Assessing In-service Teachers' Self-efficacy and Beliefs about STEM Education

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Abstract

Recently, Thailand is encouraging the support of teachers to develop STEM appropriated teaching practices via several STEM education agencies both public and private sectors. To support and empower in-service teachers to teaching STEM, we need to identify and improve understanding about teachers' belief, efficacy and the current challenges and needs for implement STEM education into classroom. In this study, Initial STEM survey (ISTEM survey) was developed and administered to in-service teachers (n = 275) to identified teachers' self-efficacy for teaching, their beliefs, and prioritized challenges and needs about teaching STEM education. Data were analyzed using descriptive statistics and analysis of variance. In the findings, the data indicated that some teacher's context such as gender and experience of teachers influenced their self-efficacy, beliefs, and attitude about STEM education. Nevertheless, we found that 29.67% of in-service teachers perceived that STEM activity is the time-consuming activity and course. In-service teachers informed that attending STEM specific workshop and providing suitable STEM educative materials such as textbooks and teacher's guidelines documents are helpful resources for them to improve the quality of enacting STEM approach into classroom.

Keywords: STEM education; STEM Integration; Self-efficacy ; Teacher's belief; In-service teacher

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Introduction

Increasing the quality of STEM education is viewed as an important way towards creating an informed citizenry that will benefit policy decisions at the national, regional, and local levels (National Research Council [NRC], 2011). In 2013, Thailand officially launched STEM policy, which focused on the integration of STEM into K-12 science instruction. Many educational agencies, for example, the Ministry of Science and Technology, Ministry of Education, and private sectors, have been involved in encouraging these efforts.

To achieve STEM education goal, students should develop necessary knowledge and skills. In other words, students have to develop STEM literacy. Many scholars suggest definitions of STEM literacy and most of them are overlap. For instance, Lederman (1998), Nobel laureate physicist, provided STEM literacy as the ability to adapt to and accept changes driven by new technology work, to anticipate the multi-level impacts of their actions, to communicate complex ideas effectively to a variety of audiences, and perhaps most importantly, to find measured solutions to problems. Besides, Toulmin and Meghan (2007) argued that STEM literacy does not simply mean achieving literacy in these four strands. It also means more than mapping the numerous overlapping interdisciplinary skills, concepts, and processes. Honey *et al.,* (2014) suggested that STEM literacy might include some combination of awareness of the roles of science, technology, engineering, and mathematics in modern society, familiarity with at least some of the fundamental concepts from each area, and a basic level of application fluency. Beyond literacy some researchers include skills, Bybee (2013) recommended that students should develop 21st century skills including adaptability, complex communications/social skills, non-routine problem solving, self-management/self-development, and systems thinking. Among mega waves of changing, teachers should be well-prepared and develop required-knowledge and skills to deliver STEM education to our future citizens. While it is easy to offer definitions and literacy of STEM education, however, putting STEM education into practice is much harder. For Thailand to upgrade to STEM education, the country must focus attention on its teachers. As Griffin (1983) pointed out, high-quality professional development is a central component of nearly every modern proposal for improving education. Policy-makers have increasingly recognized that schools can be no better than the teachers and administrators who work within them. While professional development programs vary widely in their content and format, the majority share a common purpose: to “alter the professional practices, beliefs, and understanding of school persons toward an articulated end” (Griffin, 1983).

However, based on a recent survey (Srikoom and Hanuscin, 2017) indicated that many teachers aren't aware of these efforts, and most still struggle to answer the question, "What is STEM education?" Teacher professional development is necessary in order to these efforts to succeed. Based on social cognitive theory (Bandura, 1977, 1997) a vast number of studies have shown that students' academic self-efficacy is predictive of study behavior as well as academic outcomes (see Maddux and Gosselin, 2003 ; Skaalvik and Bong, 2003). Several research scholars suggested that teachers' beliefs directly affect their perceptions and judgment of learning and teaching interactions in their classrooms and they in turn influence their classroom behavior (Clark and Peterson, 1986; Clark and Yinger, 1987). Moreover, teacher's belief may functions as a "filter and amplifier" through which teachers may screen their classroom experiences, and interpret their subsequent classroom practices (Berry *et al.*, 2015). However, the connection between teachers' beliefs and practices is, however, complicated by the fact that teachers may sometimes not be able to adopt practices that reflect their beliefs.

Since teachers' thinking and beliefs play an important role in their classroom practice and influence their learning and teaching interactions (Borko and Putnam, 1995), it is necessary to find ways of exploring teachers' beliefs and thoughts to provide insights for teacher educators to better help teachers develop. However, a problem with research on teacher self-efficacy is that there is no common agreement about how the construct should be conceptualized and how it should be measured. It has been conceptualized and measured differently by different researchers (Skaalvik and Skaalvik, 2007; Tschannen-Moran and Woolfolk Hoy, 2001). Therefore, our main research questions in this study are:

1. What are the current Thai's in-service teachers' self-efficacy and beliefs towards STEM teaching?

2. Which are the factors that influence teachers' self-efficacy and beliefs on STEM practice?

Teachers' Self-Efficacy and Belief

Several education researches showed that instructional practice and teacher decision making can be influenced by teachers' beliefs about learning and teaching (Borko *et al.*, 1990; Brophy and Good, 1974; Grossman, 1990; Nathan and Koedinger, 2000). Yasar *et al.,* (2006) argued that understanding teachers' views and beliefs in the core concept such as engineering is a necessary factor towards developing long-range plans to better integrate technology and design into K-12 education. In learner's side, the educational experience for students is dependent on teacher's quality and effectiveness, including belief towards teaching, more than perhaps any other single alterable factor (Nye *et al.*, 2004 ; Rowan, 2004).

Social cognitive theory posits the importance of reciprocal determinism in human functioning (Bandura, 1997), recognizing the conjoined forces of the person, behaviors, and environment as interactive and interdependent influences on individuals. The factors that related to the person include efficacy beliefs, which in turn influence behaviors and are also developed through experiences with the world. Furthermore, beliefs and behaviors influence and are influenced by the environment. Teacher efficacy researchers have long examined the relations between teachers' sense of efficacy and their level of teaching experience. Prior teaching experience can be considered a "mastery experience" and, as such, serves, theoretically, as a powerful source of efficacy beliefs (Tschannen-Moran *et al.*, 1998). Similarly, the contexts in which teachers teach influence how they interpret the teaching task and evaluate their perceived capabilities. According to literatures, several factors such as experience and teaching level that can be influence teachers' self-efficacy and can shape their behavior.

The first example is "experience". Gorrell and Dharmadasa (1994) found that although preservice teachers reported higher efficacy for implementing new methods of instruction, experienced teachers reported higher efficacy for classroom management, organization of instruction, and impact on students. In contrast, Campbell (1996) found that practicing teachers in Scotland and the United States reported significantly higher efficacy beliefs than did preservice teachers. Several researchers have compared the efficacy beliefs of practicing teachers with varied years of experience. Some researchers have found no relation between years of experiences and efficacy beliefs (e.g., Ghaith and Shaaban, 1999 ; Guskey, 1987), whereas others found a negative relation between years of experience and general teaching efficacy beliefs (e.g., Hoy and Woolfolk, 1993 ; Taylor and Tashakkori, 1995). Moreover, Wolters and Daugherty (2007) used the TSES and found that teachers in their first year reported significantly lower self-efficacy for instructional practices and classroom management than did teachers with more experience.

The second example is "teaching level". Several researchers compared the efficacy beliefs by grade or school level taught. Comparable findings have emerged across some published studies that suggested that preservice and practicing elementary teachers have significantly higher efficacy beliefs than do those at the middle or secondary levels (Midgley *et al.*, 1995). On the other hand, others had reported no significant differences in efficacy beliefs by teaching level (e.g., Chester and Beaudin, 1996; Ross, 1994 ; Soodak and Podell, 1996). Unless, mentioned factors above, in this study, we focused on other important factors such as age, gender, and background to cover all possible variables that might affect teachers' belief.

We strongly believe that creating of instruments, which can be used to identify what is working well and what is not working well for teacher development broadly in specific context, is one of the keys to support teacher to develop their abilities to teach in the correct direction. Besides teachers' self-efficacies and beliefs information can be used as the indicator for measurement the professional development programs and supporting solutions efficiency as well.

Methodology

Instrument

In this study, we modified the "Teacher Beliefs and Attitudes toward STEM" from *The T-STEM survey* of Friday Institute for Educational Innovation (Friday Institute for Educational Innovation [FIEI], 2012). The *T-STEM survey* was designed to ask teachers to give information about their self-efficacy for teaching; their belief that teachers affect student learning; how often students use technology; how often they use certain STEM instructional practices; their attitudes towards 21st century learning; their attitudes towards teacher leadership; and their awareness of STEM careers.

In adapting process, we translated the *T-STEM survey* into Thai, called Initial STEM survey *(ISTEM survey)* for using with Thai's science teachers who have to implement STEM education. We also checked readability by using this draft-version survey with 55 in-service teachers to get feedbacks for revisiting. After editing, items were considerably selected and recategorized into 3 parts with 5 point Likert-type scale (1 = strongly disagreed to 5 = strongly agreed). Moreover, we added some items into our survey to get the data that match with our research questions. The following sentences are details of the survey:

Part 1 General Information: this part asks about gender, age, teaching assignment (subjects and level), teaching experience, and education background of participants.

Part 2 Your Instruction: This part comprises 20 items which were separated into 2 minor parts, the first one asks about teachers' instruction (10 items). While the second part asks about teachers' self-efficacy of teaching in general. Besides, we developed and arranged items link to STEM learning process which consisted of 5 major steps: defining problem, researching, developing (including designing), optimizing (evaluating), and communicating (Figure 1).

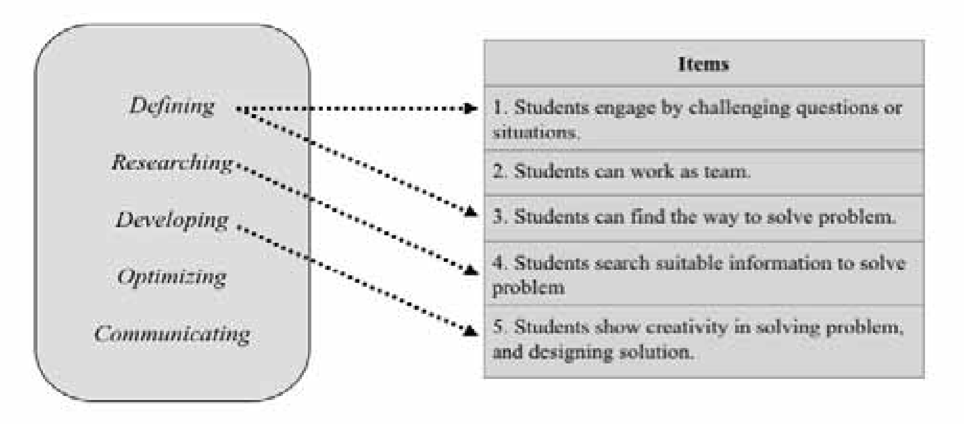

Figure 1 The Relationship between survey's Items and STEM Learning Process

Part 3 Understanding and Attitude about STEM education: in this part, teachers gave information about STEM education. It is consisted of 3 minor parts which are STEM career awareness (4 items), understanding and attitude (6 items), and confidence about teaching STEM (5 items). At the end of survey, we also asked teachers about supports and challenges of teaching STEM (2 items), which participants be able to give more than one answer in these two items.

Data collection

In 2016, we begin this project by conducting the *ISTEM survey* with 275 science, mathematics, and technology teachers across the country. All participants attained in STEM workshops that provided by several organizations such as IPST, Ministry of Education, and private agencies. We asked the participants to complete the survey and turned back before the workshops started. The demographic information of participants in this study were summarized and categorized in Table 1.

Table 1: Demographic Information of Participants in the Study

Category	Sub-Category	Number	Percentage
Gender	Female	52	19.2
	Male	219	80.8
Age Range	20 - 30 years old	73	26.5
	31 - 40 years old	101	36.7
	41 - 50 years old	59	21.5
	above 50 years old	42	15.3

Category	Sub-Category	Number	Percentage
Experience	0 - 10 years old	139	50.9
	11 - 20 years old	84	30.8
	above 20 years old	50	18.3
Teaching Subject	Science	87	31.8
	Math	118	43.1
	Science and Math	21	7.7
	Technology	48	17.5
Teaching Level	Lower Primary	63	23.2
	Upper Primary	33	12.1
	Lower Secondary	103	37.9
	Upper Secondary	73	26.8

Data analysis

After data collection, we used quantitative method to interpret our data. The descriptive analysis including frequency, mean, standard deviation were used to display overall information about demographic of participants, challenges and needs of teaching STEM. To address our two main research questions which are to explore the current Thai's in-service teachers' self-efficacy and beliefs towards STEM teaching and relationship among teacher's factor that can influence those self-efficacy and beliefs. Thus, we used the one-way analysis of variance (ANOVA) to test differences among variables that had significant effects (significance level at $p < 0.05$) on in-service teachers' beliefs and self-efficacy about teaching

Results

Teacher self-efficacy and beliefs

In term of belief about teaching, participants slightly agreed with all of learning process that exist in STEM learning process (m = 3.21-3.61, in Figure 2). However, there are some features that teachers think they found a sort of difficulties to deal with them such as communicating (m = 3.21) and technology integration (both inside and outside classroom, m = 3.25). On the other hand, researching step seem to be familiar feature that teachers have good experiences to instruct it (m = 3.61).

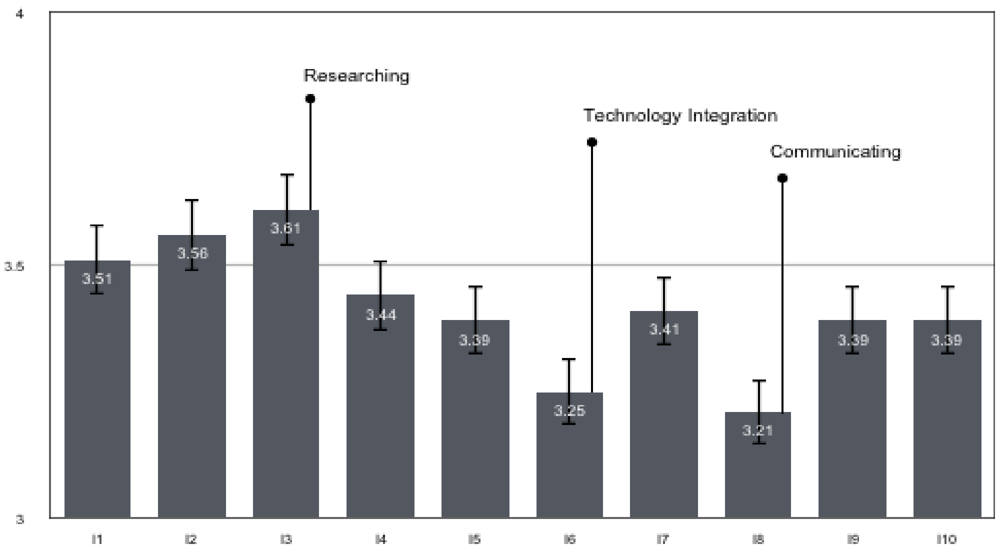

Figure 2 Teacher's belief about teaching

For self-efficacy about teaching, in-service teachers in this study held strongly concerns about content knowledge (m = 3.37, in Figure 3). It can be explained by nature of STEM which is integrated disciplines that means teachers need to prepare contents for their lessons using unconvinced concepts.

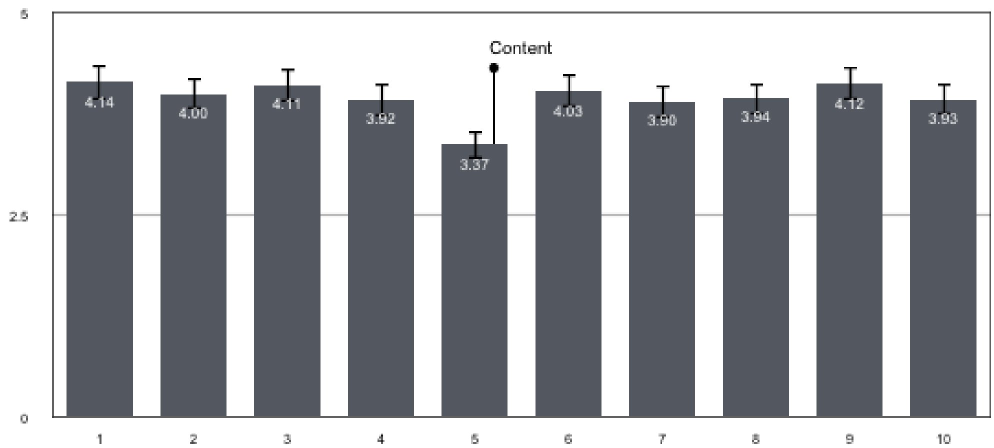

Figure 3 Teacher's self-efficacy about teaching

Attitude about STEM education

In part 3 of survey, we asked teachers to give information about STEM career awareness, STEM understanding and attitude. Participants seem to hold high level of STEM career awareness and understanding (m = 3.64-3.69) and they know how to find information about STEM career and related information. Besides, teachers believed they can be consultant about STEM careers for students and parents when required. Similarly, teacher's attitude about STEM education is pretty high. In Table 2 shown the attitude about STEM education in several aspects, for example, teachers believed that STEM education can improve their students' learning. However, STEM education is considered to be overlapped among many conceptions such as science project, problem-based learning and only science and mathematics integration (m = 4.01-4.14).

Table 2: Attitude and belief about STEM education

Items	Mean	SD
I understand STEM Education	3.76	0.631
STEM is suitable for my context	3.74	0.675
STEM should improve my student's learning	4.03	0.603
STEM is science project	4.14	0.632
STEM is problem-based learning	4.02	0.688
STEM is science and mathematics integrated	4.01	0.707

Similar to the previous study at the beginning phase (preliminary study) that provided evidence about engineering concern (Srikoom & Hanuscin, 2017). In this study, we found that among four STEM subjects, teachers thought that they know about engineering (m = 3.54) less than other subjects (m = 3.67-3.75, in Table 3). However, all of items have no significant differences among the set of items. In addition, there is such a good sign that teachers hold high confidence to implementing STEM lessons.

Table 3: Attitude about teaching STEM education

Items	Mean	SD
I can teach STEM!!	3.82	0.543
I know Science	3.67	0.725
I know Mathematics	3.75	0.627
I know Engineering	3.54	0.706
I know Technology	3.76	0.620

Belief, self-efficacy, and perception about STEM influenced factors

Based on statistical analysis, we found that teacher's contexts can influence belief, perceptions, self-efficacy about STEM teaching (some factors shown in Table 4). Our data showed that experience had significantly influence (p-value < 0.05) teachers' self-efficacy toward teaching. In details, teachers who had experience more than 20 years hold stronger in their self-efficacy in posing engaging questions to students and giving them the chance to learn by themselves, student-centered (Item 2.1.1 and 2.1.3). In group of 0-10 years of service, we found that this group holds more open-minded perception about classroom observation both observing and being observed by others (Item 3.2.6).

Although, many teachers concerned about STEM contents, teacher's education background, some graduated in other fields, had no effect to teachers' belief and self-efficacy about STEM teaching. Age range had also no significantly difference in belief and self-efficacy about STEM teaching. However, we noticed that teachers who age above fifty years old strongly agreed that STEM approach is science and mathematics integrated to solve specific problem.

Teacher's genders showed significantly differences in teachers' self-efficacy toward teaching, we found that male teachers hold significantly higher confidence to use technology or integrate technology in classroom than females (Item 2.1.6). Similar to perception, male teachers expressed that they strongly agreed that they knew how to teach engineering and technology concepts through STEM approach (Item 3.3.4 and 3.3.5).

In term of teaching assignment, teachers' teaching subject gave the evidence that teachers who teach technology subject hold significantly positive self-efficacy about engaging students work as teamwork, supporting students to search relevant data and create new ideas (creativity). Technology teachers hold strongly confidence of using technology in classroom and giving students to review about ideas and solutions that they created (redesign) as well. Moreover, we found that mathematics teachers have strongly belief about their capability of content knowledge, mathematics concepts, that will be merged into STEM lessons (Item 3.3.3).

Lastly, teaching level, upper primary teachers showed significantly confidence about how to posing engaging questions to challenge students and beyond that they understand how to draw student's attention while teaching (Item 2.1.1 and 2.1.10). In addition, high-school teachers had positive perception and were ready to integrated technology into student's life both inside and outside school (Item 2.1.6 and 2.1.7).

Table 4: Analysis of influenced characteristics by ANOVA test

Characteristics	Item	Descriptions	df	Mean Square	*F*	*sig.*
Genders	2.1.6	technology integration	3	4.00	4.39	0.037
	3.3.4	teaching technology in STEM lesson	3	2.27	4.59	0.033
	3.3.5	teaching engineering in STEM lesson	3	1.65	4.35	0.038
Teaching Assignment	3.3.3	confidence to integrate mathematics	3	2.85	7.77	0.000
Teaching Level	2.1.1	know how to engaging students	3	2.59	4.87	0.003
	2.1.10	know how to draw student's attention	3	1.11	2.86	0.038

Challenges and needs for STEM teaching

According to the data, around 30% participants concern about time management. STEM activity is viewed as time-demanding activity. This might be STEM learning process is quite new thing for teachers and it comprises of various complicated steps to follow. Surpassingly, some teachers (23%) think student's context might be challenge for them to teaching STEM. In contrast, at almost the same number of participants (20%) think teacher's context can be challenge for teaching STEM. In addition, around 18% of participants worry about accessing to suitable STEM media and materials (Table 5).

Table 5: Teacher's challenges on STEM teaching

In part of the needs for support STEM teaching, particularly, the most of teachers requested to improve their abilities for teaching such as STEM-related workshop and role model's classroom observation (around 50%) rather than pay attention to administration and management issues such as administration supporting (14.23%) and funding (6.13%) (Table 6).

Table 6: Teacher's needs for support STEM teaching

Issue	Responses	Percentage
Workshop/Long-term PD program	165	32.61
Book/Teacher's Guideline	111	21.94
Field Trip/Classroom Observation	87	17.19
Administration Supporting	72	14.23
Revised Curriculum	40	7.91
Funding/Special Budget	31	6.13
Total	**506**	**100.00**

Discussion

Although STEM education policy is sort of newly policy for Thai education system teachers hold quite high positive attitude about STEM education including instruction and students' outcomes development. However, many in-service teachers felt anxiety about their knowledge content to instruct STEM lesson. One of possible reason that relate to teacher's integration perspectives that STEM teaching can be viewed in such a varieties forms. Thus, in STEM teaching, multiple subject (concepts) and processes are surely merged or integrated that may cause of teachers' concern about their content knowledge which should cover all of the proper content areas in STEM lessons. Therefore, we believe that teacher development program must not only focus on how to teach STEM activity, we also need to develop teacher to seek the available concepts (which match student's and teacher's contexts) that associated in the real life situation and selected the suitable concepts to use for STEM lesson designing.

We discovered about in-service teachers' practice baselines. For example, we know that teachers lack of strategies to engaging student's communication skills and hold low confidence about their own content knowledge. Based on survey, we found that teachers concern about unclear STEM education policy. The teachers struggle to make decisions about how to obtain STEM lessons in school time. Because they have to balance between content coverage that required by national standard and STEM learning outcomes such as 21st century skills (creativity, collaboration, problem-solving, critical thinking, and communication skills) development. In addition, the data indicated that majority of teachers were not familiar to integrated technology into their classroom. With this finding, professional development program should be merge the strategies to deliver technology integrated concept and exemplars for teachers.

In the findings, we found a little genders gap in term of technology usages both inside and outside schools that male teachers hold more confidence to allow students to use technology devices (Item 2.1.6). Thus, STEM courses or professional development programs require to consider about genders preference activities that encourage female teachers to be confidence to use and allow students to use technology in classroom. We did not find explicit evidences that can interpret the cause of genders influence, this point should be explored and studied further to find the suitable solutions because it affect not only teacher's genders, it can be get through to students as well. Regarding to several researches, this kind of data may also help to explain why some instructional reforms succeed or fail even when they take into account genders and other contexts (e.g., Carlone *et al.,* 2011; Calabrese *et al.,* 2012).

Engineering and Technology subjects seem to be the complicated subjects for in-service teacher to teach STEM. We argued that teacher development program should pay attentions on understanding and awareness about STEM career, engineering design process, and technology literacy. All of them should be strongly addressed in professional development sources. Moreover, most of teachers insisted about the need of STEM educative materials to be adopted and adapted in the beginning time which can support them to implement STEM approach. So this part of job, for both government and private sectors, have to be considered in the front row priority.

Even if, in term of generalization, this results may not represent all of teachers' contexts in Thailand. In the other words, it is hard to claim that majority of Thai teachers are experiencing the same problems to implement STEM approach into schools. However, this study process of working, especially survey, can be used and modified for any organizations or agencies to initially assess and measure teachers' contexts (e.g., content knowledge, self-efficacy, attitude, belief). We suggest that studying of participants' context should be accomplished before staring project or program and the data should be fundamental thought for program design. We belief that can ignite participants' attitude for change and create systematically teacher development way.

We believe that driving STEM policy into school depends on many factors such as administration, resources management, teachers and students' contexts and so on. We found that both naive and experienced teachers were required a lot of effort to move forward because STEM lesson is viewed as a sort of new and ambiguous approach. This unclear situation may cause by unpredictable and indistinct of Thailand's STEM policy. For example, STEM instructional information such as STEM education purposes and STEM learning process had been launched short period later after STEM education policy announcement. This caused many teachers who early prepared for implementing STEM lessons needed to revisit their activities lesson plans.

In terms of STEM policy enactment, we agreed that one of the most important factor is change process, especially for new approach like STEM as mentioned above. STEM policy should be considered for steak-holders, especially government agencies, as long-term policy not just educational fashion theme. Providing explicit student's learning evidences directly impact to teacher's perception. To establish process of change may require more than teacher's belief and perception (practical side), in theoretical side such as policy makers, educators, curriculum developers have to perceive the same core value of STEM education and collaboratively and continually support each other.

In dimension of teachers, the results indicate that majority of in-service teachers probably need such a specific training to improve skills to teach STEM lessons. Communication and technology integration engagement strategies are some of those skills that teachers reflected uncertain condition for teaching. The effective STEM instruction should be clarified and simplified as the best practices in different integration perspectives and others. Teachers, both pre-service and in-service, should be systematically prepared through up-to-date courses, training programs, and long-term professional development systems.

In this study, in-service teachers have intention of self-development and confidence to teach STEM, however, time consuming lesson like STEM might not be appropriated for the current standard and curriculum, especially science that consisted of several content topics which need to be covered. We probably have a lot of mission to be done. Firstly, curriculum developers and researchers need to revisit national standard and curriculum by integrated STEM disciplines to boost STEM implementation possibility. Secondly, once again STEM education, both in educational field and real world, needs to be clarified and engineering design process and scientific inquiry that are overlapped in some feathers need to be distinguished and emphasized in the lesson. In dimension of teacher knowledge, teacher's content knowledge (CK), pedagogy knowledge (PK) and pedagogical content knowledge to teaching STEM (PCK for STEM) should be addressed and revealed about how those relate and impact to teacher's ability to teaching. This sort of notions can help educators improve understanding about how to support teacher development effectively.

Finally, there is on one definition of how to teaching STEM, we suggest that educators and teacher developers must provide all shade of STEM perspectives for teachers and then allow them the opportunity to judge which are appropriated to their classroom. Nevertheless, all of us need to place importance to student's STEM learning outcomes, our supreme goal, at all times.

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