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Needs assessment of Thai pre-service teachers' STEM teaching competency

Sasithep Pitiporntapin[a,*], Pattranan Vaidyakula[b]

[a] *Division of Science Education, Department of Education, Faculty of Education, Kasetsart University, Bangkok 10900, Thailand*
[b] *Division of Early Childhood Education, Department of Education, Faculty of Education, Kasetsart University, Bangkok 10900, Thailand*

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Abstract

Need assessment of Thai pre-service teachers (PSTs)' STEM teaching competency is essential for designing activities in teacher education programs aimed at facilitating efficient STEM teaching. This research pursued three main objectives: (1) to conduct the identification of PSTs' needs for STEM teaching competency, (2) to identify PSTs' reasons behind their needs for STEM teaching competency, and (3) to identify the PSTs' proposals for the solution to their needs for STEM teaching competency. The study involved 16 PSTs selected purposefully from those who had taken STEM courses. Quantitative data from the questionnaire were analyzed using mean, Standard Deviation (SD), and the modified priority needs index ($PNI_{modified}$), while qualitative data from interviews were subjected to content analysis. The finding of questionnaire data revealed the primary areas PSTs highlighted were STEM designing and development of lesson plan competency ($PNI_{modified}$ = 0.62). The focus group interview revealed three key reasons for the high ranking of this need: (1) the lack of understanding to integrate STEM disciplines, (2) a few examples of STEM lesson plans, and (3) the lack of STEM lesson plan development skills. They also proposed three solutions to this need: (1) more reflection activities to build the PSTs' understanding of integrating STEM disciplines related to STEM problems, (2) providing many more examples of STEM lesson plans, and (3) providing more time during their STEM course on developing STEM lesson plans. Implications from this study include the design of a teacher education course to develop PSTs' STEM teaching competency.

* Corresponding author.
E-mail address: fedustp@ku.ac.th (Pitiporntapin, S.).

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Introduction

STEM education integrates four disciplines: science, technology, engineering, and mathematics, to solve daily life problems and create innovations. In Thailand, STEM education is part of the government policy as shown in the National Strategy (2018–2037), which focuses on driving the economy with science, technology, and innovation (Office of the National Economic and Social Development Council, 2018). There are two main objectives of STEM education in the National Strategy. The first objective is to support STEM literacy for all students and everyone. STEM literacy concerns the knowledge and understanding of scientific concepts and processes essential for personal decision-making skills and civic and cultural participation. The second objective is to produce personnel for the STEM workforce. Therefore, Thai students are expected not only to have STEM literacy but also to study in more STEM fields (Ladachart & Ladachart, 2022).

To achieve these goals, teachers should have STEM teaching competency, which refers to the necessary characteristics and key abilities of teachers to help organize effective STEM teaching, such as designing and developing lesson plans, learning management, using digital technology, and assessment and evaluation (Chien, 2019; Koocharoenpisal, 2023; Phanprom et al., 2021; Trang et al., 2019). In addition, teachers' STEM teaching competence is shaped by the learning experiences teachers undergo in their preparation programs (Lee & Nason, 2012). However, PSTs had the most difficulty designing learning activities based on STEM education (Koocharoenpisal, 2023). They also struggled to incorporate the engineering design process into instruction STEM when designing STEM learning. PSTs often organized learning of specific subjects without making connections to other STEM fields, thus they had not yet integrated STEM. In addition, they lacked confidence in STEM teaching (Bartels et al., 2019; Ryu et al., 2018). Similarly, Pimthong and Williams (2021) pointed out that PSTs in Thailand lack a deep understanding of STEM integration, focusing more on outcomes than interdisciplinary connections, contributing to STEM teaching competency. Such limitations suggest teacher education programs to develop PSTs' STEM teaching competencies.

For effective promoting PSTs' STEM teaching competency, teacher education can utilize needs assessment, including needs identification, needs analysis, and proposing needs solutions to determine what needs to be accomplished to reach goals (Wongwanich, 2019). However, some researchers have reported on PSTs' existing STEM teaching competencies. For example, Trang et al. (2021) investigated the STEM teaching competencies of PSTs in Vietnam, and Koocharoenpisal (2023) enhanced PSTs' competency in designing learning activities based on STEM education. These studies did not focus on the needs assessment of PSTs for STEM teaching competency. Moreover, they emphasized certain components of STEM teaching competency, such as designing and developing lesson plans, and assessment and evaluation.

Therefore, this current research study aims to: (1) conduct the identification of PSTs' need for STEM teaching competency including designing and developing lesson plans, learning management, using digital technology, and assessment and evaluation, (2) identify PSTs' reasons behind their needs for STEM teaching, and (3) identify the PSTs' proposals for the solution to meet their needs for STEM teaching competency.

Literature Review

STEM teaching competency refers to the key abilities and necessary characteristics to effectively organize STEM teaching (Chien, 2019; Koocharoenpisal, 2023; Phanprom et al., 2021; Trang et al., 2021). For effective STEM teaching, PSTs should have STEM teaching competency, which covers four components as follows:

STEM Designing and Development of Lesson Plans Competency

This refers to the ability of PSTs to analyze the curriculum, set learning objectives, plan learning activities, specify learning media, and determine methods and tools for assessing and evaluating outcomes in STEM education (Chien, 2019; Koocharoenpisal, 2023; Trang et al., 2021).

STEM Learning Management Competency

This refers to the ability of PSTs to implement their STEM lesson plans, reflect on their STEM-focused teaching to identify areas for improvement, and make adjustments to enhance the learning experience for their students (Chien, 2019; Trang et al., 2021).

STEM Applying Digital Technology in Teaching Competency

This refers to the ability of PSTs to utilize innovative learning media and assess the outcomes of their use in STEM education (Chien, 2019; Phanprom et al., 2021).

STEM Assessment and Evaluation Competency

This refers to the ability of PSTs to create assessment and evaluation tools related to STEM, utilize various assessment methods and tools, and encourage student participation in the evaluation process (Chien, 2019; Trang et al., 2021).

Methodology

The research approach employed in this study is evaluation research, utilized to assess a specific problem to ensure its usability and alignment with the preferences, necessities, and aspirations of actual individuals (Joyce, 2010). In this study, the researchers conducted a needs assessment, a systematic approach employing both quantitative and qualitative methods to identify PST needs for developing STEM teaching competency.

This need assessment is crucial as it is essential for understanding, addressing, and resolving specific issues or gaps in a systematic and informed manner. It represents a critical step in designing effective solutions and interventions. A framed needs assessment, as outlined by Wongwanich (2019), includes three steps: (1) Needs identification: The results come from research instruments such as a questionnaire in a dual-response format with a five-level rating scale, analyzing and evaluating the difference between the desirable state (I) and the current state (D) to determine necessary changes. The researchers prioritized the needs using the Modified Priority Index ($PNI_{modified}$), (2) Needs analysis: After identifying the needs, the researchers delve into the root cause of the problem, analyzing it using interviews to gather data related to potential solutions, and (3) Needs solution: Solutions to the identified problems are sought. Researchers may employ focus group interviews to gather data from participants related to potential solutions.

Participants

The research participants of this study were 16 PSTs from a university in Bangkok, Thailand. The researchers used purposive selection to recruit PSTs to answer the questionnaire regarding their need for STEM teaching competencies. For selection criteria, the researcher chose these PSTs based on two factors: (1) they had already studied a STEM course during their preservice teacher education program, and (2) they volunteered to participate in this study.

The demographic data of participants showed that the majority were male (8 PSTs, 50.00%), female (7 PSTs, 43.75%), and non-identified gender (1 PST, 6.25%). They were studying in various divisions: technology (10 PSTs, 62.5%), general science (1 PST, 6.25%), general science-biology (3 PSTs, 18.75%), general science-chemistry (1 PST, 6.25%), and general science-physics (1 PST, 6.25%). Additionally, six PSTs from different majors or fields of study were purposively selected to attend focus group interviews via the Zoom online application to examine their reasons behind PSTs' need for STEM teaching competencies and propose solutions.

Research Instruments

The researchers developed research instruments, including a needs assessment questionnaire and a focus group interview protocol.

For the needs assessment questionnaire, the researchers reviewed literature, textbooks, and research related to the development of PSTs' STEM teaching competencies. Then, they divided the questionnaire into two parts: nine items for respondents' background and 40 items for a set of five-scale and dual-response format of the PSTs' perceived level of STEM teaching competency and the expected STEM teaching competency. These items covered four components of STEM teaching competency: STEM designing and development of lesson plan competency, STEM learning management competency, STEM applying digital technology competency, and STEM assessment and evaluation competency. The item-objective congruence index (IOC) of this questionnaire ranged from 0.80 to 1.00.

For the focus group interview protocol, the researchers used it to identify PSTs' reasons behind their need for STEM teaching competency and the PSTs' proposals for a solution to their need for STEM teaching competency. The researchers developed a focus group interview protocol by reviewing literature, textbooks, and research related to the development of PSTs' STEM teaching competencies and data from a needs assessment questionnaire. Then, they created two open-ended questions to ask PSTs in each rank of need identification.

These questions were: What are PSTs' reasons behind their need for STEM teaching competency? and What solution do PSTs want to propose to your need for STEM teaching competency? In total, there were eight questions for four ranks of need identification. Before implementing the focus group interview protocol, the researchers sent it to three education experts to assess the quality and appropriateness of the tool. Then, they calculated the IOC, which ranged from 0.80 to 1.00. Finally, the researchers revised the focus group interview protocol according to the feedback and recommendations from the experts before using it with an actual group of PSTs.

Data Collection

The researcher collected data from research participants in the first semester of the academic year 2023. The 16 participating PSTs received a link via email to a Google form with the needs assessment questionnaire. The researcher then used data from the questionnaire to identify needs. Subsequently, six PSTs were selected to attend focus group interviews via the Zoom online application. At the beginning of the interview, they were presented with results from the questionnaire about PSTs' need identification for STEM teaching competency. Then, they were asked to individually complete a Fishbone diagram about the cause of the problem and the solution. Once they completed the Fishbone diagram, the researcher interviewed them with questions from the focus group interview protocol and discussed their Fishbone diagram. The interview was audio-recorded and lasted about two hours. Additionally, the researchers took notes during the interview to identify PSTs' reasons behind their needs for STEM teaching competency and to identify the PSTs' proposals for the solution to their needs for STEM teaching competency.

Data Analysis

For analyzing the identification of a need for STEM teaching competency, the needs assessment questionnaire was analyzed by calculating the mean (M), standard deviation (SD), Modified Priority Needs Index (PNImodified), and identifying the quality level with these criteria (Wongwanich, 2019): (1) 1.00–1.49 = lowest level; (2) 1.50–2.49 = low level; (3) 2.50–3.49 = moderate level; and (4) 3.50–4.49 = high level. Then, the PSTs' needs identification for STEM teaching competencies was ranked by $PNI_{modified}$ from the highest to the lowest.

Content analysis of the focus group interview data proceeded with a specific focus on understanding both PSTs' reasons behind their needs for STEM teaching competency and their proposed solutions to their needs. This analysis involved two steps: (1) converting the audio file from the focus group interview to a document file and cleaning it, and (2) conducting initial data coding, which involved identifying similar words or phrases spoken by respondents and assigning codes based on the context of the data. Subsequently, the researchers coded and categorized the data according to the assigned codes.

To ensure the validity and reliability of this study, the researchers invited two experts in STEM teaching and one science educator to conduct interrater coding, review supporting evidence, assess relevance, and provide feedback on the appropriateness of the coding and categorization in the data analysis. Throughout this study, pseudonyms of PSTs were used, such as PST01, representing PST number one.

Results

According to the data analysis, the researchers presented three main areas to serve the research objectives: (1) the identification of PSTs' needs for STEM teaching competency; (2) the PSTs' reasons behind their need for STEM teaching competency; and (3) the PSTs' proposals for the solution to their needs for STEM teaching competency.

The Identification of PSTs' needs for STEM Teaching Competency

The researcher interpreted data from a needs assessment questionnaire to prioritize needs identification for PSTs' STEM teaching competencies by $PNI_{modified}$. A comparison of current states, expectation states, and prioritized needs identification for PSTs' STEM teaching competencies by $PNI_{modified}$ is shown in Table 1.

From Table 1, the greatest need identified by PSTs among the four STEM teaching competencies is STEM designing and development of lesson plans ($PNI_{modified}$ = 0.62). These findings show that STEM designing and the development of lesson plans are the most critical areas for improvement. It can be observed that the highest $PNI_{modified}$ value corresponds to the problem that requires the most urgent attention. These findings led to the needs analysis and proposed solutions for the first rank of need identification regarding STEM designing and development of lesson plan competency, which will be presented in the next item.

Table 1 The current states, expectation states, and prioritized needs identification for PSTs' STEM teaching competencies by $PNI_{modified}$

(n = 16)

PSTs' STEM Teaching Competency	The current state (D)		The desirable state (I)		$PNI_{modified}$	Rank
	M	*SD*	*M*	*SD*		
1. STEM designing and development of lesson plan competency	3.36	0.79	3.98	0.88	0.62	1
2. STEM learning management competency	3.50	0.72	3.87	0.97	0.37	3
3. STEM applying digital technology competency	3.96	0.74	4.24	0.88	0.28	4
4. STEM assessment and evaluation competency	3.53	0.96	3.99	0.98	0.46	2

Note: $PNI_{modified}$ = (I-D) / D, when I represents needs and D represents current states. Items with a greater $PNI_{modified}$ indicate a higher level of need compared to those with a lower PNImodified.

The PSTs' Reasons behind their Need for STEM Teaching Competency in terms of STEM Designing and Development of Lesson Plan Competency

Focus group interview questions sought to elaborate on PSTs' understandings of the competency of STEM designing and development of lesson plans, why it was a need for them, and why it was most significant among the STEM teaching competencies. PSTs described three key reasons for the high ranking of this need as follows.

Firstly, PSTs admitted to difficulties linking STEM problems to designing STEM learning activities. They revealed that they could not connect STEM problems to design STEM learning activities because of the lack of understanding to integrate STEM disciplines, as one PST stated, *"I do not identify the STEM problems which related to STEM disciplines so it is difficult to design learning activities focused on the engineering design process in the STEM lesson plans (PST01)."*

Secondly, PSTs did not have a clear view of STEM lesson plans due to few examples of STEM lesson plans provided in STEM course, as one PST stated, *"The lesson plan provided is not yet clear so it is impossible to design a STEM lesson plan related to use STEM for solving complex real-world problems (PST02)."*

Thirdly, they noted that their teacher education program had included few periods where they learned about developing STEM lesson plans, as noted by PST01: *"For me, I need more time to practice writing STEM lesson plans. I need to study the curriculum, learning objectives, teaching content, learning activities, and learning assessment (PST01)."*

The PSTs' Proposals for Solutions to their Needs for STEM Teaching Competency in terms of STEM Designing and Development of Lesson plan Competency

Three solutions to their needs for STEM teaching competency emerged from discussions in the focus group interview. PSTs proposed three solutions to this need as follows.

Firstly, PSTs suggested that they would benefit from extra help in identifying STEM problems in their daily lives. PSTs reflected that they need more reflective activities to connect STEM problems and design lesson plans, as one PST stated: *"I think that PSTs should practice reflection more on STEM problems in their surroundings to link with content in the curriculum for designing STEM learning activities (PST01)".*

Secondly, they proposed providing examples of STEM lesson plans with at least 2-3 examples to give them a variety of examples of STEM lesson plans, as one PST stated: *"The STEM course must have good examples of STEM lesson plans with at least 2-3 examples. I would effectively apply for developing my own STEM lesson plans (PST02)".*

Thirdly, they pointed out that the teachers should increase learning time about the design and development of STEM lesson plans because they need additional time to enable them to delve deeper into STEM lesson plans, scrutinizing lesson plans from multiple perspectives to practice writing the lesson plans, as one PST stated: *"The course should extend the learning hours dedicated to the development of a lesson plan. Additionally, it should include practical exercises that allow participants to apply their knowledge by working on lesson plans with both teachers and peers (PST05)".* This is a valuable pathway to create a more fitting and valuable STEM teaching competency for future teachers. Especially, they should focus on PSTs' writing objective plans.

Discussion

The result of the study showed that PSTs' needs identification must develop STEM designing and development of lesson plan competency. PSTs cannot

create STEM lesson plans that are valuable and beneficial for learners because they lack the understanding to integrate STEM disciplines. To support this idea, Nugraha et al. (2023) stated that PSTs encountered difficulties expressing their subject-specific topic knowledge and contextualizing and applying STEM to real-world problems. Similarly, Trang et al. (2021) found that PSTs were less capable in designing their teaching STEM and performing teaching STEM in the classroom.

For needs analysis and solutions, PSTs provided the reason behind their need to develop STEM designing and development of lesson plan competency being the difficulties in linking STEM problems to designing STEM learning activities. They need more reflection activities to build the PSTs' understanding of integrating STEM disciplines related to STEM problems. Similarly, Berisha and Vula (2021) stated that reflection is a way to help PSTs develop conceptual knowledge for different subjects and advance their pedagogical practices of STEM teaching. Reflection affects the challenges of STEM lesson planning integrating STEM as challenging, especially linking it to relevant real-world problems and topic selection. Furthermore, Margot and Kettler (2019) pointed out that in the STEM course, more time should be spent on writing lesson plans in collaboration with peers under the guidance of an expert, as they can learn together.

In addition, PSTs also pointed out few examples of STEM lesson plans provided in STEM course. Therefore, they need many more examples of STEM lesson plans. Examples of STEM lesson plans will allow PSTs to see the process of engineering design process to solve complex problems with STEM. These results are consistent with Trang et al. (2021), who pointed out that PSTs in Vietnam also suggested that there should be specific guide material on how to design and conduct STEM.

Lastly, PSTs perceived that they still lacked STEM lesson plan development skills even at the end of the STEM course, so they need more time to practice developing lesson plans. To support these ideas, Brusic et al. (2023) revealed that PSTs cannot create STEM lesson plans that are valuable and beneficial for learners because of the limitation of time and limited learning sources. The course should be designed to practice hands-on activity and writing lesson plans better than the old one. Similarly, Koocharoenpisal (2023) pointed out that STEM courses should provide group working activities for PSTs to share their opinions toward STEM education, which could promote their competency in designing learning activities based on STEM education.

To conclude, these findings about the needs assessment of PSTs' STEM teaching competency could prompt teacher educators to redesign the STEM course, particularly in the areas of STEM design and the development of lesson plans. This redesign would aim to empower PSTs with the necessary competencies to create effective STEM lesson plans.

Recommendations

From the findings, PSTs lacked the linkage of STEM problems to design STEM learning activities. It is necessary to redesign the teacher training program to provide more reflection activities to build the PSTs' understanding of integrating STEM disciplines related to STEM problems, as well as provide many more examples of STEM lesson plans for integrating the four disciplines. In addition, the findings showed that PSTs have limited practice time with STEM lesson plans, so teacher education programs may need to provide more time for PSTs to design and write lesson plans.

This study presented only the first rank of need identification for PSTs' STEM teaching competencies by $PNI_{modified}$. Therefore, in future research, the researchers should focus on other ranks in needs identification, such as STEM assessment and evaluation competency. Additionally, the researchers collected data about needs solutions only from the focus group interviewing PSTs. In the next study, the researchers should focus on other stakeholders to assess, such as STEM teachers or STEM educators, in order to gather various ideas on need solutions to design a teacher education course to develop PSTs' STEM teaching competency.

Conflict of Interest

The authors declare that there is no conflict of interest.

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References

Bartels, S. L., Rupe, K. M., & Lederman, J. S. (2019). Shaping preservice teachers' understandings of STEM: A collaborative math and science methods approach. *Journal of Science Teacher Education, 30*(6), 666–680. https://doi.org/10.1080/1046560X.2019.1602803

Berisha, F. & Vula, E. (2021). Developing pre-service teachers' conceptualization of STEM and STEM pedagogical practices. *Frontiers in Education*, *6*(5), 1–10. https://doi.org/10.3389/feduc.2021.585075

Brusic, S. A., Marcum-Dietrich, N., Shettel, J., & White, J. (2023). Building a firm foundation: Preparing pre-K-4 teachers for integrative STEM pedagogy. *Innovations in Science Teacher Education*, *8*(1), 1–21.

Chien, H. T. (2019). Designing a competencies framework for STEM teaching for pre-teachers of chemistry in the University of Education for meeting the new demands of current teachers training. Tạp chí Nghiên cứu dân tộc, *8*(2), 89–94. https://doi.org/10.25073/0866-773X/306

Joyce, R. (2010). *Evaluation research in education*. Royal College of Surgeons in Ireland. Preprint. https://doi.org/10.25419/rcsi.10780373.v2

Koocharoenpisal, N. (2023). Enhancing competency in designing learning activities based on STEM education of pre-service science teachers. *Anatolian Journal of Education*, *8*(2), 207–224. https://doi.org/10.29333/aje.2023.8214a

Ladachart, L. & Ladachart, L. (2022). อัตลักษณ์ด้านสะเต็ม: อีกปัจจัยหนึ่งที่จะส่งเสริมความสำเร็จของสะเต็มศึกษาในประเทศไทย [STEM identity: Another factor that will promote achievement of STEM education in Thailand]. *Journal of Science and Science Education*, *5*(1), 148–157. https://so04.tci-thaijo.org/index.php/JSSE/articleview/255246/173427 [in Thai]

Lee, K. T. & Nason, R. (2012). *The recruitment of STEM-talented students into teacher education program*. Paper presented at Proceeding of the 2nd International STEM in Education Conference. Beijing Normal University, China. https://eprints.qut.edu.au/56848/1/stem2012_20.pdf

Margot, K. C., & Kettler, T. (2019). Teachers' perception of STEM integration and education: a system literature review. *International Journal of STEM Education*, *6*(2), 1–16. https://doi.org/10.1186/s40594-018-0151-2

Nugraha, M. G., Kidman, G. & Tan, H. (2023). Pre-service teacher in STEM education: An integrative review and mapping of the Indonesian research literature. *EURASIA Journal of Mathematics, Science and Technology Education*, *19*(5), 1–21. https://doi.org/10.29333/ejmste/13155

Office of the National Economic and Social Development Council. (2018). *Nation Strategy 2018–2037*. http://www.nesdc.go.th/download/document/SAC/NS_PlanOct2018.pdf?

Peng, X., Wu, B. & Hu, Y. (2020). *Modeling STEM learning design competence through discourse analysis*. Paper presented at 2020 IEEE 20th International Conference on Advanced Learning Technologies (ICALT), Tartu, Estonia. https://doi.org/10.1109/ICALT49669.2020.00065

Phanprom, K., Traiwichitkhun, D., & Sriklaub, K. (2021). การพัฒนาเครื่องมือวัดสมรรถนะครูสะเต็มตามกรอบทีแพค-สะเต็ม [Development of STEM teachers' competencies measurement instrument Using TPACK-STEM framework]. *Journal of Educational Measurement, Mahasarakham University*, *27*(1), 49–64. https://so02.tci-thaijo.org/index.php/jemmsu/article/view/241481 [in Thai]

Pimthong, P. & Williams, P. J. (2021). Methods course for primary level STEM preservice teachers: constructing integrated STEM teaching. *EURASIA Journal of Mathematics, Science and Technology Education*, *17*(8), 1–14. https://doi.org/10.29333/ejmste/11113

Ryu, M., Mentzer, N., & Knobloch, N. (2018). Preservice teachers' experiences of STEM integration: challenges and implications for integrated STEM teacher preparation. *International Journal of Technology and Design Education*, *29*(3), 493–512. https://doi.org/10.1007/s10798-018-9440-9

Sanguankhruea, K. & Julsuwan, S. (2020). A study of the needs of the learning management based on STEM education for the teachers under office of the basic education commission. *Journal of Graduate School Pitchayatat*, *15*(2), 11–21. https://so02.tci-thaijo.org/index.php/Pitchayatat/article/view/244279 [in Thai]

Trang, N. T. T., Oanh, D. T, Binh, P. T., Ninh, T. T., Anh, M. T. H., Dung, L. V. & Duc, N. M. (2021). Practical investigating of STEM teaching competence of pre-service chemistry teachers in Vietnam. J*ournal of Physics: Conference Series, Paper presented at the 2nd International Annual Meeting on STEM Education (I AM STEM)*, Thai Nguyen: Vietnam.

Wongwanich, S. (2019). การวิจัยประเมินความต้องการจำเป็น ครั้งที่ 4 [*Needs assessment*] (4th ed.)]. Cu press. [in Thai]