SEAT

ISSN: 2821-9163 (Online)

International Journal of Science Education and Teaching

IJSET

IJSET Vol. 2 No. 1
(Jan - Apr 2023)

International Journal of Science Education and Teaching
Vol. 2, No. 1 (January – April 2023)

ABOUT IJSET

International Journal of Science Education and Teaching (IJSET) is supported by Science Education Association (Thailand) or SEAT. IJSET seeks articles addressing issues including science education, physics education, chemistry education, biology education, technology education, STEM education, science teacher education, early childhood science education, science curriculum and instruction, and other related science educational fields.

Peer Review Process
Articles submitted for publication must never have been previously published or currently under review at another journal. Each paper is reviewed by the editor and, if it is judged suitable for this publication, it is then sent to at least two independent reviewers for double blind peer review. Based on their recommendation, as well as consultation between relevant Editorial Board members the editors then decides whether the paper should be accepted as is, revised or rejected.

Publication Frequency
The IJSET provides an academic platform for work in the fields of interdisciplinary education. The IJSET publishes 3 issues annually. These include:

- Issue 1 (January - April)
- Issue 2 (May - August)
- Issue 3 (September - December)

Issue: IJSET Vol. 2 No. 1 (January – April 2023)
Publication Date: April 30, 2023
Publisher: Science Education Association (Thailand)

IJSET EDITORIAL TEAM

TABLE OF CONTENTS

AUTHOR INDEX

International Journal of Science Education and Teaching
Vol. 2, No. 1, pp. 1-18, Jan. – Apr. 2023
http://doi.org/10.14456/ijset.2023.1

Nurturing the Maker Mindset in Pre-Service Teachers: A Study of the Effect of a STEM Camps

Jatutip Kaya [1] and Suthida Chamrat [2*]
[1] *Doctor of Philosophy Program in Education (Science education), Faculty of Education, Chiang Mai university, Thailand*
[2] *Department of Curriculum, Instruction and Learning, Faculty of Education, Chiang Mai University, Thailand*
*Email: suthida.c@cmu.ac.th

Received: 31 Dec 2022 Revised: 25 Feb 2023 Accepted: 1 Mar 2023

Abstract. This study investigates the effect of STEM camps on developing a maker mindset in pre-service science teachers. A total of 11 pre-service teachers participated in a 2-month fieldwork experience that included attending STEM camps three times and a debrief session. The Maker Mindset questionnaire was used to assess changes in the participants' maker mindset over the fieldwork experience. The STEM camp, based on a DIY tinker and maker framework, consisted of 13 activities that aimed to promote an understanding of STEM concepts and principles through experiential learning. The data indicated significant changes in several categories of the Maker Mindset questionnaire between the pre-STEM camp and post-STEM camp. Specifically, the level of "Change," "Learn," "Play," and "Make" increased, while the level of "Self-efficacy" decreased. These findings suggest that the STEM camp had a positive effect on the development of a maker mindset in pre-service science teachers. The findings also pointed that to promote the maker mindset in STEM camps effectively, it is important to address skills such as growth mindset, grit, and collaboration.
Keywords: Maker mindset, Pre-service teachers, STEM camp

INTRODUCTION

STEM (Science, Technology, Engineering, and Mathematics) education has been identified as an important area of study for a number of reasons. There is a large body of literature that supports the numerous benefits of STEM education. Some of the key benefits that have been identified include the development of critical thinking and problem-solving skills, promoting creativity and innovation, supporting economic growth and competitiveness, and enhancing career opportunities and earning potential. These benefits have been consistently reported in a wide range of research studies and reports. According to a report by the National Science Board (2018), STEM education can help students develop skills such as problem-solving, critical thinking, and collaboration, which are important for success in the 21st-century workforce (p. 4). In addition, STEM education has encouraged creativity and innovation, as students are asked to think critically and creatively while developing solutions to real-world problems (Barrow & Stepien, 2019, p.

3). The U.S. Department of Commerce (2019) also highlights the importance of STEM education for economic growth and competitiveness, stating that "a strong STEM workforce is critical to America's economic growth and competitiveness in the global marketplace" (p. 1). Finally, research has shown that STEM occupations have grown at a faster rate and have higher median earnings than non-STEM occupations (National Science Board, 2018, p. 4).

Maker education, which emphasizes hands-on, experiential learning and problem-solving, can be a powerful complement to STEM education (Smith & Grady, 2016). Maker activities can provide students with opportunities to apply their STEM knowledge and skills in authentic and meaningful contexts, while also promoting creativity and innovation (Kapur, 2019). By engaging in maker activities, students can learn to think critically and creatively, and to develop the confidence and persistence needed to solve complex problems (Barrow & Stepien, 2019).

Maker education can also support the development of a growth mindset, which is the belief that one's abilities can be developed through effort and learning (Dweck, 2006). By participating in maker activities, students can learn to embrace challenges and failures as opportunities for growth, and to persevere in the face of obstacles (Kapur, 2019). This can help to foster a sense of resilience and determination that can be valuable in both personal and professional endeavors (Smith & Grady, 2016).

Integrating maker education into STEM instruction can lead to mutually reinforcing outcomes, as both approaches can support the development of critical skills and attitudes that are important for success in the 21st century (Kapur, 2019). Maker education, which emphasizes hands-on, experiential learning and problem-solving, can provide students with opportunities to apply their STEM knowledge and skills in authentic and meaningful contexts, while also promoting creativity and innovation (Barrow & Stepien, 2019). By integrating maker education into STEM instruction, educators can create engaging and meaningful learning experiences that support the growth and development of students as makers and thinkers (Kapur, 2019).

Pre-service teachers in science may benefit from having a maker mindset for several reasons. Having a maker mindset can help pre-service teachers to develop a deeper understanding and appreciation of the scientific process (National Science Board, 2018). Maker activities, which typically involve designing, building, and testing prototypes or solutions to real-world problems, can provide pre-service teachers with the opportunity to engage in hands-on, experiential learning that mirrors the iterative and inquiry-based nature of scientific research (Honey & Kanter, 2013). By participating in maker activities, pre-service teachers can gain a better understanding of the process of scientific inquiry, including how to ask and answer questions, gather and analyze data, and communicate findings (National Science Board, 2018).

A maker mindset can help pre-service teachers to develop their problem-solving skills and creativity (Dweck, 2006). Maker activities often require students to think critically and creatively and to develop solutions to complex problems (Honey & Kanter, 2013). Participating in maker activities allows pre-service teachers to approach challenges with flexibility, persistence, and resourcefulness, which can be valuable skills in the classroom (National Science Board, 2018). A maker mindset can help pre-service teachers engage and motivate their students (Dweck, 2006). Maker activities can be highly engaging and motivating for students, as they allow learners to take an active role in shaping their learning experiences and to see the tangible results of their efforts (Honey & Kanter, 2013). By incorporating maker activities into their teaching, pre-service teachers can help to foster a sense of ownership and agency among their students, which can in turn, enhance motivation and engagement (National Science Board, 2018).In general, developing a maker mindset can be an essential part of the professional development of pre-service teachers in science, as it can help them to become more effective and innovative educators who are able to engage and motivate their students (Dweck, 2006).

Research has shown the importance of studying the impact of STEM camps on pre-service teachers' development of a maker mindset. Maker education, which emphasizes hands-on, experiential learning and problem-solving, can complement STEM education by providing opportunities for students to apply their STEM knowledge in authentic contexts while promoting creativity and innovation. In addition, maker education can support the development of a growth mindset, encouraging students to embrace challenges and failures as opportunities for learning and growth. These skills and attitudes are critical for success in the 21st century.

Martinez and Stager (2013) argue that maker education is a stance towards learning that emphasizes agency, complexity, and perseverance. Halverson and Sheridan (2014) found that maker education can promote a growth mindset by encouraging students to embrace failure as an opportunity for learning and improvement. Bleicher and Lindgren (2020) conducted a study that examined the impact of a STEM summer camp on pre-service teachers' maker mindset, finding that the camp increased their confidence in teaching STEM subjects and willingness to incorporate maker activities in their teaching. The study also found that the camp helped to foster a growth mindset among the pre-service teachers. Similarly, Weaver and colleagues (2021) investigated the effect of a week-long maker camp on high school students' self-efficacy and attitudes towards STEM, finding a significant increase in their self-efficacy in STEM and interest in pursuing STEM careers. These studies provide evidence that STEM and maker camps can have a positive impact on the development of essential skills and attitudes among pre-service teachers and students. This can help to foster a sense of resilience and determination that can be valuable in both personal and professional endeavors. In summary, STEM and maker education can be mutually reinforcing, as each approach can support the development of essential skills and attitudes critical for success in the 21st century. By studying the effect of STEM camps on the development of a maker mindset in pre-service teachers, researchers can better understand the potential benefits of maker education and how it can be effectively integrated into STEM instruction.

RESEARCH OBJECTIVES

The research objective of a study examining the effect of STEM camps on developing a maker mindset in pre-service teachers.

METHODOLOGY

The research study described in the provided information focused on the effect of STEM camps on the development of a maker mindset in pre-service teachers in science. In this study, 11 pre-service teachers participated in a fieldwork experience that included two months of intensive STEM camp preparation, followed by attendance at STEM camps three times and a debrief session. The main research instrument used in this study was the maker mindset questionnaire developed by the first author as a part of the doctoral thesis. The research study was conducted in the year 2021, in February, and the pre-service teachers participated in the fieldwork experience during this time. The study aimed to examine the effect of the STEM camps on the development of a maker mindset in pre-service teachers. The maker mindset questionnaire was used to gather data from the participants and assess changes in their mindset over the fieldwork experience.

Participants

This study investigates the effect of STEM camps on developing a maker mindset in pre-service science teachers enrolled in a science education program in the Faculty of Education. The research study included 11 student participants who had majors in chemistry and biology and were recruited through a combination of purposive sampling and voluntary sampling from the fourth year of their program. Of the 11 participants, 9 were female and 2 were male. The participants volunteered to participate in the study and completed a 2-month fieldwork experience that included attending STEM camps three times and a debrief session. The research followed The Belmont Principles, which are three basic principles that are particularly relevant to the ethics of research involving human subjects: the principles of respect of persons, beneficence, and justice.

Research Tools

STEM Camp

The STEM camp is a special educational program organized by the school and faculty of education that aims to promote an understanding of science, technology, engineering, and math (STEM) concepts and principles through hands-on and mind-on activities. This STEM camp was based on a DIY (do-it-yourself) tinker and maker framework, which encourages students to engage in experiential learning through the use of everyday materials and specific equipment such as robots and microcontrollers. The camp consisted of 13 activities spanning various STEM disciplines, including life science, physical science, earth science, and computing science, and was conducted over a period of 18 hours at a school on Wednesdays in February 2021. A total of 300 students participated in the camp, with pre-service teachers serving as trainers to support their learning. The STEM camp provided an opportunity for pre-service teachers to develop their pedagogical skills and foster a maker mindset, as they engaged in collaborative learning, design thinking, and problem-solving activities with the students.

The maker mindset questionnaire

The Maker Mindset questionnaire, also known as the Behavior Scale, is used to measure the conceptual level of a Maker. It consists of 42 items that are divided into two parts: general information about the informant and items that measure the informant's level of feeling or behavior towards certain Maker concepts. These concepts are grouped into six categories: Change, Learn, Self-efficacy, Play, Make Participate, and Share. Pre-service individuals are asked to answer the questionnaire and indicate their level of agreement or disagreement with each statement, providing insight into their conceptual level as a Maker. The development of the research instrument involved a try-out process and expert review. The try-out process involved administering the instrument to a small group of participants to identify any potential issues or confusing items. Feedback was collected from these participants to refine the instrument. The final version was then reviewed by three experts in the field to ensure its validity and relevance. These experts provided feedback on the clarity and appropriateness of each item, as well as suggestions for any necessary revisions. The final version of the research instrument was deemed valid and appropriate for use in the study.

In the Maker Mindset questionnaire, informants are asked to rate their feelings or behaviors on a scale from *1* to *5*, with *5* indicating the highest level of agreement and *1* indicating the lowest level of agreement. By rating their feelings and behaviors on this scale, informants can provide a more nuanced and detailed understanding of their mindset and approach toward making. The categories and items included in the Maker Mindset questionnaire were documented from a range of sources, including Hatch (2013), Dougherty (2013), Chamrat (2018), Myers (2017), Pierrat (2016), Martin and Dixon (2014), Klepper et al. (2017), Pacock (2016), Gerstein (2016), Chu et al. (2015), and

Martin (2015). These sources have contributed to the development the framework of maker mindset showed in Figure 1.

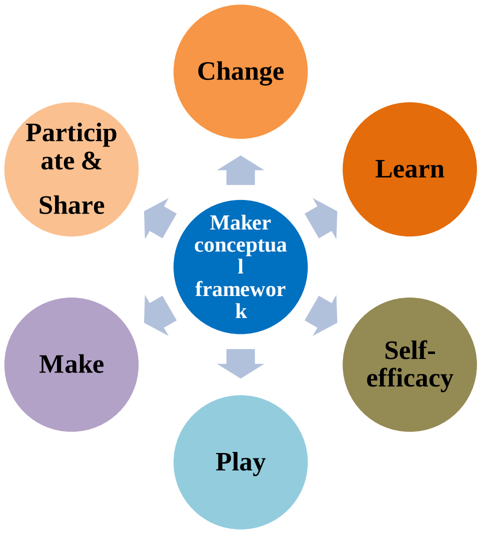

Figure 1: the conceptual framework of the maker mindset

The research methodology used in the study can be represented in the research process diagram shown in Figure *2*

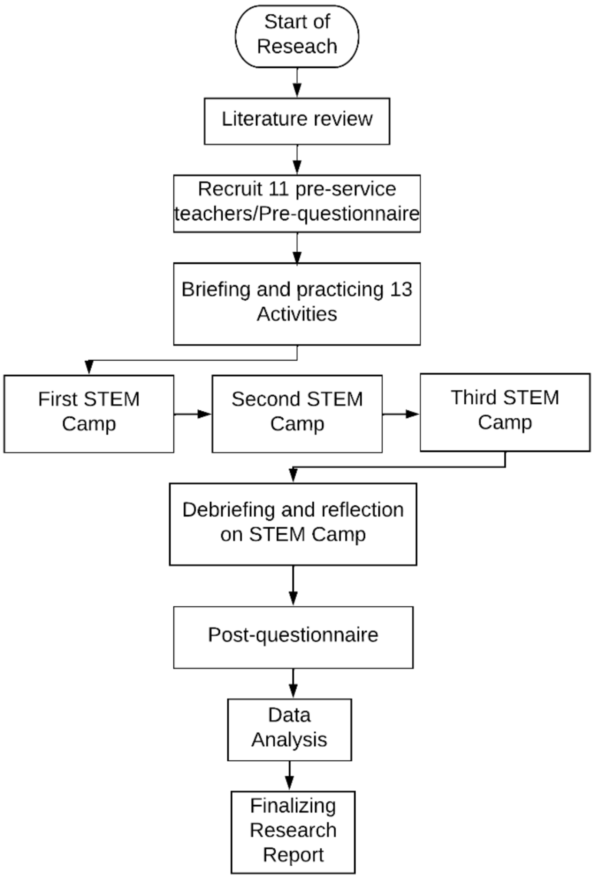

Figure 2: research process diagram

Data Collection

The data for this research study was collected both before and after pre-service teachers participated in a fieldwork experience that included 2 months of intensive STEM camp preparation, followed by attendance at STEM camps 3 times, and a debrief session.

Data Analysis

This research study used descriptive statistics to analyze the data's frequency and average. The data were analyzed in both pre-service teachers' maker mindset and the level of maker mindset in each indicator and sub-indicator. The data was analyzed by counting the frequency of each indicator and sub-indicator for each pre-service teacher. The analysis was conducted for the six categories of indicators, which were Change, Learn, Self-efficacy, Play, Make Participate, and Share, both at an individual level and an overall level.

RESULTS AND DISCUSSION

Table 1 shows each participant's average scores for the maker mindset questionnaire, both before and after participating in the STEM camp.

Table 1: Pre-service teachers' maker mindset before and after participating in STEM camp

Pre-service Teacher	AVERAGE of Pre-STEM Camp Maker Mindset	AVERAGE of Post-STEM Camp Maker Mindset
1	3.93	4.43
2	3.81	4.26
3	4.17	5.00
4	3.97	3.71
5	4.22	3.90
6	3.79	4.48
7	4.24	4.26
8	4.00	4.79
9	3.95	3.47
10	3.93	3.95
11	5.00	4.57

The table shows the average pre-STEM camp maker mindset scores and average post-STEM camp maker mindset scores of 11 pre-service teachers. The pre-STEM camp scores range from 3.79 to 4.24, with an overall average of 4.02. The post-STEM camp scores range from 3.47 to 5.00, with an overall average of 4.29. The data indicates that the majority of the participants had an increase in their maker mindset scores after attending the STEM camp, with the highest increase being from participant 3 (pre-camp score: 4.17, post-camp score: 5.00). It was found that the STEM camp positively affected the maker mindset of most participants, as their average scores increased after attending the camp. However, some participants saw a decrease in their average scores after attending the camp. A comparison of the maker mindset of pre-service teachers is shown in Figure 3.

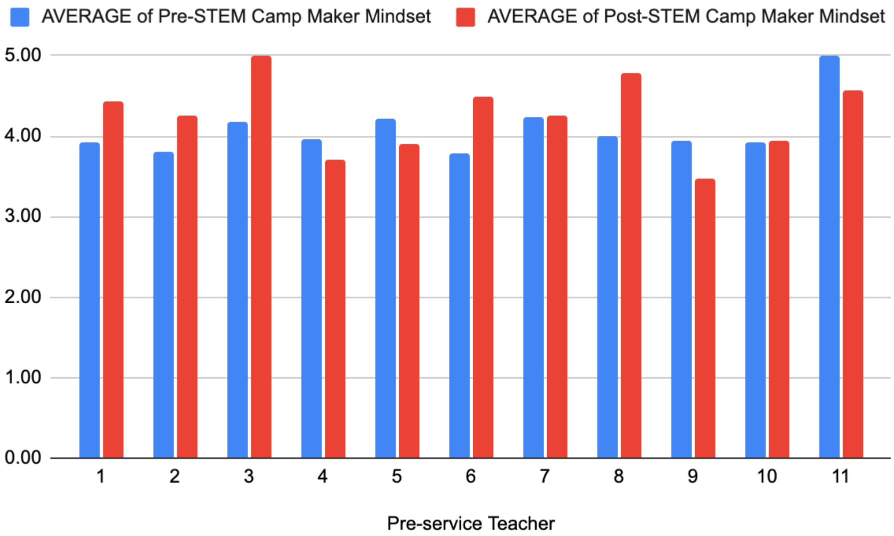

FIGURE 3: Pre-service teachers' maker mindset before and after participating in STEM camp

Tables 2 through 7 present the average maker mindset of pre-service teachers, with each maker mindset indicator consisting of 7 sub-indicators. The sentences for each sub-indicator are also provided.

Table 2: Pre-service teachers' maker mindset in each indicator 1 Change and Sub-Indicators before and after participating in STEM camp

Indicator/ Sub-indicator	Maker Mindset Indicators	Pre-STEM Camp	Post-STEM Camp
Indicator	1. Acceptance of changes that may occur (Change)	4.23	4.45
Sub-indicator 1.1	Acceptance of change: I am open to and accepting of changes that occur naturally, and am able to adapt to new situations and embrace change	4.18	4.55
Sub-indicator 1.2	Courage and risk-taking: I am courageous and confident in my decisions, and am not afraid to take calculated risks in order to achieve my goals.	4.09	4.36
Sub-indicator 1.3	Accepting mistakes: I accept my mistakes. without feeling ashamed When the mistake is caused by one's own decision or action	4.45	4.64
Sub-indicator 1.4	Positive attitude towards failure: Every time there is a failure. I always look at failure positively.	4.27	4.45
Sub-indicator 1.5	Open-mindedness: I am open to learning new things and am willing to consider new ideas and perspectives	3.91	4.09
Sub-indicator 1.6	Technology literacy: I like to be open minded to learning. and always accepting new technological changes	4.27	4.45
Sub-indicator 1.7	Seeking expert knowledge: I actively seek out information and guidance from experts and trusted sources, and value learning from others	4.45	4.64

Table 3: Pre-service teachers' maker mindset in each indicator 2 Learn and Sub-Indicators before and after participating in STEM camp

Indicator/ Sub-indicator	Maker Mindset Indicators	Pre-STEM Camp	Post-STEM Camp
Indicator	2. Learning how to learn (Learn)	4.03	4.21
Sub-indicator 2.1	Determination and persistence: I am determined and persistent in achieving my goals, and am able to maintain focus and patience in the face of challenges and obstacles.	4.18	4.55
Sub-indicator 2.2	Interest in learning: "I have a strong desire to learn and am always seeking out new opportunities to expand my knowledge and skills."	4.00	4.36
Sub-indicator 2.3	Belief in learning: “I am confident in my ability to learn and believe in the value of learning new things."	4.30	4.45
Sub-indicator 2.4	Interest in learning unique topics: "I am drawn to unusual or unconventional topics and ideas and enjoy learning about things that are different or unusual."	3.82	3.73
Sub-indicator 2.5	Learning from problems: "I am interested in learning from the problems and challenges around me and use them as opportunities to grow and improve."	4.09	4.09
Sub-indicator 2.6	Tool literacy: "I am interested in learning about and using different tools, and am willing to explore new technologies and resources in order to create the desired workpieces."	3.64	4.18
Sub-indicator 2.7	Seeking feedback: "I value receiving feedback on my work and seek out opportunities to receive guidance from experts and other trusted sources."	4.18	4.09

Table 4: Pre-service teachers' maker mindset in each indicator 3 Self-efficacy and Sub-Indicators before and after participating in STEM camp

Indicator/ Sub-indicator	Maker Mindset Indicators	Pre-STEM Camp	Post-STEM Camp
Indicator	3.Perception of self-efficacy (Self-efficacy)	4.23	4.19
Sub-indicator 3.1	Interest in learning: “I am motivated to learn and pursue topics that interest me."	4.18	4.36
Sub-indicator 3.2	Problem-solving: “I am able to find and create solutions to challenges and obstacles on my own."	4.36	4.00
Sub-indicator 3.3	Reflective practice: “I engage in regular self-reflection in order to improve my performance and better understand my own capabilities and limitations."	4.18	4.27
Sub-indicator 3.4	Self-evaluation: “I regularly evaluate my own work and processes in order to identify areas for improvement."	4.09	4.18

Table 4: (Cont')

Indicator/ Sub-indicator	Maker Mindset Indicators	Pre-STEM Camp	Post-STEM Camp
Sub-indicator 3.5	Seeking feedback: "I value receiving feedback on my work and seek out opportunities to receive guidance from experts and other trusted sources."	4.27	4.09
Sub-indicator 3.6	Autonomy in learning: "I value the freedom to pursue my own interests and learning goals, and am able to manage my own learning activities effectively."	4.27	4.09
Sub-indicator 3.7	Believe in self-learning in special and unique topics: "I have unique interests and enjoy exploring and urge for learning about unconventional or unusual topics."	4.27	4.36

Table 5: Pre-service teachers' maker mindset in each indicator 3 Play and Sub-Indicators before and after participating in STEM camp

Indicator/ Sub-indicator	Maker Mindset Indicators	Pre-STEM Camp	Post-STEM Camp
Indicator	4.Love to play with Exploration and experimentation (Play)	4.05	4.44
Sub-indicator 4.1	Playful approach to learning: "I enjoy experimenting and exploring new ideas and approaches in my learning."	4.18	4.45
Sub-indicator 4.2	Interest in learning: "I am always interested and engaged in my learning, and enjoy the process of learning new things."	4.09	4.36
Sub-indicator 4.3	Sense of surprise and discovery: "I am often surprised by what I learn and enjoy discovering new things."	3.91	4.45
Sub-indicator 4.4	Excitement about learning: "I am excited about learning and always look forward to new opportunities to learn and grow."	4.18	4.36
Sub-indicator 4.5	Pride in learning: "I am proud of what I learn and the progress I make in my learning."	4.18	4.55
Sub-indicator 4.6	Curiosity: "I am curious and enjoy exploring and learning about things that are new or unfamiliar to me."	4.00	4.45
Sub-indicator 4.7	Asking questions: "I enjoy asking questions and seek out opportunities to learn more about the things that interest me."	3.82	4.45

Table 6: Pre-service teachers' maker mindset in each indicator 4 Make and Sub-Indicators before and after participating in STEM camp

Indicator/ Sub-indicator	Maker Mindset Indicators	Pre-STEM Camp	Post-STEM Camp
Indicator	Making and creating (Make)	3.82	4.24
Sub-indicator 5.1	Enjoyment of making and doing: “I enjoy the process of making and creating, and find it to be a fun and rewarding experience."	4.00	4.36
Sub-indicator 5.2	Innovation: “I am interested in developing new ideas and approaches, and enjoy creating challenging and unique pieces."	3.91	4.09
Sub-indicator 5.3	Tinkering: “I enjoy modifying or improving things in an informal or unique way, and have a love of tinkering."	3.91	4.18
Sub-indicator 5.4	Repetition and experimentation: “I am willing to repeat experiments and try different approaches in order to bring my ideas to fruition."	3.73	4.36
Sub-indicator 5.5	Persistence: “I am persistent and determined in achieving my goals, and am able to maintain focus and patience in the face of challenges and obstacles."	3.91	4.40
Sub-indicator 5.6	Seeking feedback: “I value receiving feedback on my work and seek out opportunities to receive guidance from experts and other trusted sources."	3.70	4.20
Sub-indicator 5.7	Interest in making something unique: “I have unique interests and enjoy exploring and making about something unconventional or unusual topics."	3.60	4.10

Table 7: Pre-service teachers' maker mindset in each indicator Participation and sharing and Sub-Indicators before and after participating in STEM camp

Indicator/ Sub-indicator	Maker Mindset Indicators	Pre-STEM Camp	Post-STEM Camp
Indicator	Participation and sharing	4.19	4.09
Sub-indicator 6.1	Interest in creative design: “I am interested in the field of creative design and enjoy learning about the work of creators from around the world."	4.00	4.00
Sub-indicator 6.2	Connecting with others: “I enjoy connecting with others who share my interests and finding ways to collaborate and learn from one another."	3.60	4.00
Sub-indicator 6.3	Collaboration in maker spaces: “I believe in the value of collaboration and see maker spaces as an opportunity to exchange ideas, learn from one another, and share resources and knowledge."	4.10	4.00
Sub-indicator 6.4	Sharing experiences and knowledge: “I enjoy working with others to share new experiences and knowledge, and believe that collaboration is an important part of learning and growth."	4.30	4.20

Table 7: (Cont')

Indicator/ Sub-indicator	Maker Mindset Indicators	Pre-STEM Camp	Post-STEM Camp
Sub-indicator 6.5	Collaboration for new knowledge: "I believe that collaboration is an important way to generate new knowledge and ideas."	4.50	4.10
Sub-indicator 6.6	Sharing with others: "I enjoy sharing what I know and do with others and find joy in sharing my interests and passions."	4.30	4.20
Sub-indicator 6.7	Responsibility for the future: "I believe it is important to contribute to the development of our world and I am committed to being a part of building a better future for all."	4.50	4.10

The data set from Table 2-7 presented in Figure 4, which show more visual of maker mindset level in 6 indicators and 42 sub-indicators. The average data of six indicators are also shown.

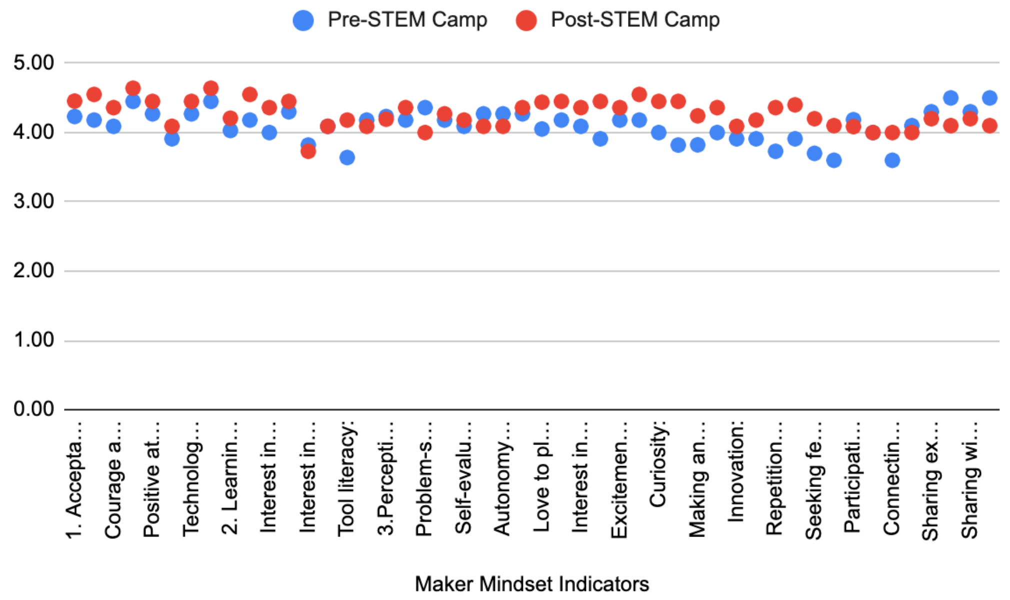

Figure 4: Comparisons of pre-service teachers' maker mindset in each indicator and sub-indicator before and after STEM camp participation

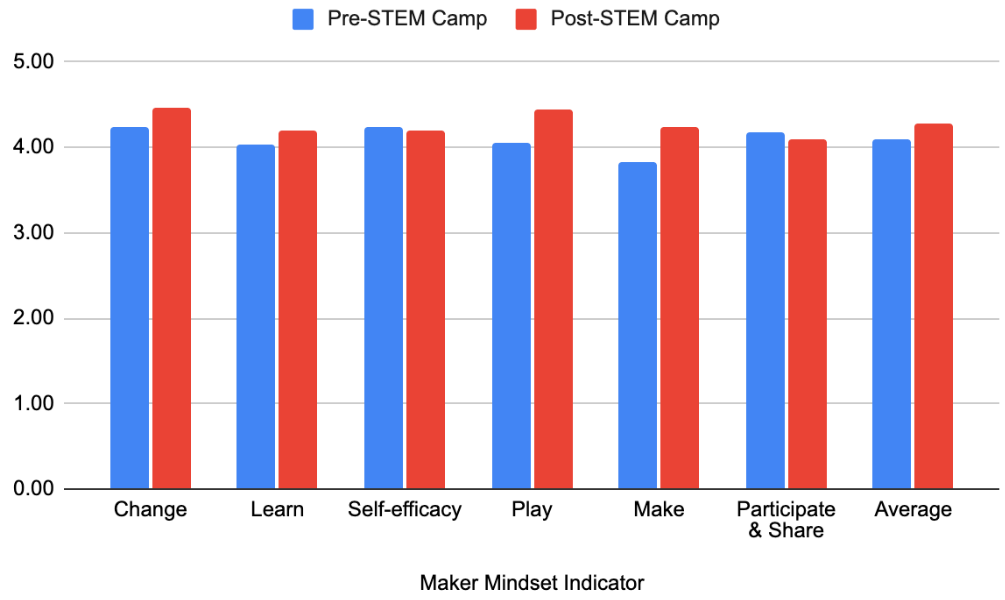

Figure: 5 Comparisons of pre-service teachers' maker mindset in each indicator before and after STEM camp participation

Comparing the pre-service maker mindset between pre-STEM-camp and post-STEM in six indicators and 42 sub-indicators reveals that the pre-service teachers' mindset increased overall. However, However, there are some indicators and sub-indicators that decreased. Comparing the scores between pre- and post-STEM camp, the data shown in Table 8.

Table 8: Comparisons of change in pre-service teachers' maker mindset in each indicator

Maker Mindset Indicator	Pre-STEM Camp	S.D.	Post-STEM Camp	S.D.	Increase/decrease
Change	4.23	0.19	4.45	0.19	0.22
Learn	4.03	0.23	4.21	0.28	0.18
Self-efficacy	4.23	0.09	4.19	0.14	-0.04
Play	4.05	4.05	4.44	0.06	0.39
Make	3.82	0.15	4.24	0.13	0.42
Participate & Share	4.19	0.32	4.09	0.09	-0.10
Average	**4.09**	**0.24**	**4.27**	**0.20**	0.18

The table above presents the average scores for each maker mindset indicator in the pre-STEM-camp and post-STEM conditions. Overall, there was an increase in the average maker mindset scores from the pre-STEM camp to the post-STEM condition. The most significant increase was observed in the "Play" indicator, which significantly increased from 4.05 to 4.44. The "Make" indicator also saw a notable increase, from 3.82 to 4.24. On the other hand, the "Change" and "Learn" indicators saw relatively small increases, from 4.23 to 4.45 and from 4.03 to 4.21, respectively. The "Participate & Share" indicator saw a slight decrease, from 4.19 to 4.09, while the "Self-efficacy" indicator remained relatively stable, with a minor decrease from 4.23 to 4.19.

These results suggest that the STEM camp positively affected the maker mindset of most participants, as most of the indicators saw an increase in scores from the pre-STEM camp to the post-STEM condition. However, because the data of Self-efficacy and Participate & Share indicators show the decline of pre-service teachers' maker mindset, the data in table 8 are present to see the details of the change in each sub-indicator.

Table 9: The Comparisons change in Pre-service teachers' maker mindset in each indicator and Sub-Indicators before and after participating in STEM camp

Maker Mindset Indicators	Pre-STEM Camp	Post-STEM Camp	increase or decrease
1. Acceptance of changes that may occur (Change)	**4.23**	**4.45**	0.22
Acceptance of change:	4.18	4.55	0.37
Courage and risk-taking:	4.09	4.36	0.27
Accepting mistakes:	4.45	4.64	0.19
Positive attitude towards failure:	4.27	4.45	0.18
Open-mindedness:	3.91	4.09	0.18
Technology literacy:	4.27	4.45	0.18
Seeking expert knowledge:	4.45	4.64	0.19
2. Learning how to learn (Learn)	**4.03**	**4.21**	0.18
Determination and persistence:	4.18	4.55	0.37
Interest in learning:	4.00	4.36	0.36
Belief in learning:	4.30	4.45	0.15
Interest in unique topic:	3.82	3.73	-0.09
Learning from problems:	4.09	4.09	0.00
Tool literacy:	3.64	4.18	0.54
Seeking feedback:	4.18	4.09	-0.09
3.Perception of self-efficacy (Self-efficacy)	**4.23**	**4.19**	-0.04
Interest in learning:	4.18	4.36	0.18
Problem-solving:	4.36	4.00	-0.36
Reflective practice:	4.18	4.27	0.09
Self-evaluation:	4.09	4.18	0.09
Seeking feedback:	4.27	4.09	-0.18
Autonomy in learning:	4.27	4.09	-0.18
Believe in self-learning in special and unique topics:	4.27	4.36	0.09

Table 9: (Cont')

Maker Mindset Indicators	**Pre-STEM Camp**	**Post-STEM Camp**	increase or decrease
Love to play with Exploration and experimentation (Play)	**4.05**	**4.44**	0.39
Playful approach to learning:	4.18	4.45	0.27
Interest in learning:	4.09	4.36	0.27
Sense of surprise and discovery:	3.91	4.45	0.54
Excitement about learning:	4.18	4.36	0.18
Pride in learning:	4.18	4.55	0.37
Curiosity:	4.00	4.45	0.45
Asking questions:	3.82	4.45	0.63
Making and creating (Make)	**3.82**	**4.24**	0.42
Enjoyment of making and doing:	4.00	4.36	0.36
Innovation:	3.91	4.09	0.18
Tinkering:	3.91	4.18	0.27
Repetition and experimentation:	3.73	4.36	0.63
Persistence:	3.91	4.40	0.49
Seeking feedback:	3.70	4.20	0.50
Interest in making something unique:	3.60	4.10	0.50
Participation and sharing	**4.19**	**4.09**	-0.10
Interest in creative design:	4.00	4.00	0.00
Connecting with others:	3.60	4.00	0.40
Collaboration in maker spaces:	4.10	4.00	-0.10
Sharing experiences and knowledge:	4.30	4.20	-0.10
Collaboration for new knowledge:	4.50	4.10	-0.40
Sharing with others:	4.30	4.20	-0.10
Responsibility for the future:	4.50	4.10	-0.40

Table 9 showed the average scores for the Learning how to learn (Learn) Maker Mindset Indicator and its seven sub-indicators for the pre-STEM camp and post-STEM camp. The sub-indicators include Determination and persistence, Interest in learning, Belief in learning, Interest in unique topics, learning from problems, Tool literacy, and Seeking feedback.

One interesting finding from the data is that the sub-indicator for Interest in learning in the Learn indicator showed a significant increase in average scores, with a change of 0.36 from pre-STEM camp to post-STEM camp. This suggests that the STEM camp experience had a positive effect on the participants' motivation to learn and their overall interest in learning new things. Additionally, the sub-indicator for Determination and persistence in the same indicator also showed a notable increase, with a change of 0.37. This highlights the potential for the STEM camp to foster key skills such as determination and persistence, which are important for success in any field. These findings indicate that the STEM camp experience positively affected the participants' attitudes toward learning and their ability to persevere in the face of challenges.

In the "Making and Creating" indicator, there was an overall increase in the average maker mindset scores from the pre-STEM camp to the post-STEM camp, with a 0.42-point increase. While most sub-indicators saw an increase, there was a decrease in the "Interest in Unique Topic" sub-indicator, with a decrease of 0.09 points. The highest increase was seen in the "Repetition and Experimentation" sub-indicator, with a 0.63-point increase. The lowest increase was seen in the "Innovation" sub-indicator, with a 0.18-point increase.

According to the results, STEM camps can be an effective way to develop the maker mindset in young people, particularly in the aspects of "Make", "Play", "Change", and "Learn" (Kabir & Brewer, 2017). One study found that STEM camps that emphasized hands-on, project-based learning and provided access to various tools and materials helped foster a maker mindset in participants. This learning environment allows campers to "Make" by actively creating and building projects and encourages them to "Play" and experiment with different materials and techniques. Another study by Buechley and Peppler (2014) found that maker-centered learning environments can help young people develop a "Change" mindset by providing opportunities for learners to take ownership of their own learning and make decisions about the direction of their projects. This type of learning can help pre-service teachers to develop a sense of agency and empowerment, as well as a willingness to embrace change and take risks.

Focusing on "Participation and sharing" and "Perception of self-efficacy", it is important to consider that the development of life skills such as participation and sharing, as well as perception of self-efficacy, can be influenced by various factors and may take time to develop. For example, a study by Chen and colleagues (2018) found that participation in extracurricular activities, such as STEM camps, can positively affect the development of self-efficacy in pre-service teachers. However, this process may be influenced by a range of factors, including the type and quality of the activities being engaged in, the individual characteristics of the participants, and the social and cultural context in which the activities take place.

The findings from Dweck's (2006) study demonstrate the importance of mindset in shaping individuals' self-efficacy and their willingness to take on new challenges. However, developing a growth mindset is not an overnight process and requires consistent effort over time. In this regard, programs such as STEM camps can play a critical role in helping pre-service teachers develop life skills such as participation and sharing, which can contribute to the development of a growth mindset (Kilinc et al., 2017). As noted by Duckworth and colleagues (2007), grit is another important factor that contributes to success in various contexts. Research has shown that grit can be developed through deliberate practice and effort, which aligns with the idea of growth mindset. Therefore, it is essential to recognize that the development of these skills is a continuous process and requires ongoing support and encouragement from educators (Duckworth, 2016). Ultimately, incorporating opportunities for experiential learning and growth mindset development in teacher education programs may not only benefit pre-service teachers but also enhance their ability to effectively teach STEM subjects to their future students (Turan et al., 2020).

CONCLUSION AND IMPLICATIONS

STEM camps can be effective in promoting the maker mindset in pre-service teachers, particularly in the areas of "Make", "Play", "Change", and "Learn". These camps can foster determination and persistence, interest in learning, and tool literacy, among other skills, through hands-on, project-based learning and access to various tools and materials. Maker-centered learning environments can also help pre-service teachers develop a "Change" mindset, as they take ownership of their learning and make decisions about the direction of their projects. However, the development of life skills such as participation and sharing and perception of self-efficacy may be influenced by various factors and may take time to develop. Programs such as STEM camps that provide opportunities for experiential learning and encourage a growth mindset may be particularly effective in helping pre-service teachers develop these skills.

To promote the Maker mindset in STEM camps, it is important to address further life skills such as growth mindset, grit, and collaboration. By fostering these skills, STEM camps can provide pre-service teachers with the tools and support they need to embrace new challenges, persevere in the face of setbacks, and work effectively with others. This can help to create a more engaging and meaningful learning experience and ultimately help pre-service teachers to develop the Maker mindset.

In this study, it is essential to note that these conclusions are based on a small sample of pre-service teachers and may need to be more generalizable to the larger population. Further research is needed to understand STEM camps' effect on maker mindsets' development.

LIMITATION OF THE STUDY

While the study provides valuable insights into the impact of STEM camps on the development of a maker mindset in pre-service teachers, there are some limitations to consider. One of the primary limitations is the small sample size. With only 11 participants, the study may not be representative of the larger population of pre-service teachers. This can limit the generalizability of the findings and suggest caution in applying them to a broader context. To address this limitation, it may be helpful to conduct larger-scale studies with a more diverse range of participants. Additionally, qualitative methods, such as interviews or focus groups, could supplement the quantitative results by providing a deeper understanding of the pre-service teachers' experiences with the STEM camp and their perceptions of its impact on their maker mindset development. Furthermore, it is important to note that the study only examined the short-term impact of the STEM camp on the pre-service teachers' maker mindset. It would be beneficial to conduct follow-up studies to investigate the long-term impact of the camp on their teaching practices and student outcomes.

In summary, while the study provides valuable insights into the impact of STEM camps on the development of a maker mindset in pre-service teachers, the small sample size and short-term focus of the study are limitations to consider. The use of qualitative methods and larger-scale studies can help address these limitations and provide a more comprehensive understanding of the impact of STEM camps on pre-service teachers' development.

ACKNOWLEDGEMENTS

This research is part of the first author's doctoral thesis, which is titled "Development of Pre-Service Science Teachers' Ability to Design and Implement in STEM Lessons Using the Maker Concepts.", Doctor of Philosophy Program in Education (Science Education), Faculty of Education, Chiang Mai university.

REFERENCES

Barrow, L., & Stepien, W. J. (2019). The impact of STEM education on student learning and career readiness. *International Journal of Science and Mathematics Education*, 17(1), 1-17.

Bleicher, R. E., & Lindgren, R. (2020). Impact of a STEM summer camp on pre-service teachers' maker mindset. *Journal of Technology Education*, 31(2), 10-23.

Buechley, L., & Peppler, K. A. (2014). The maker mindset: Empowering young people to shape their worlds. *Phi Delta Kappan*, 95(6), 22-27.

Chu, S. L., Quek, F., Bhangaonkar, S., Ging, A. B., & Sridharamurthy, K. (2015). Making the Maker: A Means-to-an-Ends approach to nurturing the Maker mindset in elementary-aged children. *International Journal of Child-Computer Interaction*, *5*, 11-19.

Dixon, C., & Martin, L. (2014). *Make to relate: Narratives of, and as, community practice.* Boulder, CO: International Society of the Learning Sciences.

Duckworth, A. (2016). Grit: The power of passion and perseverance. New York, NY: Scribner.

Dougherty, D. (2013). The maker mindset. In *Design, Make, Play: Growing the Next Generation of STEM Innovators*. https://doi.org/10.4324/9780203108352

Duckworth, A. L., Peterson, C., Matthews, M. D., & Kelly, D. R. (2007). Grit: Perseverance and passion for long-term goals. Journal of personality and social psychology, 92(6), 1087–1101. https://doi.org/10.1037/0022-3514.92.6.1087

Dweck, C. S. (2006). *Mindset: The new psychology of success*. New York, NY: Random House.

Gerstein, J. (2016). Becoming a maker educator. *Techniques: Connecting Education & Careers*.

Halverson, E. R., & Sheridan, K. (2014). The maker movement in education. *Harvard Educational Review*, 84(4), 495-465. doi: 10.17763/haer.84.4.34w8j68140382063

Hatch, M. (2013). *The Maker Movement Manifesto: Rules for Innovation in the New World of Crafters, Hackers, and Tinkerers*.New York: McGraw Hill Professional.

Honey, M., & Kanter, D. E. (2013). *Design, make, play: Growing the next generation of STEM innovators*. New York, NY: Routledge.

Hsu, Y. S., & Wu, H. K. (2018). The effect of maker education on students' learning motivation and problem-solving ability: A meta-analysis. *Journal of Educational Technology & Society*, 21(2), 136-146.

Kabir, M. N., & Brewer, J. (2017). The Maker Mindset: A Case Study of a High School Maker Club. *Journal of Pre-College Engineering Education Research*, 7(1), 31-39.

Kapur, M. (2019). Making and unmaking: How and why making in education matters. *Cambridge Journal of Education*, 49(1), 5-20.

Kilinc, E., Bicen, H., & Okur, H. (2017). Investigating pre-service teachers' STEM learning through a STEM camp. Journal of Education and Learning, 6(1), 1-12. https://doi.org/10.5539/jel.v6n1p1

Klepper, J., Pereira, J., & Zayner, Z. (2017). Maker Education. *Effective Implementation in 21st Century Classrooms*.

National Science Board. (2018). *Science and engineering indicators 2018*. Arlington, VA: National Science Foundation.

Martin, L. (2015). The Promise of the Maker Movement for Education. *Journal of Pre-College Engineering Education Research (J-PEER)*. https://doi.org/10.7771/2157-9288.1099

Martinez, S. L., & Stager, G. (2013). *Invent to learn: Making, tinkering, and engineering in the classroom*. Torrance, CA: Constructing Modern Knowledge Press.

Myers, N. (2017). What is a maker mindset? *StemMinds*. Retrieved on August 29, 2018 from: https://stemminds.com/what-is-a-maker-mindset/.

Pierrat, J. (2016). 6 Must-Haves for Developing a Maker Mindset. Retrieved from https://www.edsurge.com/news/2016-06-06-6-must-haves-for-developing-a-maker-mindset *(17) (PDF) Bridging distance: Practical and pedagogical implications of virtual Makerspaces*. Available from: https://www.researchgate.net/publication/342312568_Bridging_distance_Practical_and_pedagogical_implications_of_virtual_Makerspaces

Pocock, J. (2016). *Maker Movement 2.0. ASEE Prism*, *26*(3), 34-37.

Smith, B., & Grady, W. (2016). The maker mindset: Empowering learners to shape their world. Alexandria, VA: ASCD.

Turan, Z., Karasoy, H., & Akkoc, H. (2020). The impact of a STEM camp on the development of STEM-related skills of pre-service teachers. European Journal of Education Studies, 7(3), 178-191. https://doi.org/10.5281/zenodo.3734089

U.S. Department of Commerce. (2019). *STEM education: Building a strong workforce for the 21st century.* Washington, DC: U.S. Department of Commerce.

Weaver, S., Stirling, K., Norman, K., & Jackson, S. (2021). Impact of a week-long maker camp on high school students' self-efficacy and attitudes toward STEM. *Journal of STEM Education: Innovations and Research*, 22(2), 23-32.

International Journal of Science Education and Teaching
Vol. 2, No. 1, pp. 19-37, Jan. – Apr. 2023
http://doi.org/10.14456/ijset.2023.2

Professional Development of Science and Mathematics Teachers through a Facilitative Coaching Process

Wirin Wansomsakul[1 *], Sutthikan Tipayakesorn[2], and Peeraphat Gatephan[3]
[1]Department of Science Education, Faculty of Education, Chiangmai University, Chaing Mai 50300, Thailand
[2]Department of Curriculum Teaching and Learning, Faculty of Education, Chiang Mai University, Chaing Mai 50300, Thailand
[3]Department of Mathematics, Faculty of Science, Naresuan University, Phitsanulok 65000, Thailand
Email: wirinvisory@gmail.com

Received: 11 Feb 2023 Revised: 28 Apr 2023 Accepted: 30 Apr 2023

Abstract. This research aimed to clarify the Facilitative Coaching Process (FCP) in the workshop of teacher professional development. The FCP included the need for professional development of teachers, and teaching design of the FCP Science and Mathematics Teacher Professional Development Project. The subjects consist of the becoming a Facilitative Coach (FC) including 36 science and mathematics teachers who were working in the Chiang Mai Primary Educational Service Area Office 4 (CMPESAO 4), and 27 science and mathematics teachers who were working in science and math teachers under the Chiang Mai Primary Educational Service Area Office 1 (CMPESAO 1). The obtained information, then, was used as a database for teaching professional development training. This is one of the policies related to the promotion and development of teachers and educational personnel to provide quality learning management. The research method was carried during the workshop activities that were designed to examine utilizing worksheets on instructional design based on FCP principles and through observation and recording of participants' responses while engaging in the activities. The findings showed that this workshop's training approach assisted in preparing teachers to create lessons that would increase students' enthusiasm for learning and close the age gap between them and their students. Interestingly, the top three areas of professional knowledge that participants sought to develop the most were new information, innovative teaching techniques, and integrated teaching. The CMPESAO1 teachers concentrated on reinforcement strategies, whereas the CMPESAO4 teachers concentrated on using teaching aids.

Keywords: Professional Development of Science and Mathematics Teachers (PDSMT), Facilitative Coaching Process (FCP), Facilitative Coach (FC)

1. Introduction

Professional Development of Science and Mathematics Teachers (PDSMT)

Education in mathematics and science today is essential to the way of life. Mathematics was considered very important and useful subject in everyday life and playing an extremely important role in the development of human thought. Mathematics make human beings creative, think logically. It's a methodical system. It has a pattern that can analyze problems and situations carefully, making them possible to predict and plan to determine problem solving, and apply them in everyday life correctly and appropriately. In addition, mathematics is a tool for the study of science, technology, and other related sciences. Therefore, the Ministry of Education has designated mathematics as a course included in the curriculum from elementary to high school, both basic and additional subjects (Ministry of Education, 2009). As well as science, which plays a vital role in today and future global societies and involves everyone both in everyday life and careers. As well as the technologies, tools, appliances and productivity that human beings use to facilitate life and work. Combined with creativity and other sciences, science helps human beings develop ways of thinking, including rational thinking, creativity, critical thinking, criticism, and critical skills. Ability to solve problems systematically. Decision-making can be made by using a variety data and verifiable evidence. Science is the culture of the modern world, a knowledge-based society. Therefore, everyone needs to be developed to know science to understand nature and the technologies created by human beings. (Office of the Basic Education Commission, 2008). The last two decades since the world entered the 21st century. It's a time of rapid change and change in the world. The changes are the result of the drive of the 3 mainstreams consist of 1) globalization that fuses the whole world into one society and connecting the whole world, people can communicate or travel around the world in no time, 2) the big bang of technology has evolved by leaps and bounds and 3) the flow of capitalization where money is increasingly playing a role in the modern world globalization and financial technology have made money drives the world in virtually every way, along with the development of more digitized forms (Thanin et al., 2020). The context and environment, both inside and outside the country, are likely to change rapidly. It is highly dynamic and has a wide range of complex dimensions that will affect the future of the country's development. Therefore, the country needs a comprehensive development strategy in all dimensions and aspects, have knowledge, competencies, and skills that correspond to various changes, be able to be cognizant and adaptable to be able to live life. Especially, in a rapidly changing world where systems and supporting factors are needed along the way, both in terms of teaching and learning systems and developing skills which consistent with the development of people of different ages (National Strategy 20 years, 2018) This twisted and fast-paced change. As a result, social conditions. The politics and economy with which people are accustomed to changing, too. To cope with this volatile global trend, everyone is focused on education, which is the cornerstone of people's development. Therefore, education must be reviewed and adjusted to create learners with the necessary skills and competencies, able to adapt to a rapidly changing global society. It can be twisted, uncertain, complex and ambiguous, and ready for current and future changes. Hence learning in the 21st century, teachers as instructors, should focus on providing learner-centered instruction. At the same time, teachers themselves are important people in different roles. The role of the teachers in the current class must therefore consider the fundamentals of learners with a wide range of differences. In the context of a variety of different classrooms and the development of learners following the circumstances of living in the 21st century. This emphasizes that learners have the competencies they need to work. Problem-solving and livelihoods Build learners with the necessary skills and competencies, able to adapt to a rapidly changing global society (Rajuptook, 2020).

The PISA program asked students about the methods teachers used to teach science from these four methods 1) teacher-directed instruction, where the teacher explains scientific concepts and principles or uses demonstrations, 2) teacher-directed instruction, 3) teacher-directed instruction and 4) quest-based teaching. According to student reports, teachers use a combination of the four methods in their teaching, but some may be more common. Information from Thai students compared within the same school found teachers in all groups of schools use a higher direct teaching-leading approach than others. Thai students reported that teachers use this method the most. (Institute for the Promotion of Teaching Science and Technology, 2018)

Professional Development (PD)

The Office of the Basic Education Commission (2016:7) proposed teachers' professional standards and provided teachers with the appropriate abilities and teaching skills to improve learners' learning as well as being good role models in order to build students' confidence and trust. Therefore, professional development plays a paramount role in education reform and school reform. If the academy has been reformed, then courses and instruction will be developed. Teachers and administrators must also develop. (Ngsawat et al., 2009; Chakraborty, 2014; Cox, 2018) The professional teachers use activity-based teaching through science and arts. Teachers always play the role of parents or mentors (Srisamrithi, 2013; OECD, 2009; Bredeson, 2003). Teacher professional development is the process of continuous and systematic teacher development. It focuses on developing teachers in terms of knowledge, skills, and attributes for teachers to learn and develop performance from thinking, review work and innovate learning. Therefore, (Dictionary of Contemporary Education, 2015:399) says that teaching professional development is the development of educational institutions aimed at learning learners. As Khammani (2017:230) mentioned that the teacher component qualifications of teachers' self-development in teaching preparation and organizing learning activities is developing the learning process to achieve that goal. Teachers are the closest and most directly impactful individuals to learners' learning. Teachers with good teaching are often self-developed teachers. They always been developed to learn in different ways. Schools that want to succeed in developing the learning process need to focus on the teaching arrangements of their teachers and should help and facilitate teachers to prepare quality teaching.

Teacher professional development (PD) is a learning process that teachers should have on a continuous basis throughout the teaching career to be able to ensure that they have knowledge, competencies, and skills suitable for continuous classroom teaching practices, amid rapid changes in society, economy, and technology. Because effective teaching cannot happen by chance, in a short amount of time, it takes new boarding teaching years to acquire the skills and knowledge. They need. the ability to practice teaching effectively or even experienced teachers. Teaching may be problems caused by many factors such as changes in the curriculum, increasing or decreasing content, and advancement of technology or even the cause of individual learners if teachers do not receive effective professional development. It will result in the students lacking the opportunity to learn and Self-Development (Rakwijitkul, 2017). Teacher development needs of modern teachers under the strategy of education reform, an important indicator of development is competencies as a base for professional work in teacher professional development, there are basic competencies that are essential for performance, especially student-centered learning. A study was conducted by Queensland University of Technology, Australia (2002) found important issues that Thai teachers want to develop in a competency-based way. There are seven areas of the profession: a new form of knowledge, a new type of teaching strategy, measurement and evaluation, integrated teaching, information technology competencies, monitoring and support systems, and operational research (Pahe, 2010)

Desimone (2023) mentioned that rethinking teacher PD must focus on how to improve student learning. The field of professional development has evolved considerably over the past several decades. An abbreviated recent history might highlight the 1970s-1990s, when the much maligned 'one-shot' workshop ruled the day. During this time period, the predominant means for evaluating professional development consisted mainly of post-workshop surveys that gauged how much teachers enjoyed the experience. Grounded in previous correlational and case study research, and using national data from the U.S., the field coalesced on five key features necessary for effective professional development – a focus on content or how students learn content, opportunities for active learning, participating collectively with other teachers, ensuring coherence with school and organizational-level mandates and teacher beliefs, and learning activities of sufficient duration to allow practice and feedback. Did teachers think the novel approach had potential to help their students learn? Each of these factors – principal support, individualization and teacher buy-in – was found to play a critical role in the uptake of ideas and practices targeted in PD. Perhaps the most important idea generated from the review and reflection on rigorous causal studies in PD is that we need to distinguish between our ability to change what teachers know and do (does PD work to support productive teacher change?) from the ability of those new practices to improve student learning (If teachers change in the ways supported by the PD, will student learning grow?) The work published in Professional Development in Education, as well as many other international education journals, has shown that we absolutely know how to change what teachers know and do. Unequivocally. We know how to do it virtually, and we know how to do it in person. We can do it with coaches, or with collaborative teams. We can do it with system (e.g., district) level PD, and we can do it with school-level PD. We can do it in math, and we can do it in science, literacy, and technology. We know what it takes. A focus on content or how students learn content. Provision of active learning opportunities, so teachers can analyze, ask questions, share experiences, get feedback – practice. Ensuring coherence with district and school mandates, curriculum, beliefs. Providing sufficient time for teachers to engage with their learning, and to try it out in their classrooms and integrate it into their instructional routines. Providing coaches or instructional leaders who are experienced and have relevant content-area expertise and know how to calibrate learning to the teachers' needs. Supporting teachers in adapting the new ideas and practices. As we continue on our journey to understand more about professional development – for example, in this issue, unpacking its complexity, identifying the role of leadership, mentoring and coaching, the evolution of teacher needs over time, the interaction of beliefs and behavior's, the role of dialogue, team-based approaches, morality, mindfulness, context, relevance and efficacy – I urge us all to keep in mind the 'what' of professional development-what are we seeking to get teachers to believe, know, and do, and to what extent do we have evidence that will bolster student understanding and learning? I hope the next generation of professional development studies will be grounded in a conception that acknowledges that we are not just studying if and how we get teachers to change – we are studying whether those changes matter for student learning.

According to Thailand National Strategy 20 years (2018: 34, 37) The development of a learning system that responds to changes in the 21st century involves designing a new learning system. by rebranding the role 'Teacher' as a new generation teacher by adjusting the role from "teacher" to "coach" or "facilitator" acting to motivate inspire, introducing how to learn and how to organize, building knowledge to design activities and create learning innovations for students, and researcher development to learning process for student achievement Including adjusting the production and development system of teachers starting from attracting, selecting high-caliber people to become quality teachers. There is a continuous development system for teachers' potential and competency. This is therefore a guideline that the researcher considers as the main principle in carrying out. The project of professional development of science and mathematics teachers through a facilitative coaching process.

Approaches to Coaching

Instructional coaches implementing the impact cycle take a dialogical approach to coaching. As the table below illustrates, the dialogical approach represents one of the three most common approaches to coaching, the other being facilitative and directive coaching. Each approach has its unique strengths and weaknesses, and I have summarized each. (Jim Knight, 2021)

Table 1 Three Models for Approaching Coaching

Facilitative	Dialogical	Directive
Coach does not share expertise	Coach share expertise dialogically when appropriate	Coach's expertise is the focus of the coaching session
Teacher does most of the thinking	Coach and teacher think together	Coach does most the thinking
Teacher- focused goal	Strategy- focused goal	Student- focused goal

Facilitative Coaching

Facilitative coaches, like dialogical coaches, see collaborating teachers as equals who make most if not all decisions during coaching. As Sir John Whitmore (2002) has written in his influential book Coaching for Performance: GROWing People, Performance, and Purpose, "the relationship between the coach and coachees must be one of partnership in the endeavor, or trust, of safety and of minimal pressure" Facilitative coaches encourage coachees to share their ideas openly by listening with empathy, paraphrasing, and asking powerful questions. Additionally, facilitative coaches do not share their expertise or suggestions with respect to what a teacher can do to get better. They keep their ideas and knowledge to themselves because they assume that:

- Coachees already have the knowledge they need to improve, so a coach's role is to help them unpack what they already know.
- Coaches who share their expertise with coachees could inhibit progress by keeping coachees from coming up with their own solutions.

Facilitative coaching can be used in all kinds of situations, so it has the potential to address issues that dialogical and directive coaching are not able to address. For example, facilitative coaching could be used to help a teacher get along with a difficult team member, a principal lead culture change in her school, or a student use his time more effectively. In the classroom, facilitative coaching works best when the teachers being coached already have the knowledge they need to improve. However, it is less effective when teachers do not have the knowledge they need to address issues in the classroom. A teacher who is struggling to create a learner-friendly classroom culture and who has not learned effective strategies for classroom management will likely need an instructional coach to help him master teaching behavioral expectations, reinforcing appropriate behavior, and correcting inappropriate behavior. Facilitative coaching, because it asks coaches not to share their expertise, is not an appropriate vehicle for schools or districts intending to use coaching to share instructional practices.

Directive coaching

In many ways, directive coaching is the opposite of facilitative coaching. The directive coach's goal is to help coachees master some skill or set of skills. The directive coach/coachee relationship is like a master/apprenticeship relationship. The directive coach has special knowledge, and his job is to transfer that knowledge to the coachee. The relationship between the directive coach and teacher is respectful, but not equal. In contrast to facilitative coaches who set their expertise aside, the directive coach's expertise is at the heart of this coaching approach. The job of the directive coach is to make sure teachers learn the correct way to do something, so directive coaches tell teachers what do to, model practices, observe teachers, and provide constructive feedback to teachers until they can implement the new practice with fidelity. Directive coaches work from the assumption that the teachers they are coaching do not know how to use the practices they are learning, which is why they are being coached. Secondly, they also assume that teaching strategies should be implemented with fidelity, which is to say in the same way in each classroom. The goal of the directive coach is to ensure fidelity to a proven model, not adaptation of the model to the unique needs of children or strengths of a teacher. The best directive coaches are excellent communicators, who listen to their coachees, confirm understanding with effective questions, and sensitively read their coachee's understanding or lack of understanding. They need to especially be effective at explaining, modeling, and providing constructive feedback. When teachers are committed to learning a teaching strategy or program, directive coaching can be effective. However, directive coaching, deprofessionalizes teaching by minimizing teacher expertise and autonomy and therefore frequently engenders resistance. Teachers mentioned that they had to do something a certain way treats teachers more like laborers than professionals, and it often leads to resistance more than change.

The directive approach to coaching also often fails because it over simplifies the rich, complex world of the classroom. The unique, young human beings who attend our schools are too complex for one-size fits all approaches to learning. What teachers and students need are an approach to coaching that combines the facilitative coach's respect for the professionalism of teachers with the directive coach's ability to identify and describe effective strategies that can help teachers move forward. That approach is the dialogical approach.

Dialogical coaching

The facilitative coach focuses on inquiry, using questions, listening, and conversational moves to help a teacher become aware of answers he already has inside himself. The directive coach focuses on advocacy, using expertise, clear explanations, modeling, and constructive feedback to teach a teacher how to use a new teaching strategy or program with fidelity. The dialogical coach balances advocacy with inquiry. Like a facilitative coach, a dialogical coach embraces inquiry, asking questions that empower a collaborating teacher to identify goals, strategies, and adaptations that will have an unmistakable impact on students' achievement and wellbeing. Dialogical coaches ask powerful questions, listen, and think with teachers, and collaborate with them to set powerful goals that will have a powerful impact on student's lives. They employ a coaching cycle, like The Impact Cycle, that is driven by back-and-forth conversations about the current reality and a teacher's desired reality in the classroom. Like a facilitative coach, a dialogical coach embraces inquiry, asking questions that empower a collaborating teacher to identify goals, strategies, and adaptations that will have an unmistakable impact on students' achievement and wellbeing. Dialogical coaches ask powerful questions, listen, and think with teachers, and collaborate with them to set powerful goals that will have a powerful impact on student's classroom.

Dialogical coaches do not give advice; they share possible strategies with teachers and let teachers decide if which strategy they will use to try to meet their goals. Dialogical coaches partner with teachers to identify goals and teaching strategies, and then describe strategies precisely, while also asking teachers how they want to modify the strategies to better meet students' needs. Then they help the teachers implement the strategies and gather data on whether they lead to students hitting their goals. Dialogical coaches don't keep their ideas to themselves, but they realize that sometimes strategies have to be modified to meet student's needs and to align with teachers' strengths. They also understand that student-focused goals that matter to teachers are essential for effective coaching. During dialogical coaching, the standard for excellent implementation—in contrast to directive coaching—is not the coach's opinion but the goal itself. If a teacher implements a strategy in a way that is radically different from how it was designed to be used, the coach doesn't take a top-down approach and tell the teacher how to teach the strategy with fidelity. The coach simply says, "Let's see if we can hit the goal." If the goal isn't reached, then the teacher and coach can go back to the description and consider whether or not the strategy should be taught with greater fidelity.

Facilitative and directive coaching both involve conversation, but they do not involve dialogue. A dialogue is a meeting of the minds, two or more people sharing ideas with each other. It is not a dialogue if I withhold my ideas, and it is not a dialogue when I tell you what you should do. It is a dialogue when I share my ideas in a way that makes it very easy for others to share their ideas. A dialogue is thinking with someone (Jarusombat, 2018). It is believed that both the facilitator style and coaching style roles share key skills. Especially building relationships, listening, asking and facilitate learning so that people or groups of people can find the answers themselves, so Courage to Coach calls their own coaching and facilitating process Facilitative Coaching.

Facilitative coaches encourage coaches to share their ideas openly by listening with empathy, paraphrasing, and asking powerful questions. Additionally, facilitative coaches do share their expertise or suggestions concerning what a teacher can do to get better.

Inner world factors that drive external behavior inner potential, real elements, or being the principles of Personality and Human Relations International (PRH), were born in the 1970s based on the research of Luo Wong Father Andre Rochais to make sure everyone understands what they want to know, such as being perceived as "Who am I", to discover the potential for growth in individuals and to become fully who we are. The "true element" (Being) is the foundation upon which we are all, from the source of personality to the foundation of aptitude and abilities to the center of individual goodness. True elements, like the seeds of plants in us. It's been with us since birth. As we get olde, these seeds sprout and grow at the same time, and growth depends largely on their upbringing and environment. Discovering one's self, inner potential, or being, is like finding the best qualities in us. It gives us the capacity, talent, ability, and inspiration to accomplish many things according to the mission we were born human beings. When we see treasures or resources within ourselves, it increases self-understanding. Discover the potential in yourself, that there is so much and enough to live and work, such as being responsible, committed, compassionate, and sharing, etc. (Jarusombat, 2018; Knight, 2021).

Facilitative Coaching Process

Jarusombat (2018) said that "I live my life through Jimi the Coach Group and Courage to Coach, they crystallized their thinking and lifestyle skills and a tool for happiness and success called the Facilitative Coaching Process," Group Coaching and Team Coaching Process (6C MODEL) as see in the Figure 1

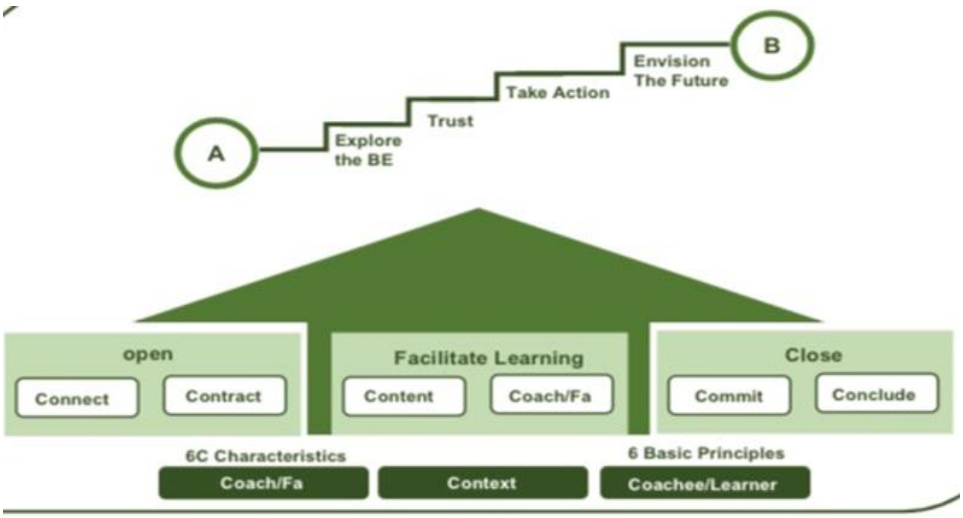

Figure 1: 6C Model (Jarusombat, 2018)

Table 2 Coaching individuals in a group setting or coaching team process.

Phase	Parts	Steps
Open	The Open is the beginning of group coaching and team coaching, creating a dignified and safe space for learning, talking, growing, and changing for group members. There are different styles. Have different learning intentions. There are different souls.	Connect
		Contract
Facilitate Learning	Coaching individuals in a group setting or coaching team Learning Sessions This step is at the heart of coaching a team that will spend as much time together as possible. This is when coaches invite important topics to start talking about and open up spaces for group members to exchange ideas. Opinions, hands-on experiences, shares, concerns. Jammed barriers Get coached and come up with some discoveries called Insights.	Content
		Coaching individuals in a group setting or coaching a team
Close	Closed range This is a period of encouragement to act. Group coaching and team coaching are like individual coaching that emphasizes responsibility. A sense of belonging, and commitment. Act on your findings, new choices, new activities, and specific activities to create positive change and growth in different areas of life.	Commit
		Conclude

Based on the experiences in the work of coaches and literatures (Capello, 2017 cited in Jarusombat, 2018), the executive coaching and ICE core competencies could be categorized into 4 topics and 11 core competencies. Four topics included setting the foundation, co-creating the relationship, communicating effectively, and facilitating learning and results. The topic of setting the foundation consists of 2 core competencies including 1) meeting ethical guidelines and professional standards, and 2) establishing the coaching agreement. The topic of co-creating the relationship consists of 2 core competencies including 1) establishing trust and intimacy with the client, and 2) coaching presence. The topic of communicating effectively consists of 3 core competencies including 1) active listening, 2) powerful questioning, and 3) direct communication. The topic of facilitating learning and results consist of 4 core competencies including creating awareness, 2) designing actions, 3) planning and goal setting, and 4) managing progress and accountability.

Six Essential Skills of an Effective Facilitator.

Chander (2014) mentioned that facilitator's responsibility is to make a process easier or facilitate a process through adequate planning. A facilitator acts like a guide to help people move through a process. They guide the participants towards an exploratory journey of learning by helping them to delve into their inner self to realize their strengths and weaknesses, helping them to share their experiences and learning from the experiences of others.

Facilitators achieve this by helping the group to analyze what they wish to accomplish. Good facilitators understand their group and adopt a customized approach while working in the group. They plan, manage, and guide a group event effectively ensuring that objectives are met. A good facilitator keeps away from the real content and maintains a neutral stance.

The question is what does it take to be an effective facilitator? What are the competencies you need to build in order to effectively drive a group towards their objective?

Six competencies given below are the ones. Of-course there are many more. In fact, every facilitator has a unique style that corresponds to a unique competency.

Figure 2: Six Essential Skills of an Effective Facilitator (Chander, 2014).

Communication Skills

A good facilitator encourages open communication. He ensures inclusion whereby each member can participate and scans nonverbal cues through behavioral observations of the group. He ensures conclusion at the end of meetings and paraphrases for clarification. He also ensures that the group is focused and not deviating from the topic.

Active Listening

Comprehension of the message that the speaker is conveying requires active listening. Statistics reveal that most of us listen to just 25-50% of what we hear and forget almost 46% of what we have heard. The totality of the message being conveyed should not get lost and so effective listening is extremely important. There might be some natural barriers to listening like noises and other barriers could be talking more and listening less, boredom, being engrossed in personal issues, preconceived ideas and assumptions. A facilitator should develop the skill of active listening. They should maintain a body language that makes the group feel assured about his physical presence by facing them squarely, making eye contact, nodding, keeping an open posture and so on. He also should be able to attend to the speaker at a psychological level by understanding what is not being conveyed explicitly and he should be able to pick up from nonverbal cues. Paraphrasing and repeating back what was said and asking questions reflects that he is actively listening.

Rapport Building

A facilitator should be able to connect with the group. Trust and empathy are essential for building a relationship with the group. Building a relationship with a new group requires finding some common goals and interests, shared values and outlook.

Structuring and recording facts and feelings

A facilitator should be able to record precisely the information gathered during the course of the discussion. He can do it himself or assign a note gatherer for it. He could do it using a flip chart for this purpose. Noting key words and accuracy is extremely important.

Developing Synergy

Teamwork is an essential in any workshop or session. A skilled facilitator knows how to bring the participants together based on shared interests and goals. The facilitators should facilitate synergy in the group by removing distractions, by making them sit face to face, in arena type arrangement for open discussions. He should encourage sharing of views, respecting each other’s views, reaching consensus and through brainstorming sessions.

Effective Techniques of Questioning

The purpose of questioning is to seek clarification and to check for comprehension. Facilitators ask questions primarily to probe the understanding of the participants and to help them in critical thinking and for evaluating information. Socratic questioning method is a very effective questioning method whereby one just does not raise questions but finds out the answers himself. It helps in developing critical thinking skills. Facilitators often use this technique to unravel the basic issues, identify the problem areas, and develop accuracy, increase creativity and logical thinking. Facilitators should possess good probing skills through open ended and closed ended questions. The manner of questioning in terms of timing and accurate delivery is extremely important. The APPLE technique is often applied. The acronym for APPLE is the following:

A: Asking the question.

P: Pausing for allowing participants to comprehend the question and think of an answer.

P: Picking a member to provide the answer

L: Listening to the answer.

E: Elaborating on the answers obtained

Apart from the above-mentioned skills, a good facilitator should be receptive and should be able to develop new skills as and when required depending on the participating group and should be open to ideas.

Thanetpongtham (2014) talked about acting as a good facilitator, i.e., stimulating the learning process in small groups to create learning. Help the chairman direct group activities. Encourage learners to bring their prior knowledge up for discussion. Encourage groups to set learning objectives that align with the lesson. Assess the skills of the learners and the group process. Giving feedback to learners. A facilitator is a practice in which the learning process takes place in the company. Control of activities the planning of the study was planned. A medium to exchange the knowledge of the people in the company and to share it with the members of the company

Based on the statements mentioned above. The investigators were assigned under NEDA Order No. 271/2018 from the Office of the Basic Education Commission to carry out cognitive building on facilitative coaching to enable teachers to use their knowledge to design learning activities to develop learners to be ready for assessment of students at all levels. Inservice Group Monitor and evaluate the educational activities of the CMPESAO1, therefore, provides a workforce development program to enhance learner quality to student readiness for student evaluation. Mathematics and Science Facilitative Coach to teachers affiliated with CMPESAO1 and according to official letter no. 04050/3214, courtesy of the investigator to be a lecturer in a workshop for teachers affiliated with the CMPESAO4 In the study of the process. Workshops, facilitative coaching processes, and professional development needs of teachers attending workshops, math, and science teacher development projects to become facilitative coaches within the district of responsibility of the CMPESAO1and CMPESAO4 to provide the results of the study to the school district office. To continue to train teachers for professional development.

2. Research Objectives

1. To study the facilitative coaching process.
2. To study qualitative data to develop assumptions for designing the workshop about enhancing mathematics and science teachers to become facilitative coaches.

3. Methodology

To examine PDSMT, a mixed-methods research approach was employed (Creswell & Clark, 2017). The mixed methods approach was considered appropriate because qualitative data can be used as a supportive set of data to illustrate the quantitative results.

A mixed research study on PDSMT with the FCP. The researcher has divided the research process into 2 steps as follows.

Step 1 A study of procedures and processes in the workshop. The project is to develop mathematics and science teachers to be Facilitative Coach (FC) by using data recording of various activities during the workshop

Step 2: A study of the preparation and application of knowledge of teachers attending the workshop. Mathematics and science teacher development project to become a facilitator and the needs of teachers who attended the training on the needs of professional development in 7 areas using a questionnaire, and a study of instructional design for being a facilitator by using a classroom instructional design exercise based on 6C principles

Subjects

The subjects consist of the 27 CMPESAO 1 and 36 CMPESAO 4 science and mathematics teachers. These subjects were obtained by voluntary sampling.

Research Tools

Research toots included questionnaires for FCP and FC. The questionnaire for Teacher Development Program for Mathematics and Science in the FCP of the CMPESAO1 and CMPESAO4 included 3 parts. These included 1) general information of the training recipients, 2) preparing for training by 3 sets of shares assembled to prepare for training, 3) teachers' preferences for professional development in 7 issues and the design of classroom instruction based on the FCP (6C Model)

The tools for Teacher Development Program for Mathematics and Science in the FC program of the CMPESAO1 and CMPESAO4 included participant observation and informal interview that could be carried out during the workshop.

Data analysis

The mixed methods approach was considered appropriate because qualitative data can be used as a supportive set of data to illustrate the quantitative results The researcher analyzed the data by collecting the records and draw conclusions about the same and the difference between CMPESAO1 and CMPESAO4 teachers were gathered to achieve the objectives of the study.

1. To take the questionnaire about teacher participation in the workshop.

2. The questionnaire on teacher needs for professional development of teachers participating in the workshop was taken. Mathematics and Science Teacher Development Project for FC check the score The score was given according to the A rubric with a rating scale was used by (Sri Sa-at. 1989: 103) as follows:

Table 3 Rating Scale

Rating	Equivalent
5	most agree
4	very agree
3	moderately agree
2	less agree
1	least agree

3. To bring a questionnaire about promotion support the teaching of attending workshops. The project mathematics and science teacher development for FC to collect results and summarize the differences between of teachers under CMPESAO1 and CMPESAO4 (Content Analysis).

4. To take the questionnaire about participation in the project and the questionnaire about the needs of teacher professional development of attending workshops. The project mathematics and science teacher development for FC and analyzing the mean by setting 5 levels to interpret the criteria as follows:

Table 4 Rating Scale

Rating	Equivalent
4.21-5.00	Excellent
3.41-4.20	Very Good
2.61-3.40	Good
2.61-3.40	Fair
1.00-1.80	Poor

4. Research and Discussion

A study of professional development of science teachers and mathematics this time. The researcher was conducted by regular science and mathematics teachers who had attended the workshop. Developing mathematics and science teachers to be FC by taking notes during the event. The questionnaires use on classroom problems to support learning in the classroom, and teachers need to develop their professions in various fields. The results of operations are as follows:

4.1 Part 1 Results of the FCP study

The organizing workshops of FCP showed teachers' competencies in teacher development projects and mathematics and science in FC. These could be viewed as the Table 4.

Table 4 Displays the recording of the teacher's activities during the inquiry.

Activity	CMPESAO 1	CMPESAO 4	Comparison(6C)
Check-in Teacher's preferences Regular Science and Mathematics Training	Techniques, teaching methods, and other opportunities to be used for classroom instruction, how to inspire students to learn important activities. Applying the surroundings to the classroom and exchanging technical techniques with other teachers.	Apply what you receive from your training to your own teaching. It can be more appealing to students. Reduce the age gap between students and teachers to adapt to changes in the dynamics that occur and to adjust the attitudes of children studying both science subjects and mathematics.	**Connect /Contract** When the school was born. Requirements for Learn by force. Inspiration or adjustment Attitudes of students Contents
Self-knowledge activities using being	Teachers will apply, namely, applying Being to work in groups by dividing duties according to being to be compatible and most suitable for children. The use of being born in children and children. Students find their own beings with their teachers, supplements, and support and use of activities in subjects Guidance to observe children's behavior and use reinforcement techniques with being.	It is to look at schoolchildren from a more individualized perspective and use individual reinforcement methods. Being's an approach to career development, leading students to find potential and passion, and to adjust the attitudes of teachers who have the ability to appreciate Being.	**Content** being used by students, for students Harness your potential Come out as much as possible to explore the subject of classes and guidelines in Development to bring to the table Career
Sound activity in the head	Thinking back to yourself whether you're a good listener or not,and after this listen to students more and give advice on solving problems, not acting approach to problem solving for students.	Teachers do not receive enough information and guidance from schoolchildren, including guiding the methods of communication rather than receiving enough information from schoolchildren, considering the reasons.	**Conversations** Adaptation of teachers to Good stuntman Get a baby More students

Table 4 (Cont')

Activity	CMPESAO 1	CMPESAO 4	Comparison(6C)
Check Out Events	Teachers received from coming to this workshop is learning to live together with other teachers in the school and reflecting on themselves come out to understand more, able to access feelings, and the needs of children more techniques for making classroom activities more interesting and look at students in a more positive light.	The teachers received from this workshop to be more open and listen to students, how to bring interesting lessons changing attitudes toward students thus reducing the age gap between teachers and students were changing perspectives to better understand what the students want to express.	**Commit/Conclude** Teachers gain a greater understanding of student identity and adaptation. Perspectives on students and methods for organizing classroom activities to be more suitable and interesting

According to Table 4, it showed what the science and mathematics teachers of the CMPESAO1and CMPESAO4 want to earn from the same workshop is to apply the knowledge from this workshop to the amount for teaching in one's own classrooms and to use it for teaching in one's own classes. Inspiring and optimistic perspectives between students and their studies in science and math courses. What teachers are doing in science and math at CMPESAO1 and CMPESAO4 The same applies to the concept of being to the student by using the student's findings. Being blessed with support by using reinforcement techniques to guide future careers that teachers do not accept. It's only good to know what schoolchildren are doing to the media and to propose guidelines for solving problems rather than helping students find ways to curb principles and reasons. Getting more exposure to the students and what students are doing is important. Changing students' perspectives, ideas, and attitudes, and how activities and lessons are organized, is more interesting and engaging.

Quantitative information about the project

Table 5 Promotion data display table Support the classroom teaching of the participants of the workshop.

List of inquiries	CMPESAO1		CMPESAO4	
	Rating	Description	Rating	Description
1. See the importance of this project.	4.14	Very good	4.15	Very good
2.Be prepared to receive training.	4.14	Very good	4.15	Very good
3. Meeting the students from the classroom	3.29	Good	3.26	Good
4. Expectation to receive the guidelines of solving problem from the training	4.11	Very good	4.33	Excellent
5. Become more self-conscious.	4.18	Very good	4.03	Very good
6. In term of teaching condition, there is greater distress.	4.21	Very good	4.05	Very good
7. There is more frustration from schools	4.29	Excellent	4.00	Very good
8. Receive guidance on how to improve classroom management	4.43	Excellent	4.26	Excellent
9. Learn additional teaching skills from this training.	4.39	Excellent	4.26	Excellent

Table 5 (Cont')

List of inquiries	CMPESAO1		CMPESAO4	
	Rating	Description	Rating	Description
10. Have a more positive attitude toward teaching.	4.21	Very good	4.13	Very good
11. Have a more positive attitude toward students	4.32	Excellent	4.23	Excellent
12. There is satisfaction with this training.	4.14	Very good	4.05	Very good
13. The training will be used in the teaching process.	4.21	Very good	4.10	Very good
14. Training foster me to improve this manner.	4.14	Very good	4.15	Very good
15. You feel that the training provides you worthiness.	3.29	Good	3.26	Good

Table 5 showed that techniques was used to promote supporting learning that teachers under the CMPESAO1 use the most of reinforcement techniques and techniques used to promote supporting learning that teachers under the CMPESAO4 use the most are creation of media used in teaching.

Qualitative data on supplementary methods to support classroom instruction (Content Analysis)

Table 6: Frequency of CMPESAO 1 and CMPESAO 4 used teaching methods or techniques to support classroom instruction

information	CMPESAO1 **Frequency (Person)**	CMPESAO4 **Frequency (Person)**
1. Use of reinforcement techniques	4	3
2. Studying based on individual interests	3	3
3. Complementary science experiments	2	-
4. Use of technology and internet access in information processing	2	-
5. Buddy's ditch-catching the rest of the way.	1	-
6. Project enhancement	1	-
7. Teaching materials	1	4
8. Individual analysis	-	2
9. Conceptualization	-	2
10. Arrange the angle of the hole.	-	1
11. Integration of content with school grounds	-	1
12. On-site education	-	1
13. Story Analysis	-	1
total	**14**	**18**

Table 6 showed how frequency of teachers' techniques used to promote supporting learning. It found that most of CMPESAO1 teachers under used the reinforcement techniques and techniques to promote supporting learning. However, most of the CMPESAO 4 teachers used the creation of media in teaching.

4.2 Part 2: the development of mathematics and science teachers to be FC

The effect of qualitative and quantitative data for preparing, the project for the development of mathematics and science teachers to be FC by using data from questionnaires for the workshop.

Qualitative information on the needs of teachers' professional development

Table 7: the details of professional development requirements.

Issues of PD requirements	CMPESAO 1		CMPESAO 2	
	Mean	Level	Mean	Level
1. Need for new knowledge.	4.32	Excellent	4.05	Very good
2. Need for new teaching strategies.	4.11	Very good	4.05	Very good
3. Measurement and evaluation	3.71	Very good	3.77	Very good
4. Integrated teaching	4.07	Very good	3.87	Very good
5. Information technology competencies	3.93	Very good	3.82	Very good
6. In the in-service system, follow up on the remaining information.	3.93	Very good	3.82	Very good
7. Organizing research	3.93	Very good	3.72	Very good

According to the table 7, it indicated that the top 3 most common are the same: in the form of new teaching strategies and integrated teaching strategies, which are the same as the two most common, and the most common things of CMPESAO1 are measurement and evaluation, and of CMPESAO 4 is the organizing research.

4.3 Part 3: Developing assumptions for designing the workshop about enhancing mathematics and science teachers to become facilitative coaches

This section will clarify some information that could be generated in order to develop assumptions for designing the workshop about enhancing mathematics and science teachers to become facilitative coaches. The CMPESAO1 teachers listed some issues about teaching and learning. The frequency of the issues may suggest the ideas of designing the workshop. The table 8 showed what 11 science and 10 mathematics CMPESAO 1 gave the information. According to table 8, it showed a link to what math and science teachers have led FCP. The top 3 most common and accurate teaching methods are to add Q&A, workshops, and presentations to classroom activities.

Table 8: the frequency of FCP used in teaching design.

Information	Number of Science teachers	$\bar{x}$	Number of math teachers	$\bar{x}$	Number of all teachers	$\bar{x}$
Q&A	5	45.45	4	40	9	42.86
Doing the work	5	45.45	5	50	10	47.62
Presentation of skepticism	5	45.45	4	40	9	42.56
Discussion	4	36.36	3	30	7	35
Surveying	4	36.36	2	20	6	28.57
Critique	1	9.09	-	-	1	4.76
Exchange of opinions	2	18.18	1	10	3	14.29
Analysis	2	18.18	-	-	2	9.52
Connection to everyday life	-	-	1	10	1	4.76

5. Conclusion

It could be viewed that facilitative coaching process workshop has implication for science and mathematics teacher development in term of becoming facilitative coach. The study clarified teacher development that teachers could gain their knowledge from the workshop. There are a lot of difference and complexity in the professional development of both CMPESAO1 and CMPESAO4, the largest 3 issues are same true in the form of a new verticality. New teaching strategies and integrated teaching practices and the differentiation of complementary methods. Support the classroom teaching of teachers affiliated with the CMPESAO1 is the use of reinforcement techniques for teachers affiliated with the CMPESAO4 is the use of teaching materials. Teachers can behave following the guidelines of the facilitator as a facilitative coach. The teachers, who become facilitative coach, considered with children' s learning and hands on practice, reinforcement techniques, what and how to do for improving students, pedagogical designing, psychology for children, and strategies for student motivation. The literatures also suggested these issues for enhancing teachers becoming facilitative coach (Boonploy, 2009; Jaff and Scott, 1988; Queensland University of Technology, 2002).

6. Acknowledgement

We would like to thank the Faculty of Education, Chiang Mai University, Thailand, for supporting to professional development of teachers FCP. And, we are very appreciated for the great supporting from the director, teachers, and staffs of CMPESAO 1 and CMPESAO 4.

References

Bharat, S., Ratchadan K. (2010). N.Y.A model for the development of the competence of professional teachers in the school is affiliated with the Chiang Mai Elementary School district Office. District 2.

Boonploy, M. (2009). Development of student-type learning behavior in the CSE399 instruction set writing practice course. By using reinforcement techniques. Retrieved August 23, 2018 from https://www.spu.ac.th/tlc/files.Maliwan-CSE399P.52.pdf.

Bredeson. Designs for Learning: A New Architecture for Professional Development in Schools; 2003. Retrieved August 24, 2018 from https://eric.ed.gov/?id=ED471571

Chakraborty, U. (2014). Teacher professional competence development. Journal of Research and Development Suan Sunandha Rajabhat University. 8(1); 35-43.

Chander, A. (2014). 6 Essential Skills of an Effective Facilitator. Retrieved August 24, 2018 from https://www.linkedin.com/pulse/ 20140619061555-1334077-6-essential- skills-of-a-effective-facilitator.

Chiang Mai Primary Educational Service Area Office 1. (2018). S.P.C. Order No. 217/2018 on the establishment of a Committee for the Development of Teachers for Mathematics and Science. In the directorate/support of facilitation learning.

Chiang Mai Primary Educational Service Area Office 4. (2017). Government Letter No. 04050/3214. Courtesy of the speakers in teacher training according to the development project. Potential teachers to teach mathematics and science. Secondary school level. Retrieved December 24, 2017 Policy 60. Basic Education Fiscal 2018. from https://docs.google.com/viewer?a=v&pid=sites>srcid=b WhzMS5nby50aHxtaHMwMXxneDoxN2Q0OTljMTgyNzZhM2Rl.

Creswell, J. W., & Clark, V. L. P. (2017). Designing and conducting mixed methods research: Sage publications.

Desimone, L. M. (2023). Rethinking teacher PD: a focus on how to improve student learning, Professional Development in Education, 49:1, 1-3, DOI: 10.1080/19415257.2023.2162746

Ethiophithon, T. (2020). How will humans build new skills, learning, to cope with 'change' in the future? Retrieved August 20, 2020.

Jaffe, D. T. & Scott, C. D. (1998). Take this job and love it. New York: Simon & Schuster, 116-117.

Janelle, C. (2018). Top 5 Teaching Strategies. Retrieved September 24, 2018 from http://www.Teachhub.com/top-5-teaching-strategies.

Jarusombat, T. (2018). The Right Life in Coach, and Fa. Bangkok.

Jim Knight. (2021). Instructional Coaching. Retrieved April 24, 2023 from https://www.instructional coaching.com/category/impact-cycle/.

Knight, J. (2021). Three Approaches to Coaching. Retrieved April 24, 2023 from https://www.instructionalcoaching.com/blog/three-approaches-to-coaching.

Institute for the Promotion of Teaching Science and Technology. (2018). FOCUS ISSUES FROM PISA 2015. No. 29.

Khammani, T. (2017). Pedagogical Science: Cognitive to organize an effective learning process. Bangkok: Chulalongkorn University Press.

Kindergarten in Muang Mai Chonburi. (2018).Research and development of professional teacher competency models using: Integrated learning processes for international standard schools . Retrieved August 23, from http://www.mmc.ac.th/images/sub1413789281/Professional Teacher Articles.pdf.

Ministry of Education. (2009). Core Curriculum of Basic Education. Bangkok: Agricultural Cooperative Publishing House of Thailand Ltd.

Meelue, P. (1997). A study of teacher-researcher competency. Thesis, M.Ed. (Educational Research). Bangkok: Graduate School Chulalongkorn University. Photocopy.

National Strategy 20 years. (2018). Announced in the Royal Gazette 2018 – 2037.1st edition published. Retrieved August 23, 2018 from https://www.sepo.go.th/assets/document/file/NationalStrategic Plan %2020%20years%20.pdf.

Ngsawat, A. et al. (2009). The relief of professional aptitude: The research was funded by the National Bureau of Educational Testing (Public).

OECD. (2009). Teacher evaluation: A conceptual framework and examples of country practices. In the OECD Review on Evaluation and Assessment Frameworks of Improving School Outcomes. Retrieved August 24, 2018 from http://www.oecd.org/pdf.

Office of the Basic Education Commission. (2008). Core Learning Indicators and Strands, Science Learning Strand. Bangkok: Agricultural Cooperative Assembly Printing House of Thailand Co., Ltd.

Office of the Basic Education Commission. (2016). A practical handbook driving education reform of the Ministry of Education in the region. Bangkok: Ministry of Education.

Queensland University of Technology. (2002). The Thailand Education Reform Project. Retrieved September 24, 2018 from http://www.edthai.com/publication/0005/fulltext.pdf.

Pahea,S. (2010). Professional development of teachers in the second decade. Nakhon Prae Hotel Township Prairie Elementary School District Office 2.

Rakwijitkul, N. (2017). Teacher Professional Development. Journal of Education. Mahasarakham University, 11(1); 21-33.

Royal Academy. (2017). Dictionary of Contemporary Lexicography, Royal Edition. Bangkok: Samnak Ngong Royal Academy.

Srisamrit, K. (2013). A professional development model to enhance the child's teachers' fitness, experience, and psychological skills. Childhood. Ph.D., Graduate School, Silpakorn University, Nakhon Pathom.

Chitrasai, V. (2012). Capacity Development of Facilitators 2012. Retrieved August 25, 2018 from http://61.19.73.142/km/?p=171.

Rajuptook, W. (2020). Thai Children's Competencies in a VUCA World Thai Learners' Key Competencies in a VUCA World. Khurusapha witthajarn Journal of Teacher Professional Development, 1 (1).

International Journal of Science Education and Teaching
Vol. 2, No. 1, pp. 38-50, Jan. – Apr. 2023
http://doi.org/10.14456/ijset.2023.3

The Professional Learning Community for Teachers' Professional Development Training in Classroom Action Research for Enhancing Students' Science, Mathematics and Technology Competencies in New Normal

Panwilai Dokmai[1*], Wanicha Sakorn[2] and Ramnaree Nontapa[3]
[1]*Master Science Education Program, Rajabhat Maha Sarakham University, Thailand*
[2]*Master Computer Education Program, Rajabhat Maha Sarakham University, Thailand*
[3]*Master Mathematics Education Program, Rajabhat Maha Sarakham University, Thailand*
*Email: panwilai.ch@rmu.ac.th

Received: 27 Feb 2023 Revised: 25 Apr 2023 Accepted: 30 Apr 2023

Abstract. The purposes of this research were to: 1) conduct teachers' professional development training in classroom action research for enhancing students' science, mathematics, and technology competencies in new normal, 2) study competency-based learning management framework and 3) study competency assessment framework. The target group was 40 teachers including 14 science teachers, 13 mathematics teachers and 13 technology teachers from Maha Sarakham Province, Roi-et Province and Kalasin Province. The research tools were the teacher needs survey questionnaire and the PLC record forms. The data analysis was done by using descriptive statistics and content analysis. The findings revealed that the target group teachers have developed ability in classroom action research, competency-based learning management and competency assessment through the teachers' professional development training. The target group teachers could develop the competency-based learning management in new normal. These included 4 learning models in science, 1 learning models in mathematics and 4 learning models in technology. They shared common in the competency assessment in new normal on using activity sheet, worksheet, practice, and competency assessment inventory. There were two types of competency assessment tools including rubrics score and rating scale.

Keywords: Professional Learning Community, Teachers' Professional Development Training, Competency-based Learning Management, Competency-based Assessment

INTRODUCTION

The 21st century learning emphasized on scaffolding skills to support students to become literate and master both content and professionals. The students need deep understanding and participation with others for problem solving in both school and real-life situation. They also need to be creative and innovative to become the 21st century world citizen and be able to lead Thailand to go forward with the other country. The question is "How to potential students to help them possess the necessary competencies for the 21st century world?". The Thai ministry of education revised the national curriculum learning standards and indicators in science, mathematics, and technology in 2017, intended to conduct students in applying learning knowledge and experience for technology invention and benefits of the individual and society (The Ministry of Education, 2017). These being the case, the teachers responsible to integrate the 21st century skills into the subject lessons. They hence require teaching strategies and tools in classroom practice. The teachers have to adjust their teaching according to students' competency to solve real-life problem rather than problem on the tests. The problems which cannot solve by rote learning, on the other hand, call for competency and ability to confront to solve complex and unfamiliar problems in real-world settings. There are three science competency performances: explain phenomena scientifically, evaluate and design scientific inquiry, interpret data and evidence scientifically. The four mathematics competency performances are formulating, employing, interpreting and mathematical reasoning. And the five technology competency performances are ICA 1 (accessing, evaluating, and managing information and data), ICA 2 (sharing information and communicating), ICA 3 (transforming and creating information and digital content), ICA 4 (problem-solving in a digital context and computational thinking) and ICA 5 (appropriate use of ICT (online security, safety and risk awareness and skills) (IPST, 2022).

Competency-based education require students the skills to apply rather than memorize information that they could forget after completion of the courses. These requirements counted as students' competency which refers to a description of a particular mental ability or skill students are expected to learn (Gilmer, et al., 2011). Therefore competency-based learning management need to be differed from traditional teaching methods in both learning activity and assessment. The competency learning activity should be concerned that students tend to find some individual skills or competencies more difficult than others and allowed them to move at varying paces within a course (Gervais, 2016). As well as the competency assessment require to identify specific learning outcomes in terms of behavior and performance, including the appropriate criterion level to be used in evaluating achievement (Lattuca, et al., 2011).

The competency-based education is not an only new challenge for science, mathematics and technology teachers. The instruction during the COVID-19 pandemic is also a big impact for the teachers. The COVID-19 has created the largest disruption of education systems. The social distancing and restrictive movement policies have significantly disturbed traditional educational practices. The Thai ministry of education recommended 5 teaching models which the teachers could adopt for their class: 1) onsite teaching at school in the green areas, 2) on air learning at home through distance learning television (DLTV), 3) online teaching through the school recommended online platforms, 4) on demand learning through the share applications of the teacher and students and 5) on hands which the teacher prepare a programmed instruction for students' self-study at home with sometime visit of the teacher. However, these teaching models do not harmony with the competency-based education which need deep inquiry and highly participation in problem solving. The teachers therefore sought for a balance in these challenges and called them "the teaching in new normal"

While the teachers figure out how to deal with the competency-based education in new normal, national education act also drives them to engage research into their professional development. The Thai national education act B.E. 2542, Section 30 stated that “An establishment of education … shall promote an instructor to be capable of conducting research for a development of learning suitably for the learner in each level of education” (National Education Commission Office, 1999). The classroom action research seems to be the key for the teachers this time. The teachers could employ classroom action research in parallel with their competency-based teaching practice. Classroom action research is mentioned as an effective solution for teacher development in contexts (Bissonnette and Caprino, 2014). It could be used as a tool to find out strategy to solve problem in the classroom (Mettetal, 2002). The classroom action research will indicate the teachers what works best in their own classroom or what could improve student learning. The benefits of classroom action research have been stated in several studies in supporting professional development (Capobianco and Joyal, 2008), helping teachers develop their intellectual capacities and provoking awareness of how to create a context that supported change (Balach and Szymanski, 2003), increasing teachers’ levels of self-efficacy and feelings of empowerment (Farrell, 2003) and also making professional relationships with their colleagues and students (Capobianco and Joyal, 2008).

The classroom action research has been reported on the growth of the group as a professional learning community (Balach and Szymanski, 2003). Recently, the use of classroom action research and the professional learning community (PLC) concept to support teacher teaching experience is accepted as contributing factors for the improvement of teaching practices (Johannesson, 2020; Sagor, 2010).. The PLC is a group of teachers sharing and critically interrogating their practice in an ongoing, reflective, collaborative, inclusive, learning-oriented, growth promoting way (Stoll and Louis, 2007). This based on the desire for individual and community improvement and is enabled by the mutual respect and trustworthiness of the professional learning team (Hord, 1997). The professional learning team (PLT) include 1) model teacher who want to improved teaching performance and increase student achievement, 2) buddy teacher who’s there for helping and supporting the model teacher, 3) administrator who provides supportive conditions for professional learning community and supervision the process through the professional learning community, 4) mentor who could closely mentor until the model teacher succeed e.g. head of the department or skillful teacher in the department/school and 5) expert who is a professional in the area of the issue practice of professional learning community e.g. university lecturer, educational supervisor, guru, etc. There are quite clear that the academically successful professional learning communities are require a shared vision that is developed from an unswerving commitment on the part of PLT team to students' learning and that is consistently articulated and referenced for their work, a collective learning among the team and application of the learning to solutions that address students' needs, the visitation and review of each teacher's classroom behavior by PLT team as a feedback and assistance activity to support individual and community improvement as well as physical conditions and human capacities that support such an operation (Hord, 1997). The literatures have been reported on the success of professional learning community on driving higher achieving students and performance teachers to school (Louis, 2006; Wilson, 2016; Brown, Horn and King, 2018). Moreover, the professional learning community is mentioned as safety place where the teachers could openness to new ideas, suspension of judgments, and commitment to inquiry exist can true reflection and dialogue occur between them (Sergiovanni, 1994).

The teachers in Maha Sarakham Province, Roi-et Province and Kalasin Province are concern and want to get ready for the competency-based curriculum that will be launch in their school very soon. The professional learning community classroom action research could be a scaffolder for them to go through the new curriculum and the new normal of teaching and learning.

RESEARCH OBJECTIVES

There were four research objectives addressed in this study.

1) Conduct teachers' professional development training in classroom action research for enhancing students' science, mathematics and technology competencies in new normal.

2) Study competency-based learning management framework for enhancing students' science, mathematics and technology competencies in new normal.

3) Study competency assessment framework in science, mathematics and technology.

METHODOLOGY

The professional learning community for teachers' professional development training in classroom action research for enhancing students' science, mathematics and technology competencies in new normal were conducted in 3 phases.

1) Phase I: background and need survey.
2) Phase II: classroom action research and competency-based leaning/assessment design
3) Phase III: classroom action research investigation on competency-based leaning/assessment.

Target Group

The research involved 40 target group teachers: from schools in Maha Sarakham Province, Roi-et Province and Kalasin Province on the northeast of Thailand. All participants voluntarily participated in the research study.

1) 14 science teachers.
2) 13 mathematics teachers.
3) 13 technology teachers.

Research Tools

There were two types of research tool.

1) The survey questionnaire on teacher needs in classroom action research for enhancing students' science, mathematics, and technology competencies in new normal was five-point rating scale online survey, consisted of three parts: (1) personnel information, (2) opinion on ability to do classroom action research and (3) ability to do competency-based learning management and competency assessment.

2) The professional learning community record forms were open-ended form. These were used during the PLC processes for finding out a conclusion of the PLC meetings on classroom action research for planning in enhancing students' competency, designing of competency learning activity, designing of competency assessment, results of competency-based learning management and competency assessment, as well as, data analysis and report writing of classroom action research.

Data Collection

The research methodology employed in this study was a multi-phase design encompassing three phases.

3) In Phase I, the researchers used a quantitative approach by online survey the teachers on their background in teaching, experiences in classroom action research and competency-based education and their needs in classroom action research for enhancing students' science, mathematics and technology competencies in new normal. Then, the

survey data were analyzed for each item to identify teachers teaching background, needs in classroom action research for enhancing students' competencies and opinion on their own ability to do classroom action research, competency-based learning management and competency assessment.

4) In Phase II, the researchers used qualitative research using professional learning community (PLC) process to meet the teachers need in classroom action research and competency-based learning management and competency-based assessment. The professional learning team of each school including a model teacher who was the research target, a buddy teacher who was teaching the same subject with the model teacher, an administrator who was the head of department, a mentor who won Kurusapha (Teacher's Council) award, an expert who was a lecture from Rajabhat Maha Sarakham University. Besides, Rajabhat Maha Sarakham University provided 2 workshops for the target group teachers on competency-based education and classroom action research. After workshops the target teachers and their professional learning team had professional learning community meetings for planning on the competency-based learning/assessment and classroom action research. Then, the PLC record forms and the teachers' lesson plans were analyzed to categorize how do the teachers planned to enhance students' science, mathematics, and technology competencies in new normal and how do they assess students' competency.

5) In Phase III, the mixed method was employed. The researchers used qualitative research using professional learning community process to help the teachers improve their teaching and assessment. The PLC meetings were done several times after each or few teaching classes of each model teacher. The professional learning team of each school observed the model teachers' teaching along with discussed on students' works. The suggestions from the professional learning team were used for improving the teaching and competency assessment of the teachers. The PLC record forms were analyzed to find out how science, mathematics and technology teachers managed competency learning /assessment in new normal.

The quantitative approach in Phase III from the online survey on teachers' opinion of their own ability to do classroom action research, competency-based learning management and competency assessment was done to identify of each item.

Data Analysis

The quantitative data analysis was descriptive statistics, e.g., mean, standard deviation and percentage with the survey data. The qualitative data analysis was content analysis of PLC record forms, teachers' lesson plans and students' works.

RESULTS AND DISCUSSION

This research aimed to bring out the benefits of the professional learning community to: 1) conduct teachers' professional development training in classroom action research for enhancing students' science, mathematics and technology competencies in new normal, 2) study learning management framework for enhancing students' science, mathematics and technology competencies in new normal and 3) study competency assessment framework in science, mathematics and technology. The researchers started the research by survey 229 teachers in Maha Sarakham Province, Roi-et Province and Kalasin Province on their background in teaching, experiences in classroom action research and competency-based education and their needs in classroom action research for enhancing students' science, mathematics, and technology competencies in new normal. The background in teaching of the teachers is given as follows.

Table 1: Personnel information of teachers

Items	Number (person)	Percentage (%)
Gender		
Male	51	22.27
Female	178	77.73
Affiliation Area		
Maha Sarakham	119	51.97
Roi-Et	40	17.47
Kalasin	64	27.94
Others	6	2.62
Subject Teaching		
Science	91	39.74
Mathematics	86	37.55
Technology	52	22.71
Grade Teaching		
Elementary	25	10.92
Secondary	111	48.47
High school	89	38.86
Others	4	1.75

Table 1 show that most of the teachers are female (77.73%), their schools are in Maha Sarakham area (51.97 %) and teaching science subject (39.74%) in lower secondary level (48.47%). From all 229 teachers were only 40 teachers attended to participate in this research study as target group teachers. The researchers focusing inquired on the target teachers' opinion in their ability to do classroom action research and ability to do competency-based learning management and competency assessment in new normal. The results are as the follows.

Table 2: The teachers' opinion on their performance before attend the training

Items	$\bar{X}$	S.D.	Performance
Understanding in classroom action research	4.03	2.56	Good
Ability to do classroom action research	3.93	2.77	Good
Understanding in competency-based learning management.	3.75	2.32	Good
Ability to do competency-based learning management.	3.13	2.74	Average
Understanding in competency-based assessment.	3.22	2.56	Average
Ability to do competency-based assessment.	2.82	2.32	Average
Total	3.48	2.63	Good

As shown Table 2 the target teachers indicated their own ability to do classroom action research and ability to do competency-based learning management and competency-based assessment in new normal in "Good" performance ($\bar{X}$ = 3.48, S.D. = 2.63). This data implied that the target teacher had knowledge on classroom action research and competency-based education somehow. Therefor the researchers decided to hustle on training the target teachers to classroom action research and competency-based education through professional learning community. We did review the target teacher a little with one day workshop on classroom action research and one day workshop on competency-based education. Then after that the professional learning community process was implemented in designing classroom action research for enhancing students' science, mathematics and technology competencies in new normal of the target teacher's professional learning team. The researchers analyzed data from lesson plans of the target teachers and the findings are as follows.

Table 3: The teachers' competency-based learning management in new normal

Subject Teaching	Competency Based Learning Models	Steps in Learning
Science	5E Learning Cycle	1. Engagement -teacher engage students to the lesson and review prior knowledge. 2. Exploration -students do hands on activities as preliminary investigation to generate scientific knowledge. 3. Explanation -students explain their understanding of concepts and the teacher corrects students' misconceptions. 4. Extension -students share information and ideas or apply their knowledge and skills to other disciplines or daily life. 5. Evaluation -teacher evaluate students understanding and progression as well as encourage them to assess their understanding.
	Problem Based Learning	1. Define the problem -teacher present problem scenario that reflect learning objective and the real world to engage student's problem solving. 2. Problem analysis – students discuss the problem in a small group, clarify the facts of the case and identify what they need to learn to work on the problem. 3. Conducting research -students brainstorm to find out possible solutions to the problem and test the potential hypotheses. 4. Knowledge synthesis -students bring the knowledge they have studied to the group for discussion. and synthesize the knowledge that has been learnt 5. Summarize and evaluate the value of the answer -each group of students summarize and evaluate the value of the answer whether be able to answer all the questions without doubt. If it's not, they are still questioning, knowledge must be sought out and they must conduct more research to answer the question. 6. Presentation and evaluation -students present their results. Teacher and the others assess the performance and reflects on the strengths and highlights areas that should be revised.

Table 3: (Cont')

Subject Teaching	**Competency Based Learning Models**	**Steps in Learning**
	STEM Education	1. Problem identification -students make consideration and identifying the problem includes discerning what is needed for problem solving or innovation. 2. Related information search -students investigate related information and ideas on sciences, mathematics and technology for problem solving or innovation. 3. Solution design - students apply the related information and ideas for problem solving or design innovation concerning available resources, restrictions and condition of the given situation. 4. Planning and development - students design sequence steps in problem solving or innovation and develop methods for problem solving or construct innovation. 5. Testing, evaluation and design improvement - students test and evaluate the problem solving method or innovation. The result may need improvement for an effective problem solving. 6. Presentation -students present ideas and steps in problem solving or innovation.
	General Instruction	1. Introduction -teacher engage students to the lesson, inform of purposes and stimulate attention. 2. Body -teacher recall student's prior knowledge, present information, and provide practices. 3. Closure -teacher and students discuss and summarize what have been learnt, conduct assessment and feedback.
Mathematics	IPST Teaching Model	1. Introduction -teacher assess students' prior knowledge. 2. Teaching -teacher teaching new knowledge to students. 3. Summarize -teacher and students summarize the main idea of the lesson. 4. Practice -students do practice worksheets. 5. Application -teacher and students discuss how to apply the knowledge into new situations. 6. Evaluation -teacher evaluate the learning result and knowledge applications of the students.
Technology	Project Based Learning	1. Presentation -teacher introduce students into the problem situation and students study relevant situation related to content in the lesson plan as a learning guideline. 2. Planning -students cooperative planning, brainstorming and discussion to find out the conclusion for the action plan. 3. Action -students conduct activities and write results report.

Table 3: (Cont')

Subject Teaching	**Competency Based Learning Models**	**Steps in Learning**
		4. Evaluation – teacher use authentic assessment to assess whether students are meeting the desired learning goals of the lesson plan.
	Think-Pair-Share	1. Think -teacher asks specific question to the lesson and students think about what they know or have learned about the topic. 2. Pare -student pairs with another student or a small group and then find out the answer of the question through 4 steps: 2.1 Motivation -teacher introduce the lesson to students. 2.2 Information -students study the lesson. 2.3 Application -students test achievement of the learning outcome. 2.4 Progress -teacher evaluate the students' learning achievement. 3. Share - students share their thinking with their partner and discuss for the final conclusion.
	STEM Education	1. Problem identification -students make consideration and identifying the problem includes discerning what is needed for problem solving or innovation. 2. Related information search -students investigate related information and ideas on sciences, mathematics and technology for problem solving or innovation. 3. Solution design - students apply the related information and ideas for problem solving or design innovation concerning available resources, restrictions and condition of the given situation. 4. Planning and development - students design sequence steps in problem solving or innovation and develop methods for problem solving or construct innovation. 5. Testing, evaluation and design improvement - students test and evaluate the problem solving method or innovation. The result may need improvement for an effective problem solving. 6. Presentation -students present ideas and steps in problem solving or innovation.
	General Instruction	1. Introduction -teacher engage students to the lesson, inform of purposes and stimulate attention. 2. Body -teacher recall student's prior knowledge, present information, and provide practices. 3. Closure -teacher and students discuss and summarize what have been learnt, conduct assessment and feedback.

Table 3 showed the competency-based learning management for enhancing students' science, mathematics and technology competencies in new normal of the target teachers included STEM Education, Problem Based Learning, 5E Learning Cycle, IPST Teaching Model, General Instruction and Think-Pair-Share. These teaching models overarching categories of inquiry, problem solving, self-direct learning, critical thinking, creative thinking, collaboration and communication which are important tools for students' competency development in science, mathematics and technology.

The target teachers' lesson plans analysis revealed competency assessment framework in science, mathematics and technology as shown in Table 4.

Table 4: The teachers' competency assessment in new normal

Subject Teaching	**Competency Assessment Tool**	**Characteristics**
Science	Activity	Students performed activity and teacher used rubric to score students' competency from the activity record or performance. The range of scores were 1-3 points according to science competency level.
	Worksheet	Students answered worksheet questions and teacher assessed students' science competency through rubric scoring. The range of scores were 1-3 points according to science competency level.
Mathematics	Practice	Students demonstrated mathematics problems solving and teacher assessed students' mathematics competency through rubric scoring. The range of scores were 1-3 points according to mathematics competency level.
	Activity	Students performed activity and teacher used rubric to score students' competency from the activity record or performance. The range of scores were 1-3 points according to mathematics competency level.
	Worksheet	Students answered worksheet questions and teacher assessed students' mathematics competency through rubric scoring. The range of scores were 1-3 points according to mathematics competency level.
Technology	Worksheet	Students answered worksheet questions and teacher assessed students' technology competency through rubric scoring. The range of scores were 1-4 points according to technology competency level.
	Activity	Students performed activity and teacher used rubric to score students' competency from the activity record or performance. The range of scores were 1-4 points according to technology competency level.
	Technology competency assessment form	The technology competency assessment form was 5 points rating scale for students' self-assessment on ICT competency area ICA 1-5 after each lesson plan.

Table 4 showed the competency assessment tools that the target teachers used for determine the students' science, mathematics and technology competencies in new normal were activity, worksheet, practice and assessment form. The tools shared common in 2 characteristics which are 1) using rubrics in scoring acquisition student's answers, problem solving and competency performance and 2) using rating scales for student self-competency assessment or for teacher assessment of students' competency performance.

After the completed, the target teachers were surveyed again on their opinion in ability to do classroom action research and ability to do competency-based learning management and competency-based assessment in new normal. The results are as Table 5.

Table 5: The teachers' opinion on their performance before attend the training

Items	$\overline{X}$	S.D.	Performance
Understanding in classroom action research	4.63	1.84	Very Good
Ability to do classroom action research	4.40	2.53	Very Good
Understanding in competency-based learning management.	4.19	1.97	Good
Ability to do competency-based learning management.	3.99	2.65	Good
Understanding in competency-based assessment.	4.17	2.01	Good
Ability to do competency-based assessment.	4.01	2.37	Good
Total	4.23	2.53	Very Good

As shown Table 5 after the professional learning community for teachers' professional development training in classroom action research completed, the target teachers stated their own ability to do classroom action research and ability to do competency-based learning management and competency assessment in new normal in "Very Good" performance ($\overline{X}$ = 4.23, S.D. = 2.53). This indicated that the target teachers have developed ability in classroom action research, competency-based learning management and competency assessment.

CONCLUSION AND IMPLICATIONS

The research revealed the effectiveness of professional learning community on the teachers' professional development training in classroom action research for enhancing students' science, mathematics and technology competencies in new normal. The PLC process supported the teachers' collaborative working on every step of classroom action research for enhancing students' science, mathematics, and technology competencies. The PLC facilitated professional learning team to design and problem solving of classroom action research, competency-based learning activity, competency-based assessment, competency learning management, and classroom action research data analysis and report writing. The "new normal" things seemed bothered the target teachers at first. They worried about the online competency learning management, online classroom observation and online PLC meeting will not work well. The competency-based education requires students' inquiry, problem solving and performance. How could these be done online. Also, how could the model teacher expresses students' competencies to the professional learning team during the classroom observation since the camera stand still. Later, the teachers had changed their mind, mentioned the convenient of the online platforms that provide them to share the teaching videos to the professional learning team member who missed the actual class. Even the professional team members who do real time online classroom observation were impressed with the re-observation that they could go backwards and forwards the posted video to carefully observe on the target competency of students. As well as the online PLC meeting could be done easier than onsite meeting. The online PLC meeting could be done after dinner or weekend day!

The PLC provides expertise sharing and collaboratively working to improve teaching skills and the academic performance of students. The target group teachers felt more confident in conducting classroom action research, competency-based learning management and competency-based assessment after the training from high level to highest level. The competency-based learning managements in new normal which they had designed were vary on the subjects they are teaching. The science competency-based learning management was according to 4 learning models: 5E inquiry, Problem Based Learning, STEM Education and general instructional method, the mathematics competency-based learning management based on only one learning models and the technology competency-based learning management was according to 4 learning models: Project Based Learning, Think-Pair-Share, STEM Education and general instructional method. While the competency assessment was shared as activity sheet, worksheet, practice and competency assessment inventory. There were two types of competency assessment tools: 1) rubrics to score answer quality, problem solving performance and competency performance of the students and 2) rating scale to indicate competency level of performance of the students or students self-assess their own competency level of performance. Those performances of the target teachers highlighted the powerful of PLC. The PLC leaded and scaffolded them in conducting classroom action research, competency-based learning management and competency-based assessment from the beginning. As well as the feeling that professional learning community team is right there to help, was really support the target teachers in their professional development. These confirmed Díaz-Maggioli (2004) statement “a career-long process in which educators fine-tune their teaching to meet their students’ needs”. The PLC is effective profession development as ongoing, intentional and systematic, highlighting the fact that only through sustained involvement. In such actions provide teachers effectively update their knowledge base so that it better relates to their learners’ learning. (Guskey, 2000).

ACKNOWLEDGEMENTS

This work was supported by the Institute for Promotion of Teaching Science and Technology (IPST).

REFERENCES

Balach, C. A. and Szymanski, G. J. (2003). The Growth of a Professional Learning Community through Collaborative Action Research. *In the 2003 Annual Meeting of the American Educational Research Association,* Chicago, Illinois.

Bissonnette, J. D. and Caprino, K. (2014). A Call to Action Research: Action Research as an Effective Professional Development Model. *Mid-Atlantic Education Review*, 2(1): 11-22.

Brown, B. D., Horn, R. S., and King, G. (2018). The Effective Implementation of Professional Learning Communities. *Alabama Journal of Educational Leadership,* 5: 53-59.

Capobianco, B.M. and Joyal, H. (2008). Action Research Meets Engineering Design. *Science and Children*, 45(8): 22-26.

Farrell, J. B. (2003). Empowering Beginning Teachers through Action Research. *In the 2003 Annual Meeting of the American Educational Research Association*, Chicago, Illinois.

Gervais, J. (2016). The Operational Definition of Competency-based Education. *The Journal of Competency-Based Education,* 1(2): 98–106

Gilmer, P. J., Sherdan, D. M., Oosterhof, A., Rohani, F., and Rouby, A. (2011). *Science Competencies That Go Unassessed.* Retrieved May, 2022 from https://files.eric.ed.gov/fulltext/ED525233.pdf.

Díaz Maggioli, G. (2004). *Teacher-centered Professional Development*. Association for Supervision and Curriculum Development, Virginia.

Guskey, T.A. (2000). *Evaluating professional development*. Corwin Press, California.

Hord, S. M. (1997). *Professional Learning Communities: Communities of Continuous Inquiry and Improvement.* Southwest Educational Development Laboratory, Texas.

IPST. (2022). *The Document for Competency-based Learning Workshop.* IPST, Thailand. Retrieved May, 2022 from https://drive.google.com/drive/folders/12stWNxfMIFPc0w2v2yT6I0ckczSm4n5A.

Johannesson, P. (2020). Development of professional learning communities through action research: Understanding professional learning in practice. *Educational Action Research,* 30(3): 1-16.

Lattuca, Lisa R.; Stark, Joan S. (2011). *Shaping the College Curriculum: Academic Plans in Context*. John Wiley & Sons, New Jersey.

Louis, K. S. (2006). Changing the Culture of Schools: Professional Community, Organizational Learning, and Trust. *Journal of School Leadership,* 16(5): 477-489.

Mettetal, G. (2002). Improving Teaching Through Classroom Action Research. *Essays on Teaching Excellence: Toward the Best in the Academy*, 14(7): 1-4.

National Education Commission Office. (1999). *National Education Act. B.E. 2542.* Prigwan Graphics, Thailand.

Sagor, R. (2010). *Collaborative Action Research for Professional Learning Communities*. Solution Tree Press, Indiana.

Sergiovanni, T. J. (1994). *Building Community in Schools*. Jossey-Bass, San Francisco.

Stoll, L., and Louis, K. S. (2007). Professional Learning Communities: Elaborating New Approaches. *Professional Learning Communities: Divergence, Depth and Dilemmas,* 1-13.

The Ministry of Education. (2017). *Basic Education Core Curriculum B.E. 2008 (Revised B.E. 2560).* Kurusapa Ladprao Printing, Thailand.

Wilson, A. (2016). From Professional Practice to Practical Leader: Teacher Leadership in Professional Learning Communities. *International Journal of Teacher Leadership,* 7(2): 45-62.

International Journal of Science Education and Teaching
Vol. 2, No. 1, pp. 51-59, Jan. – Apr. 2023
http://doi.org/10.14456/ijset.2023.4

Pre-service Science Teachers' Awareness of Knowledge and Skills for Inquiry Teaching during Their Teaching Practices in Schools

Jirakan Yuenyong[1,*], Pratuengsook Maneelam[1], and Jiraporn Tupsai[1]
Khon Kaen University Demonstration School, Khon Kaen, Thailand
[*]Email: hjirak@kku.ac.th

Received: 4 Apr 2023 Revised: 28 Apr 2022 Accepted: 30 Apr 2022

Abstract. This study examined preservice science teachers' awareness of knowledge and skills for inquiry teaching during their teaching practice in schools. The participants were 3 preservice science teachers enrolled in a school internship course of Khon Kaen University (KKU) in order to practice their teaching in KKU Demonstration School (modindaeng). The KKU teaching practices course allowed these preservice teachers to practice their teaching for 2 semesters in the fifth year of their course. These 3 preservice teachers had finished their teaching practice at the secondary school level, in different schools, before they came to practice primary science teaching in the KKU Demonstration School. An interpretive paradigm was used for the research. Tools of interpretation included questionnaires, interviews, and participant observation. The findings clarified what and how the pre-service teachers learned and became aware of knowledge and skills for improving their teaching, with a focus on inquiry teaching. The paper will discuss their perceptions of problems and solutions for their teaching, pathways of gaining knowledge and skills for inquiry teaching, and the awareness they had of knowledge from 4 years of course work before taking part in these teaching experiences.

Keywords: Science teacher, awareness, knowledge, skills, inquiry teaching

1. Introduction

It should be noted that scientific literacy was an objective of Thai science education. The emphasis placed on scientific knowledge, the essence of science, and the connection between science and technology and society was the purpose. However, it appeared that rather than teaching science as a means of knowing, Thai education was mainly interested in the students' scientific accomplishments. Research, articles, national exams, and teaching and learning data from Thai science teachers revealed insufficient interest in science as a method of knowledge (Wongsila and Yuenyong, 2019; Yuenyong & Narjaikaew, 2009). Students should engage in inquiry in scientific classes in order to meet the objectives of Thai science education. Students who learn science through inquiry may be able to build their scientific thinking and construct the meaning of scientific concepts as well as learn about the nature of science (Asay & Orgill, 2010; Thao-Do and Yuenyong, 2017).

Although teachers recognized the potential advantages of employing inquiry in a scientific classroom, there appeared to be difficulties in actually putting inquiry into practice (Abd-El-Khalick et al. 2004; Crawford 2000; Krajcik et al. 1998; Lee & Songer 2003). Many obstacles prevent teachers from implementing inquiry in the classroom. They were concerned that during inquiry-based activities, they wouldn't be in control of their classes. Time constraints prevent the allowed curriculum from being covered through inquiry. Or perhaps even students are incapable of conducting research projects experiences (Asay & Orgill, 2010). In order to provide powerful chance of scientific inquiry, teachers should gain knowledge and skills of providing scientific inquiry activities (Yuenyong et.al., 2015).

The majority of science teachers agreed that in order to achieve the purpose of science education, it is necessary to make science instruction more relevant by putting an emphasis on student-centered learning and lifelong learning that should take into account the relationship between science, technology, and society (Attapan and Yuenyong, 2019; Samranwanich et.al, 2016; Sohsomboon and Yuenyong, 2022). Many Thai teachers, however, continue to be unaware of the necessity for change. Instead of emphasizing practice and experience-based learning, science teachers place a heavy emphasis on theory, lectures, textbook reading, and teacher-centered education. In contrast to how information is applied to diverse educational purposes, they continue to place more emphasis on how much prospective teachers learn (Meedee and Yuenyong, 2021; Thongnoppakun and Yuenyong, 2019; Souysaart and Sohsomboon, 2022).

Even though this knowledge is frequently irrelevant to them and rarely used in the classroom, preservice science teachers learn how to memorize facts well from their courses. To achieve Thailand's goal of science education, science teaching and learning focused more on information than on opportunities for students to apply critical thinking, self-expression, and self-learning. When teaching science, science teachers may provide help by explaining the nature of science and how it relates to technology and society (Chanserm et.al., 2019; Sutaphan and Yuenyong, 2021). The skills of teachers need to be developed so that they may work as professionals who can identify the best approach and create lessons for various constructivist learning scenarios (Tupsai et.al. 2015; Udomkan et.al., 2015; Yuenyong and Thatthong, 2015).

Preservice program in Faculty of Education, Khon Kaen University (KKU) enhance students regarding NOS for him or her teaching. The program provided them science content, pedagogy, and pedagogical content knowledge during their four years of course work before school internship in the 5th year. Fundamentally, all preservice science teachers perceived to provide his or her class as scientific inquiry. They expected to know how to provide inquiry activities appropriate to science content and students' existing ideas and context. This study aimed to examine preservice science teachers' awareness of knowledge and skills for inquiry teaching during their teaching practice in schools. The study may suggest some issues of enhancing new preservice science teachers to construct their pedagogical content knowledge.

2. Methodology

Methodology was qualitative research that regarded narrative inquiry. Regarding on the narrative inquiry, the ways of helping people tell stories begin from a 'not knowing' position – rather than 'expert' position (Riessman, 2008). The narrative inquiry is story of preservice science teachers' awareness of knowledge and skills for inquiry teaching during their teaching practice in schools. Their drawing key aspect of knowledge and skills for science teaching as inquiry (5Es) will be questionnaires, interviews, and classroom observation.

2.1 Setting

The participants were 3 preservice science teachers (Suda, Piti, and Thorn) enrolled in a school internship course of Khon Kaen University (KKU) in order to practice their teaching in KKU Demonstration School (modindaeng). The KKU teaching practices course allowed these preservice teachers to practice their teaching for 2 semesters in the fifth year of their course. These 3 preservice teachers had finished their teaching practice at the secondary school level, in different schools, before they came to practice primary science teaching in the KKU Demonstration School.

The participants applied different kinds of science teaching strategies for inquiry such as Predict Observe Explain (POE), Inquiry Cycle (5Es), and Science Technology and Society (STS). However, the 5Es was held as fundamental preparing the lesson plan. An Inquiry Cycle (5Es) consists of five main stages, that is, engagement, exploration, explanation, elaboration, and evaluation (IPST, 2002). Engagement step allows 1) teacher introduces students to engage lesson within their interesting topics, and 2) students ask questions and determine issue to study. Exploration step suggests students plan and determine methods to explore or investigate their interesting topics. And, then, students set hypothesis, determine potential choices, and use various methods to collect data and information to test hypothesis. Explanation step is about fostering students to analyze and interpret data and information to derive results of study that may support or reject the hypothesis. Elaboration step asks students to elaborate and apply acquired knowledge by linking it with existing knowledge and using it to explain situations or events. And, evaluation step asks students to evaluate learning with respect to both processes and products of learning.

2.2 Tools of interpretation

The story of preservice science teachers' awareness of knowledge and skills for inquiry teaching was interpreted through Questionnaire of Reflective Teaching Practice (QRTP), interviewing, and classroom observation. The QRTP provided ten questions to ask preservice teachers at the end of second semester of school internship. These questions include:

1. Some of impressive thing during school internship
2. What problems do you have during school internship? How can you find the solutions for those problems?
3. What did you learn in school internship?
4. Did you find some appropriate ways for your science teaching when you applied 5Es for teaching? Why?
5. Did you find some advantages or problems for your science teaching when you applied 5Es for teaching? Please explain.
6. Are there any differences for applying 5Es in different school level (primary and secondary schools)? Please explain.
7. Which school level do you like to teach students as inquiry cycle (5Es)? Why?
8. What did you learn from experiences of school internship in different school level? Please explain.
9. Did one year of school internship provide you learn something more? Why?
10. What knowledge or courses in four years do you use as knowledge for your teaching practice in school internship?

Interview was carried out in order to probe pre-service teacher further what and how they understood after they completed the QRTP. Classroom observation allowed researcher could be able to interpret what preservice tried to reflect.

2.2 Data analysis

Data analysis was about what we gained from narrative knowing. Analysis was the interpretation of the QRTP, interview and classroom observation in order to provide a meaning making about the story of preservice science teachers' awareness of knowledge and skills for inquiry teaching. Then, the story was shaped in order to organize information about how preservice teachers' awareness of knowledge was constructed and reconstructed.

3. Research Findings

Three preservice science teachers' awareness of knowledge and skills for science teaching as inquiry will be clarify through 1) their perception about problems and solution in teaching practice, 2) influences of gaining knowledge and skills for science teaching as inquiry, and 3) awareness of lesson of 4 years course work as knowledge base for improving science teaching as inquiry.

3.1 Perception about problems and solutions in teaching practice

The Suda, Piti, and Thorn preservice science teachers' narratives reflected what they perceived about problems and solutions in teaching practice. Suda's narrative showed that she concerned about students' attention, difficulty of classroom management and pedagogical knowledge, solving school regulation about students' using internet. Piti' s narrative reflected that he concerned about teachers' social role in science classroom. Thai social role influence on classroom management. He also learned about the difficulty of taking the theory about pedagogy into practice. Thorn concerned about motivating students through media and difficulty of classroom management. These could be interpreted through Suda, Piti and Thorn' s narrative as following.

Suda' s narrative

My initial start, I felt, had some issues. I discovered that my expectations were not met by the actual classrooms. The students didn't appear to be listening to me. I was unable to inspire them. I'm at a loss for solutions to this issue. I enquired of the adviser to my school's teachers how I may proceed and what role I would play. …. Fortunately, I had familiar to students' behavior because I had some experiences from the previous school. Therefore, I was confident to act my teacher role. ….. The inquiry cycle approach to teaching science (5Es) has benefits. First, using the 5Es as a teaching technique for science could be beneficial because it aids students in discovering their own knowledge. Experiment activities allow students to learn the steps of activities and develop their own knowledge. Secondly, students have chance to practice science process skills and gain more attitude toward science. Thirdly, it motivated students to learn science. Students were not boring to learn science. ….. However, inquiry cycle (5Es) has also limitations. It could not apply for all topics. Finding learning activities or instructional media would be challenging if we were to apply the 5Es to science topics that do not include experiments. Activities of searching from internet could not motivate students any more. They didn't want to study by themselves. …. Students in Khon Kaen are not permitted to use the internet to conduct research; otherwise, they visit other websites. I chose not to search and instead gave them sheets. …… I knew that I should try to apply other inquiry approach. Other inquiry approach, like STS, has difficult for me. Students loved to role play but they didn't try to find the solutions of STS issues. When I taught about sound pollution, for instance, it appeared that I applied the STS approach through trial and error.

Piti' s narrative

Unlike students from outside the university, SMD students usually speak out something without carefully thinking. Students seemed to do not respect me. They may perceive that I was preservice teachers. I was not real teachers. ….. Students usually talked loudly together and did not pay attention on my assignment. Short term of my solving problem was social punishment e.g., no teaching until the class readiness. My long-term solving problem was well preparing lesson plan e.g. provide more details of organizing the classroom, adapting my moody for fun, starting the classroom with exciting and funning activities. I believed that these activities could motivation or engagement students to learn science. The most importance for handle the classroom was clearly activities description. When students understood details or steps of activities, they knew what they should do. …. Some topics were hard to prepare lesson plan because it contains remembering contents. If we started to teach these topics with funning activities, it would motivate fifty percents of students. … I think that if we teach science through 5Es learning cycle, it would be good for students to learn science. The problem is difficulty of finding some activities related to students' everyday life for "Exploring stage." If we can provide activities which allow students to inquiry relating to their context, it will motivate them because they will know what and why they must do those activities.

Thorn's narrative

I had some problems about classroom management or controlling the class. I consult my school advisors, share my friends some ideas and learn techniques of classroom management from book and internet. I learned that I needed to know what students were interesting in order to provide motivating instructional media. … Science teaching inquiry through 5Es allowed students to learn themselves. They have chance to do experiments that enhance their understanding the scientific concepts rather than remembering. But, it's difficult to finish the lesson in time because of time consuming from individual differences and students' attention and self-regulation.

3.2 Influences of gaining knowledge and skills for science teaching as inquiry

Obviously, the Suda, Piti, and Thorn improved their skills about classroom management. They learned from practicing how to prepare some activities to motivate students. Strategies for motivation depend on students' age, nature of contents, and school contexts. Primary school students may like more funny activities but secondary school students like something different. Secondary school students may enjoy with teenaged style of language. They learned about different kinds of rewards between primary and secondary school students. Teaching strategies for scientific inquiry also need to be provided differently for primary and secondary school. Practicing in both primary and secondary schools situated them to know what preferring styles of teachers. Suda and Piti love to prepare scientific inquiry for a primary school student but Thorn prefer to do for secondary school students. Their narrative indicated that the steps of 5E inquiry regulated them how to prepare scientific inquiry activities. They aware of the different ways of communicating for different student graders. These could be interpreted through Suda, Piti and Thorn' s narrative as following.

Suda' s narrative

School internship allowed me to learn how to apply psychology for supporting students' learning, classroom controlling, and time allocating (classroom management). First coming to school, I spent amount of time for lesson plan writing because I had no ideas to put in the lesson plan. I got various ideas of constructing instructional media after I passed the first semester of teaching practice. …. When I had teaching experiences in primary schools, I became aware of intriguing games and activities that helped make my teaching more lively and motivating. Unlike, KKW secondary school, teachers could not provide only sheet for SMD primary students. Teachers must provide more activities for primary students. They may be boring when teachers ask too many questions. If they could not answer those questions, I think I will find other exciting activities. For example, if teacher provide primary students role play as Mo-luck fortune-teller, they may fun and be exciting. …. I am aware of school workload, responsibilities, and role model for students. I perceived that science teaching through 5Es inquiry cycle allowed students to set hypothesis, designing, and doing experiment, and drawing conclusion. Students may have positive attitude toward science when they have chance to act like scientists. ….. However, 5Es seemed to be difficulty for primary students because they could not be able to draw conclusion. Students usually asked me how to draw conclusion. Then, I explained them to conclude regarding the experiment objectives. If they don't understand, I will probe more. ….. School internship in different grade and school allowed to learned nature of students and pedagogy for different topics. When I taught Grade 8 students (secondary school), it seemed to be difficult to provide experiment or hand on activities for biological concept. I, therefore, told students to follow the sheets. First week of second semester, I taught SMD primary students like what I did in KKW secondary school in first semester. I perceived that my students in SMD felt sleepy. I learned from my school advisor that I must put the game in scientific inquiring. Rewards also may motivate primary students. Even though Primary science teaching does not deal to amount of scientific concept like secondary school science, teachers have to spend amount of time for interesting activities. …. I may spend long time for teaching practice in order to obtain my goal. I hope that I could prepare my language for communicating to students, particular primary students. It's easy for me to communicate to secondary students because their age was not much different from me. I have also learned about teacher characteristics. I worried about my dressing during weekend. If students saw I wore blue gene short, what questions will students ask me in the next classes.

Piti's narrative

Strategies of primary science teaching are different from secondary science teaching. When I taught secondary school students, I could divide students into group by students' ID number. But primary science teaching should not be organized like that. I had to write the number on the table tennis ball. Then, students selected the ball for setting the group. … primary school teaching is different from secondary school teaching. For example, I may assign groups of secondary school students based on the number of students. To split primary school students into groups, however, we must consider what enjoyable and exciting activities should be offered, such as picking up a ball at random because each ball has a different number. … During my school internship, I developed my communication skills with young pupils. To make it possible for them to follow, I must give them a small portion of the story. … In order to keep my pupils interested every day, I need to set up my classroom with a variety of teaching methods for each individual class. And, I must carefully think about if those teaching methods fit to the nature of topics and students. … I also gained work experience in Thailand's schools. In addition to teaching science, I am also responsible for running homeroom, planning school camps, and planning events for significant Thai holidays. Running homeroom allowed me to understand my students' behaviors. These activities teach me how to solve the problems that I never study before in the university. … I think that 5Es could not be used for all topics. I think it should be used when we will teach some topics that have to provide some experiments. … However, I have to write my lesson plan through 5Es even though it is not appropriate topic such as topic related memorized content. … First semester, I taught Grade 7 and then I taught Grade 6 in second semester. I learned that the nature of the activities is not very different. Because the children are around the same age The difference is that secondary school Grade 7 content is more difficult than primary school Grade 6 and can teach more profound areas. Science teaching through 5Es could more motivate Grade 6 students than Grade 7 students. The reason of this story may relate to science content. Grade 7 students need to learn more deeply content than Grade 6 students. … I love to teach science as inquiry for Grade 6 students because I can easily find the right activities to engage student to investigate with fun. However, managing a seventh-grade classroom is simpler than a sixth-grade one. …By the way, one year of practicing my teaching in school allowed me to learn how to communicate to students.

Thorn's narrative

I learned that school practicing is not only teaching but also various kinds of school working such as academic office, administrative work, school registration work, and so on. These kinds of job are things that I will do when I become actual teacher. … I love more teacher job when I am practicing in school. … I aware of the different kinds of students in different grade level. And, same Grade in different school also have different kinds of students. … I think the 5Es foster me to find the appropriate ways of preparing my science learning activities. … I taught secondary school students in the first semester and primary school students in second semester. I think there are some different issues of teaching between secondary and primary school. As primary school teacher, I must be careful my demeanor of the teacher. My wording and gestures should be good role model for students. And, I must act as lovely and nice teacher all the time when I am teaching primary school students. Instructional media for primary school student is different comparing to secondary school student. Because secondary school students are older than primary school students, managing a secondary classroom is simpler. My classroom is chaos when I teach science with 5Es teaching for primary school students. … Because of my teaching in both primary and secondary school, I understood what and how should I prepare my teaching for different student graders. I must prepare a game for my science teaching in primary school.

3.3 Awareness of lesson of 4 years course work as knowledge base for improving science teaching as inquiry

Interestingly, Suda, Piti and Thorn reflected several issues about how the 4 years course work prepared them knowledge base for organizing their classroom through scientific inquiry. These issues included instructional media, teaching strategies for scientific inquiry (e.g. cooperative learning, STS), nature of content, writing lesson plan, knowledge and skills about research, science teacher and primary school teacher characteristics, and teacher values. These could be interpreted through Suda, Piti and Thorn' s narrative as following.

Suda' s narrative

I think that the course of my preservice teacher program should provide preservice teacher to know how to construct instructional media for different school level – primary and secondary school. So, I do not know how to construct or use instructional media for primary school students. Anyway, I can learn about it when I consult my school teacher advisors. And, I would like to prepare various kinds of activities for my lesson plan but I could not do because of limitation of my teaching experiences and knowledge of teaching strategies. However, I can find some solutions when I consult my school teacher advisors. …. The course about research provides me only meaning or feature of educational research, instead of research design and constructing research instrument. I enrolled to study the course of evaluation and assessment when I was the 3rd year. So, I forgot it when I was teaching practice in the 5th year; for example, how to do test blue print. … Teaching profession 1 – 3 supported me a lot when I practiced for school internship. This course provided me some perceptions of lesson plan writing, real situation of teaching, and different of school contexts and students. However, I think this course was not well prepared for me because I was the first cohort of the 5-year program of preservice teacher. …. The science courses that I studied from Faculty of science support me how to provide experiment and skills for doing experiment. With strong of science content, I could provide meaningful scientific explanation linking to each of student groups. …. I think I can remember the important things from the course about science teaching and learning even I passed it for long. It provided me how to analyze science content standard, long lesson plan, and writing lesson plan.

Piti's narrative

I improve my understanding about science when I teach my class. I expected to learn more about pedagogy and science content. I supposed to know more teaching strategies and what teaching strategies are propriate for each science concept learning. I have more understand about what science content should be taught for Grade 6. And, what learning activities should be provided in those concepts and for those students. … I got some knowledge about research. However, I am not clear in research methodology. I knew that research should be started from the research question. But, what should I do next when I get research problem?

Thorn's narrative

I learned many things during my 4 years of coursework before school internship. These included innovative teaching like "cooperative learning", "STS", and so on. I think that STS is difficult for me because I hard to find social issues to connect to scientific inquiry. I learned many styles of writing lesson plans. The courses of teacher profession 1, 2, and 3 suggested me to know students, schools, classroom management, teaching techniques, and scientific knowledge. I learned from my school teacher mentors (Ajarn Thong, Ajarn Suchat, and Ajarn Chalong). Ajarn Thong showed me how to become nice teacher. Ajarn Chalong showed me about science teaching techniques. …. And, Ajarn Suchart showed me about classroom management. Sometimes, even though Ajarn Suchart was asleep, the children still did not dare to talk.

4. Conclusion

This study reflected what and how three preservice science teachers learned, aware, and improve their knowledge and skills for their organizing science teaching as inquiring during their school internship. They not only learned universal science teaching as inquiry but also awareness of science teacher characteristics regarding on Thai value. They found their viable strategies for scientific inquiry based on student graders, school contexts, and nature of science concepts. The school internship with school teacher mentoring suggested them to undertake their own independent investigations and connect their findings with approaches for employing inquiry in their own classrooms (Hand & Peterson, 1995; Stofflett & Stoddart, 1994). Three preservice science teachers' narrative represented also how they improve their pedagogical content knowledge. These could be viewed when they mentioned what and how to find teaching techniques appropriated for different student graders, nature of science contents, school context, and teacher characteristics for primary and secondary schools.

5. References

Abd-El-Khalick, F., Boujaoude, S., Duschl, R., Lederman, N. G., Mamlock-Naaman, R., Hofstein, A., et al. (2004). Inquiry in science education: *International perspectives, Science Educatio*n, 88, 397– 419.

Asay, L.D. & Orgill, M.K. (2010) Analysis of Essential Features of Inquiry Found in Articles Published in The Science Teacher, 1998– 2007, *Journal of Science Teacher Education*, 21:57–79

Attapan, N., and Yuenyong, C. (2019). Explicit Nature of Science in the STS Contact Lens "Big Eyes" Unit. *Journal of Physics: Conference Series*, 1340 (1), 012066

Chanserm, T., Tupsai, J., and Yuenyong, C. (2019). Grade 11 student's mental model of the Nature of Light. *Journal of Physics: Conference Series*, 1340 (1), 012086

Crawford, B. A. (2000). Embracing the essence of inquiry: New roles for science teachers, *Journal of Research in Science Teaching*, 37, 916–937.

Hand, B., & Peterson, R. (1995). The development, trial and evaluation of a constructivist teaching and learning approach in a preservice science teacher education program. *Research in Science Education*, 25(1), 75-88.

Krajcik, J., Blumenfeld, P. C., Marx, R. W., Bass, K. M., Fredricks, J., & Soloway, E. (1998). Inquiry in project-based science classrooms: Initial attempts by middle school students, *The Journal of the Learning Sciences*, 7, 313–350.

Institute for the Promotion of Teaching Science and Technology (IPST). (2002). *Standard of science and technology teacher*. Bangkok: Institute for the Promotion of Teaching Science and Technology. [in Thai]

Lee, H., & Songer, N. B. (2003). Making authentic science accessible to students, *International Journal of Science Education*, 25, 923–948.

Meedee, C. and Yuenyong, C. (2021). Redox Reaction Teaching and Learning for Enhancing Students' Ability in Constructing Scientific Explanation through Action Research. *Asia Research Network Journal of Education*, 1 (3), 179-204

Riessman, C. K. (2008). *Narrative methods for the human sciences*. Thousand Oasks, CA: Sage Publications.

Sohsomboon, P. & Yuenyong, C. (2022). Examine in-service teachers' initial perceptions toward STEM education in Thailand. *Asia Pacific Journal of Educators and Education*, 37 (2), 325–352.

Souysaart, T., & Sohsomboon, P. (2022). Science Pre-service Teacher Reflection on Pedagogical Knowledge and Other Essential Practical Skills Needed for Practicum according to School Context in Thailand. *International Journal of Science Education and Teaching*, 1(1), 44–54.

Stofflett, R. T., & Stoddart, T. (1994). The ability to understand and use conceptual change pedagogy as a function of prior content learning experience. *Journal of Research in Science Teaching*, 31(1), 31-51.

Sumranwanich, W., Art-in, S., Maneechom, P., and Yuenyong, C. (2016). Existing Nature of Science Teaching of a Thai In-Service Biology Teacher. *Chemistry: Bulgarian Journal of Science Education*, 25(3): 394 – 405

Sutaphan, S and Yuenyong, C (2021). Examine pre-service science teachers' existing ideas about STEM education in school setting. *Journal of Physics: Conference Series* 1835 (1), 012002

Thao-Do, T.P and Yuenyong, C. (2017) Dilemmas in examining understanding of nature of science in Vietnam. *Cultural Studies of Science Education*. 12(2):255–269

Thongnoppakun, W. and Yuenyong, C. (2019). Pre-service science teachers' professional learning through content representations (CoRes) construction. *Journal for the Education of Gifted Young Scientists*, 7(4), 1263-1275.

Tupsai, J., Yuenyong, C. , Taylor, P.C. (2015). Initial implementation of constructivist physics teaching in Thailand: A case of bass pre-service teacher. *Mediterranean Journal of Social Sciences*, 6(2), 506-513.

Udomkan, W., Suwannoi, P., Chanpeng, P., Yuenyong, C. (2015). Thai Pre-service Chemistry Teachers' Constructivist Teaching Performances. *Mediterranean Journal of Social Sciences*, 6(4 S3), 223-232.

Wongsila, S. and Yuenyong, C. (2019). Enhancing Grade 12 Students' Critical Thinking and Problem-Solving Ability in Learning of the STS Genetics and DNA Technology Unit. *Journal for the Education of Gifted Young Scientists*, 7(2), 215-235.

Yuenyong, C. and Narjaikaew, P. (2009). Scientific Literacy and Thailand Science Education. *International Journal of Environmental and Science Education*. Vol. 4 No.3 pp. 335 – 349

Yuenyong, C. and Thathong, K. (2015). Physics teachers' constructing knowledge base for physics teaching regarding constructivism in Thai contexts. *Mediterranean Journal of Social Sciences*, 6(2), 546-553.

Yuenyong, J., Tupsai, J., & Yuenyong, C. (2015). Thai Pre-service Teachers' Aspects of Epistemology and Cognitive Processes for Providing Scientific Inquiry Activities. *Mediterranean Journal of Social Sciences*, 6(2), 465 – 470.

Published April 30, 2023 by
Science Education Association (Thailand)
Sukhumvit 23, Bangkok, 10110, THAILAND
Tel: 66-2204-2528 Fax 66-2204-2528