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THE SYNTHESIS OF THAI PROFESSIONAL DEVELOPMENT PROGRAM IN STEM EDUCATION: A CASE OF THAI REGIONS AFFECTING ON SCIENCE TEACHER PERFORMANCE

A case study

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Abstract

The research objectives were to 1) study Thai PD project features, 2) synthesize Thai regional factors affecting teacher performance, and 3) present the guideline of PD activities for STEM education at the primary level. The sample group was the two years research project reported in 2021 on PD for primary science teachers' training programs in STEM education in Thailand. The meta-analysis was used to synthesize the results from training groups. The research instruments were a checklist of the PD project features form and guidelines for the PD evaluation form. The qualitative data were analyzed using content analysis. The statistics used for data analysis were mean standard deviation and one-way ANOVA. As the results, they indicated that: 1) Thai PD project had high-quality components based on experts in the field. Mainly features showed the process of checking the quality of curriculum program and received a good amount of feedback, 2) the analysis results showed no evidence of regional difference affecting teachers' performance at .05 confident level, and 3) there were 6 modules for training activities empowering primary science teachers in STEM. There were recommendations for using this PD in STEM education at different levels of education, but needs adjusted activities and time duration of each step in PD, and STEM learning should be integrated into other studies such as in art and history.

Keywords: professional development, STEM Education, regions, teachers' performance

1. Introduction

For many years in many world leader countries the need to educate and support our teachers to implement reforms in science and mathematics education has been ongoing throughout the world (ISTES organization, 2022). In Thailand, the main master plan of national development is to equipped Thai citizens with 21st century skills to align with the direction of global education reform (Sangnapaboworn, 2018). It has been recognized that integrated STEM subjects in to science classroom can be a powerful tool to engage students into science, technology, engineering, and mathematics (Australian Education Ministers, 2015). STEM education can be defined as integrated teaching of four disciplines: science, technology, engineering and mathematics and establishing links between them. It also aims to make students to have interdisciplinary cooperation, systematical thinking, being open to communication, having ethic values, searching, producing, creativity and abilities of solving problems appropriately. (Duraković, 2022). Therefore, teachers become the key facilitators of student learning in STEM education and they are needed to be prepared and obtained the professional development (PD) programs in STEM education (Johnson, Macalalag, & Dunphy, 2020). The PD activities should improve teachers' intention to integrate STEM

activities in future lessons (Stanislaw, 2021). To be effective, science teachers especially in primary level must be prepared to successfully implement current and research-based pedagogical practices in their classrooms. Effective teaching of STEM education and building the innovation have become a significant concern for teachers' PD since teachers are not familiar with STEM strategies and do not possess the disciplinary knowledge or strategies demanded by STEM teaching and engineering design (Xiao Huang et al., 2022).

In term of Thailand, as Thai science teachers, they also need a proper PD program that help them conceptualizing and applying STEM education skill to teach in their classrooms. (Chamrus et al., 2016). Although STEM education and PD programs are determined as important policy and needed to provide for all science teachers, still teachers showed some difficulties and hesitates integrating them into their classrooms. Prior studies showed many researches focused on improving science teachers in secondary level, not many in primary school level. (Institute of promoting science and technology teaching, 2014). Until recently, in 2021 after three year of training and conducting research project Thai science teachers' PD project in STEM education was fully reported by Mahidol University and Organisation for Economic Co-operation and Development (OECD). The results of implementations this project with science teachers in primary level from 225 districts all over the country bring a need of closely attention on how the project has impact on teacher performance and their feedback on the training activities. Also, the factor of regional area of the country has showed interesting impacts on STEM education activity from the study. It stated that the barriers of STEM educational learning management had occurred in northern region of Thailand in designing STEM education network, and especially in designing the curriculum for teacher developing plans (Sritrakul, 2018). Since Thailand has 4 mainly regions in which they are different to each other in many contexts such as languages, beliefs, population, weather, and cultures.

Therefore, this study was focused on synthesizing the documents from this Thai PD project, regional factor affecting, and finding out the activity steps of successful PD program in STEM education for primary science school teachers. this study was aimed to synthesize those regions affecting on science teachers' performance after participating in this PD program in STEM education.

1.1. Research objectives

1) To study the research features of Thai PD program in STEM education for primary school teachers.
2) To synthesize the difference of primary school teachers' performance before and after participating in Thai PD program based on four regions of Thailand.
3) To present the guideline of PD activities for STEM education in primary level.

1.2. Research framework

This study was the documentary research. The synthesis of research report was used to find out the answers on research features and analyze the secondary data. To analyze the difference of teacher performance based on four regions is shown in figure 1.

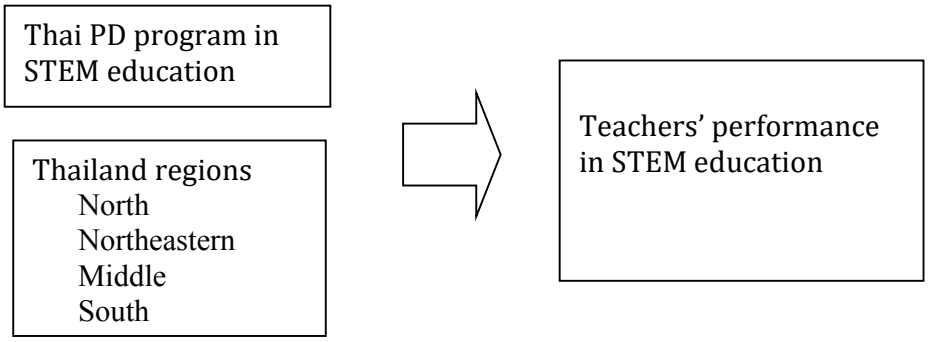

Figure 1. Research framework

2. Research methodology

2.1 Method

Thai PD program in STEM education conducted by Mahidol University researcher team. The research is done by using one group pre-test and post-test design as shown in table 1.

Table 1. *one group pre-test and post-test design*

Pre-test	Test	Post-test
T_1	X	T_2

When T_1 is defined as the test that was done prior to conducting the test (Pre-test)

X is defined as conducting an activity to educate test group by using an integration method to improve teaching performance

T_2 is defined as the test that was done after conducting the test (Post-test)

The meta-analysis was used to synthesize the results from training groups.

2.2 Population and sample

Population of this research was Thai PD program project full report conducted between 2020-2021 and the report was released in 2021. There were 2,281 Thai science teachers participated in this project. This study was documentary study and a case study, we mainly focus on phase 2 of the project as research sample. These phases were when primary school teachers in science participating in training program for 20.5 hours. There was one group for each phase and they were divided into four regions to analyze the difference of teachers' performance in STEM education before and after attending this PD program.

2.3 Research tools

This was the recording protocol, consisting of; 1) general information, 2) the research project methodology, 3) the research results. The research instruments were checklist of PD project features form and guideline of PD evaluation form. Teacher Performance in PD project assesses teachers' ability, self-efficiency and job satisfaction in STEM education comparing the average score before and after attending the program by checking the attendee's knowledge and self-assessment. The tools of the project were evaluated by 5 experts to check the index of correspondent (IOC) which was between 0.60-1.00 which is in the acceptable range. The evaluation of each protocol is done by finding the classification power (r) according to the Brennan method, the results of the classification power (r) were between 0.24 and 0.88. The reliability of the program was assessed using Lovett's method, the result shows a

reliability factor of 0.84 which is considered very reliable.

2.4 Data collection

We collected the full report and other materials related to data analysis of this teacher training between 2020-2021. The data were organized and prepared to be synthesized and analyzed by using descriptive and inferential statistics.

2.5 Data analysis

In this study, we synthesized the documents and received the results from Thai PD program in STEM education conducted by Mahidol University researcher team. The content analysis was used to analyze and made the summary on the training activities and participants feedback in phase 2 of the project. The descriptive statistics that were frequency, percentage, average, and standard deviation were used to analyze research features. To analyze the regional factor affecting teachers' performance in STEM before and after participating in this Thai PD program we used one-way ANOVA.

3. Results

3.1 The results of research features

Based on the research characteristics form we can summarize the Thai PD program in STEM education it showed table 2.

Table 2. *General information of teachers in the regions*

Research characteristics	Findings
1. General information	- This research project was research and development. - The total of schools all over the country participated in this project were 2,250 primary schools and there were 2,281 science teachers. It was conducted by Mahidol university researchers for this two-year project funded by OECD of Thailand.
2. Research methodology	-The research method was mixed method which means there were both quantitative and qualitative method used. -There were five phases of this research as follow: 1) study literature review and develop the program for STEM training, then conducting the pilot study and modify this program, 2) use the modified training program for four groups of science teachers in primary schools in many regional headquarters, 3) meet the teachers for doing knowledge management to receive teachers' understanding of STEM and feedback, 5) write all results and publish the full research findings. - The descriptive statistics and independent t-test were used to analyze data.
3. Research results	Each group of teachers had significantly higher performance scores after they participated in this Thai PD program in STEM education.

The science teachers in primary schools all over the country participating in this project were 2,281. They could be divided into four original regions where they taught science classes

that were north, northeastern, middle, and south. The number of teachers in each region are as follow in table 3.

Table 3. *General information of teachers in the regions*

Region	Frequency	Percentage
1. North	288	12.62
2. Northeastern	736	32.27
3. Middle	796	34.90
4. South	461	20.21
Total	2,281	100.00

These data shows that the majority of science teachers who participated in STEM education training program were from middle region of Thailand 34.90%. Then the second group shown from Northeastern of Thailand 32.27%. The third group from South of Thailand 20.21%. The least number is shown from north region with 12.62%.

3.2 The difference of science teacher empowered after trained by teacher training program among four regions.

The difference of teachers' performance before and after participating in Thai PD STEM education are shown in table 3 and 4. Table 3 indicates that teachers' performance from pre-test and post-test based on their schools' region is as follow.

3.2.1 Self-improvement of teachers prior to the training

From analyzing the comments about knowledge, teaching abilities, developing teaching tools from stem teaching of teachers received the training the results are shown in Table 4.

Table 4. *Level of self-improvement of attendees on average*.

Analysis subject	Level of self-improvement						t	p
	before			after				
	$\overline{X}$	S.D.	Interpret	$\overline{X}$	S.D.	Interpret		
1.knowledge level on stem education	1.71	1.00	low	3.67	0.74	high	63.504	0.00
2.Education management of stem education	1.66	1.08	low	3.53	0.76	high	60.439	0.00
3.Transfering knowledge on stem education	1.65	1.11	low	3.48	0.82	high	58.494	0.00
4.Developing education tools for stem education	1.68	1.06	low	3.51	0.80	high	58.710	0.00
Summary	1.67	0.97	low	3.55	0.69	high	69.680	0.00

* Statistically significant at .05

From table 4 defined as low means are 1.51 – 2.50, as average means are 2.51 – 3.50, and as high means are 3.51 – 4.50. We can see that before attending the training activity the teacher had a rather low level of abilities analyzed ($\overline{X}$ = 1.67, S.D = 0.97). If the analysis were done

per subject of knowledge level on stem education, education management of stem education, transferring knowledge on stem education and developing education tools for stem education we can see the scores were ($\overline{X}$ = 1.71, 1.66, 1.65 and 1.68 respectively). After attending the workshop, we can see that the average score improved rather significantly ($\overline{X}$ = 3.55, S.D = 0.69). If the analysis were done per subject of knowledge level on stem education, education management of stem education, transferring knowledge on stem education and developing education tools for stem education we can see the scores were ($\overline{X}$ = 3.67, 3.53, 3.48 and 3.51 respectively).

To summarize, teachers who attended the workshop had significantly improved their abilities, over the .05 mark.

3.2.2 Teachers' performance before and after participating in training program.

The teacher's performance scores based on their regions after they participated in the training program are shown in table 5.

Table 5. *Teachers' performance before and after participating in training program based on their regions.*

Region	Pre-test		Post-test	
	Mean	SD	Mean	SD
North	19.92	0.33	24.48	0.12
Northeastern	18.96	1.02	23.60	0.58
Middle	18.93	0.70	23.98	0.56
South	18.69	0.93	23.56	1.65

* Statistically significant at .05

The data results shows that teachers' post-test scores are higher that pre-test for all regions. The most successful performance, however, is shown from teachers in the north of Thailand. The other regions are shown having similar performances among each other.

3.2.3 Comparing performance of teachers from all regions before and after training.

The comparison of teacher performance scores in STEM education knowledge between 4 Thailand regions as shown in table 6.

Table 6. *The comparison of teachers' performance scores among 4 regions*

Between 4 Regions	Mean	SD	F	P
Pre-test	19.02	0.84	.917	.464
Post-test	23.83	0.82	.654	.597

* Statistically significant at .05

The comparison shows that teachers from 4 regions, north, northeastern, middle, and south have no significantly difference between them neither pre-test or post-test. However, if we consider the mean scores, the post-test is higher than pre-test.

3.3 The guideline of PD activities for STEM education in primary level.

Thai PD program in STEM education conducted by Mahidol University researcher team the training was conducted for 20.5 hours training team. The guideline of PD activities for STEM education in primary level. There were 6 main steps for training activities empowering primary science teachers in STEM.

Training module 1 The 21st Century Education (1.5 hours)
Training module 2 Inspiration (1.5 hours)
Training module 3 Creation of STEM Education Innovation) (9 hours)
Training module 4 Process of Developing STEM Education Innovation (5.5 hours)
Training module 5 Learning Process of STEM Education (1.5 hours)
Training module 6 Smart STEM Education Trainer (1.5 hours)

Each module is linked to each other. Teachers should be encouraged to attend all 6 training modules. The training was conducted using workshop and active learning method to develop teachers and assess performances before and after the training, including feedback for training activity which will be used for further trainings.

4. Discussion

This study examined the research features of Thai PD in STEM education and comparison of teachers' performance before and after participating in the main training activities based on their original region in Thailand. The discussion is presented based on two main research objectives as follow.

1) the results of research feature can be summarized that this Thai PD program in STEM education was a research and development. For teachers' regional background are from the north, northeastern, middle, and south of Thailand. This showed similar results to the study that used the document to analyze secondary data as well. (Iksang & Minjung, 2021). There were both quantitative and qualitative method used. The total of schools participated in this project were 2,250 primary schools and there were 2,281 science teachers attending this training program. There were five phases of this research; 1) study of related literature and research, then develop the training program and conducting the pilot study, 2) use of the training program curriculum for three main groups of science teachers, 3) conduct knowledge management to receive teachers' STEM feedback, and 5) write and publish the full research report. For teachers' regional background, north, northeastern, middle, and south. The finding showed that mostly teachers came from middle region, secondly found from northeastern, then from the south and north respectively.

2) the results of synthesis, as when we looked at teaching and learning of international Survey in 2018 of the U.S. data based on this research results (Yoon & Kim, 2021) that they analyzed various factors such as background and socio-demographics of teachers they showed that the individual differences in PD experience of teaching in any specific subject. They could have impacted on teachers' ability, self-efficacy, and job satisfaction in STEM education. But in our study in Thai context, we had not found any difference based on regional background on teachers' performance. The teachers' post-test scores are higher than pre-test for all regions. The most successful performance, however, is shown from teachers in the north of Thailand. The other regions are shown having similar performances among each other. However, science teachers from four regions, north, northeastern, middle, and south have no significantly difference of STEM education performance between them neither pre-test or post-test. In another study based on the beliefs and understandings of preservice primary teachers had on teaching and preparing to teach STEM subjects (Premnadh, Michael, Greg & Xia Li., 2017) by using the Australian Office of the Chief Scientist they suggested that the teachers

recommended that they should be prepared for how to teach STEM in the school curriculum. They were not confident in their teaching STEM without more professional preparation and development. The same results indicated also in this study of Thai PD in STEM education that teachers were more confident and empowered if they had trained by this program on teacher STEM in their classroom. For one similar study (Xiao, et al., 2022) it showed the statistical analysis of two groups of teachers' pre-test and post-test taking STEM summer program because their STEM discipline knowledge, abilities, and attitudes were indicated very vary in how teachers understand the different components of STEM knowledge. These suggested that the requirement of the most attention for further professional development were needed. However, this has difference result from Thai PD of our study. In which, it showed more understanding of STEM knowledge on Thai teachers after participating in this PD.

3) The training guideline of Thai PD in this study was new and not the same as other models in the similar fields. They showed that it should consisted of 6 modules; 1) The 21st Century Education, 2) Inspiration, 3) Creation of STEM Education Innovation), 4) Process of Developing STEM Education Innovation, 5) Learning Process of STEM Education, and 6) Smart STEM Education Trainer. The time period of PD program was 20.5 hours. In the study of Zhejiang-Indiana STEM summer program (Xiao, et al., 2022) for conducting STEM training activities focusing on developing strategies of teaching STEM for 82 teachers in science, technology, or mathematics had been consuming time for two weeks.

5. Conclusion

These conclusions are made based on three research objectives. First, the results of research feature can be summarized that this Thai PD program in STEM education was a research and development. There were both quantitative and qualitative method used. The total of schools participated in this project were 2,250 primary schools and there were 2,281 science teachers attending this training program. There were five phases of this research; 1) study of related literature and research, then develop the training program and conducting the pilot study, 2) use of the training program curriculum for three main groups of science teachers, 3) conduct knowledge management to receive teachers' STEM feedback, and 5) write and publish the full research report. For teachers' regional background, north, northeastern, middle, and south. The finding showed that mostly teachers came from middle region, secondly found from northeastern, then from the south and north respectively. Second objective, the results after synthesis the data they show that teachers' post-test scores are higher that pre-test for all regions. The most successful performance, however, is shown from teachers in the north of Thailand. The other regions are shown having similar performances among each other. However, science teachers from four regions, north, northeastern, middle, and south have no significantly difference of STEM education performance between them neither pre-test or post-test. Lastly, we presented the guideline of the training program as totally 20.5 hours in which there are 6 modules; 1) The 21st Century Education, 2) Inspiration, 3) Creation of STEM Education Innovation), 4) Process of Developing STEM Education Innovation, 5) Learning Process of STEM Education, and 6) Smart STEM Education Trainer. Each module is linked to each other. Teachers should be encouraged to attend all 6 training modules conducted using workshop and active learning to develop teachers' performances in STEM teaching and learning.

6. Recommendation

6.1 Application of the research

The science teachers in primary schools of Thailand can adapt STEM training steps into their own personal development and their STEM activity. The educators, STEM policy makers as well as STEM trainers can apply Thai PD program for their areas and workspace to empower science teachers or STEM areas for teaching STEM education and create innovation through their classrooms. Educational policy makers should extend this project specific in some areas such as in the south of Thailand based on this case study results.

6.2 Future study

According to the research results, the future study should bring on the STEM education 6 steps into other educational levels such as secondary level and higher education. The time duration for each step shows interesting idea on what if it has adjusted either reduce or extend, how it could have impact on teachers' performance or attention. The analysis of teacher's gender, age, and background may affect teacher's interest in Thai PD program in STEM education. The future research can also follow up these teachers after spending some time teaching in the real STEM classroom.

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