integrated STEM Teaching	• Integrated STEM teaching strategy brings together concepts from more than one discipline. • Integrated STEM instruction provides students with opportunities to apply STEM concepts in relevant contexts.

Data Analysis

All the participants completed pre and post tests using the same unique identifier (using self-selected last five digit of any phone number). All the participants were pre-tested prior to the programme and post-tested them at the conclusion of our programme on site using the same instruments. Paired sample t-test was conducted to identify significant changes in the participants' knowledge, beliefs, attitudes and efficacy of integrated STEM teaching. Pearson's Correlation analysis was conducted using the pre-test scores to identify relationship between the participants' knowledge, beliefs, attitudes and efficacy of integrated STEM teaching and learning. The pre-test scores were used because the *Bitara-STEM™ Training of Trainer Programme* was designed to attend to these variables, and thus the post-test values may be less representative of the ecology of participants knowledge, beliefs, attitudes and efficacy of integrated STEM teaching.

Results of Research

Analysis was begun by calculating the internal reliability of our instruments using the pretest scores. The Cronbach's alpha for the measure of beliefs for integrated STEM teaching was found to be 0.97, indicating a high level of reliability. The Cronbach's alpha for our measure of efficacy for integrated STEM teaching was found to be 0.86, revealing a good level of instrument reliability. For our attitude toward integrated STEM teaching we calculated a Cronbach's alpha of 0.76, indicating an acceptable level of reliability. For knowledge of integrated STEM teaching and knowledge of STEM content module revealing a good level of reliability with a Cronbach's alpha 0.89 and 0.96 respectively.

Table 1. Reliability of the questionnaire.

Constructs measured	Number of items	**Reliability (α)**
Knowledge of Integrated STEM Teaching	11	0.89
Beliefs of Integrated STEM Teaching	15	0.97
Attitudes of Integrated STEM Teaching	14	0.76
Integrated STEM Teaching Efficacy	10	0.86

Level of Attitudes, Beliefs, Efficacy and Knowledge

To conduct this analysis, the data matching all pre-test scores to post-test scores were conditioned. A series of pair sample t-test were conducted using pre and post-test scores. The analysis revealed that the mean scores increases in value, and this increase is significant for attitudes of integrated STEM teaching ($p<0.05$), beliefs of integrated STEM teaching ($p<0.05$), knowledge of integrated STEM teaching ($p<0.05$), and integrated STEM teaching efficacy ($p<0.05$). The means, standard deviations, t-test scores, and p-values are shown in Table 1.

Table 1. Means, standard deviations, t-test, and level of significance for the *Bitara-STEM™* trainers' knowledge, beliefs, attitudes of integrated STEM teaching and learning and perceptions of integrated STEM teaching efficacy (N=35).

	Pre		Post		Paired t-test	Sig.(2 tail)
	M	S.D	M	S.D	T	p
Knowledge of Integrated STEM Teaching	3.6000	0.54688	4.2026	0.54638	5.555	0.000*
Beliefs of Integration STEM Teaching	4.1450	0.42335	4.3874	0.39228	3.887	0.000*
Attitudes of Integration STEM Teaching	3.8643	0.31121	4.1714	0.57449	3.175	0.003*
Integrated STEM Teaching Efficacy	3.9619	0.48278	4.2889	0.46223	3.911	0.000*

Significant at 0.05

Level of Knowledge of STEM Content

A series of pair sample t-test was conducted using pre and post-test scores. There was also found an increase in mean scores for the participants' knowledge of STEM content. The increase found to be significant ($p<0.05$) as shown in Table 2.

Table 2. Means, standard deviations, t-test, and level of significance for the *Bitara-STEM™* trainers' knowledge of STEM modules' content (N=35).

	Pre		Post		Paired t-test	Sig.(2 tail)
	M	S.D	M	S.D	T	p
Knowledge of STEM Module' Content	3.4593	0.57151	4.1956	0.55470	7.446	0.000*

Significant at 0.05

Relationship between Affective Variables

The findings of this study have revealed that there is a significant ($p<0.01$) strong and positive relationship between participants' perception of their STEM teaching efficacy and knowledge of integrated STEM teaching, such that when level of knowledge increased so did level of efficacy with teaching STEM. The results also found a significant ($p<0.05$) positive relationship between the participants' belief of STEM integration and attitude of STEM integration, such that when level of belief increased level of attitude increased.

Table 3. Correlation between trainers' knowledge, beliefs, attitudes of integrated STEM teaching and perceptions of integrated STEM teaching efficacy.

	Knowledge of Integrated STEM Teaching	Beliefs of Integrated STEM Teaching	Attitudes of Integrated STEM Teaching	Integrated STEM **Teaching Efficacy**
Knowledge of Integrated STEM Teaching	--	0.207	-0.144	0.571**
Beliefs of Integrated STEM Teaching		--	0.402*	0.201
Attitudes of Integrated STEM Teaching			--	-0.073
Integrated STEM Teaching Efficacy				--

**p<0.05, **p<0.01*

Discussion

The goal of this study was to provide a professional development opportunity for STEM teachers or facilitators to enhance their STEM content/subject matter knowledge, attitudes, beliefs and knowledge of integrated STEM teaching, and perceptions of efficacy for teaching integrated STEM activities. The findings of this study have revealed significant increases in our participants' efficacy, attitudes, beliefs, and knowledge of integrated STEM teaching. In addition, the participants also expressed significant increases in content/subject matter knowledge at the completion of the *Bitara-STEM™ Training of Trainer Program*. This finding indicates that our professional development intervention was effective at modifying our participants' affective variables, while increasing their STEM content/subject matter knowledge.

The result revealed that knowledge of integrated STEM teaching is related to perceptions of efficacy for teaching STEM. In other words, as teachers learn more about integrated STEM instructional strategies and STEM concepts, they feel more comfortable in teaching STEM (Nadelson et al., 2013). This finding reinforces the notion that a lack of knowledge could make a teacher feel unsure about his/her abilities, which would be manifested in a reduced confidence in teaching STEM, a reduction in efficacy, and an overall feeling of being uncomfortable teaching STEM concepts (Nadelson et al., 2013). Educators, who feel deficient in their content knowledge, are less likely to believe they can teach the material effectively (Peterson et al., 1989). According to Nadelson et al. (2013), the teachers' perceptions of efficacy will then influence their comfort of contentment with teaching STEM during the implementation process. This finding implies the focus of this programme on increasing the participants' knowledge of how to teach STEM led to increased teachers' efficacy within the domain. It is consistence with previous research by Nadelson et al. (2013) between participants' knowledge of and efficacy for teaching STEM content. This association warrants for addressing a wide range of affective and pedagogical construct when working to increase teacher efficacy for teaching STEM. Teachers' instructional competencies act as a critical component of professional development.

The analysis of this study found that there is a relationship between participants' attitudes and beliefs. This finding is consistent with the literature that highlights a positive link between teachers' attitudes and beliefs. Teachers' attitude was found to positively affect teachers' beliefs, ultimately adding to the total effect of attitudes on instructional practice (Wilkins, 2008). Thus, not only were beliefs found to have the strongest direct effect on instructional practice, but they also played a role in mediating the effects of teachers' knowledge and attitudes. In addition, teachers' beliefs about STEM, in particular, beliefs about the effectiveness of particular instructional methods, are important in determining how teachers will teach and should be at the forefront of any teacher education program. Increasing the level of STEM content knowledge without also helping teachers develop positive beliefs and attitudes related to STEM will in the end limit the value of learning the content. It is the teachers' beliefs and attitudes that ultimately shape their instructional practices which can then be enriched or enhanced, but not driven, by content knowledge. In other words, connections among beliefs may lead to the generation of certain attitudes, which will ultimately influence or determine behavior (Ajzen, 1985; Pajares, 1992).

The findings also revealed that the participants perceived their knowledge of STEM content increased sig-

nificantly. There is a mixture of evidence linking teachers' subject matter (content) knowledge to their classroom practice and their students' achievement (Ball, 1988; Lederman, Gess-Newsome & Latz, 1994; Wilson, Floden, & Ferrini-Mundy, 2001). The anticipated relationship between these constructs and variables provided the justification for developing, implementing and assessing professional development opportunities that attend to affective and cognitive elements influencing teacher effectiveness for teaching STEM, which we applied in the context of teaching STEM (Appleton, 1995; Darling-Hammond & Bransford, 2005).

The shift in perceptions of teaching STEM along with content/subject matter knowledge of STEM provides further supports for the influence of professional development on an array of variables related to teaching. These findings indicate that our professional development intervention was effective at modifying our participants' perceptions and conceptions of teaching of STEM, while increasing their STEM content/subject matter knowledge. The ability of this professional development intervention to significantly influence a wide range of variables may be attributed to the integrated structure module, which was designed to attend to a wide range of educational needs and teacher preparation. The ability of a four-day intensive professional development intervention to bring about change in these variables provides the justification for offering these opportunities to teachers, for our data suggests the experience can be transformative in multiple ways. The substantial increase in the level of sophistication of the responses indicates the intervention was effective for increasing perceptions of engagement and knowledge of STEM. Perhaps the most promising result was the substantial increase in motivation for teaching STEM, which may be attributed to the participants' increased content/subject matter knowledge and perceptions of their ability to teach STEM.

Conclusions

The *Bitara-STEM™* Training of Trainer Programme was developed to increase STEM teachers or facilitators' abilities to teach integrated STEM instruction and to increase their efficacy, beliefs and attitudes of integrated STEM teaching. The participants of this professional development program were revealed to have significant increases in their knowledge, attitudes, beliefs and efficacy in relation to teaching integrated STEM. The findings of this study have also revealed significant relationship between (i) participants' knowledge of integrated STEM teaching with perceptions of efficacy for teaching integrated STEM and (ii) participants' attitudes of integrated STEM teaching with beliefs towards integrated STEM teaching. Unlike the normal professional development programme that only focusing in lecturing, our programme requires participants to experience in conducting the integrated STEM instruction through combination of "hands on" and small group discussion. Thus, it can be concluded that the experiential features of our programme that provide participants with experience in conducting the integrated STEM activities by themselves appears to be having positive effect on facilitators' affective variables, knowledge of integrated STEM instruction and STEM content knowledge. However this study has some limitations. The first limitation was the configuration of our study population. The participants in our study were a self selected group with interest in improving their STEM education knowledge and teaching, and therefore may not be representative of the larger teacher population. Additional research with a broad selection of teachers with a wide range of interest in and motivation for increasing their STEM teaching capacity may be needed to fully substantiate our findings. The second limitation was, that the study only involved one group and with small number of participants. Since the design did not include a control or comparison group, it is not possible to attribute the results of this study to the program alone, nor are the results generalizable. Therefore, this finding suggests that future study could do a two group design with large number of participants. The limitations of our study provide excellent contexts and directions for future investigation in this line of STEM education research.

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Received: *September 18, 2014* Accepted: *January 10, 2015*

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