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Self-reported STEM teaching competence among elementary in-service teachers: Evidence from Ho Chi Minh City, Vietnam

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ABSTRACT

Teachers' STEM teaching competence is important for the quality of STEM integration in primary schools. This study examined the self-reported level of STEM teaching competence among in-service elementary teachers in Ho Chi Minh City, Vietnam, to identify areas requiring further professional development support. A quantitative cross-sectional survey design was employed. The instrument was derived from a four-component STEM teaching competence framework and comprised 18 items assessed via a four-point Likert-type scale. To ensure the measurement's quality, the instrument underwent expert reviews, pilot tests, and validation of reliability and validity. Data from 455 generalist elementary teachers across 15 primary schools were collected and analyzed using statistical and psychometric analyses. The CFA results supported the four-component structure of the instrument ($\chi^2/df = 2.80$, GFI = 0.912, TLI = 0.956, CFI = 0.963, RMSEA = 0.063). Overall, teachers reported a moderate level of competence across the four components. Teaching implementation had the highest mean score, while assessment and revision had the lowest. No statistically significant differences were found in STEM teaching competence based on gender or teaching experience. The findings highlight the need to strengthen lesson design and post-instruction assessment and revision in teacher professional development.

Contribution/Originality: This study provides empirical evidence of the self-reported STEM teaching competence of elementary in-service teachers within an urban context in Vietnam. It also points to competence areas that may warrant priority attention in professional development, particularly STEM lesson and instructional plan design, assessment, and revision.

1. INTRODUCTION

STEM education is broadly framed as an integrative approach that links disciplinary knowledge with authentic contexts and practical applications (Seage & Türegün, 2020; Yurchenko, Yurchenko, Proshkin, & Semenikhina, 2022). Studies have associated such learning experiences with stronger academic outcomes, increased interest in STEM subjects and careers, and the development of competencies such as critical thinking, collaboration, creativity, and innovation (Ghani et al., 2023; Moore, Johnston, & Glancy, 2020; Mustafa, Ismail, Tasir, & Mohamad Said, 2016; Nuraeni, Putri, Majid, & Iskandar, 2024; Riskowski, Todd, Wee, Dark, & Harbor, 2009; Seage & Türegün, 2020).

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At the primary level, early engagement in STEM learning is particularly important because it helps build foundations for students' longer-term learning and development (Kurup, Li, Powell, & Brown, 2019). In the primary years, STEM learning opportunities can help children develop competencies needed to deal with future life challenges while also broadening their awareness of fields that are increasingly valued in the labour market (Anagün, Karahan, & Kılıç, 2020; Kurup et al., 2019; Moore et al., 2020). Therefore, opportunities to participate in STEM learning should be provided from the early years of schooling rather than delayed until later grades (Ghani, Rosli, & Maat, 2025).

Teachers play a key role in making these opportunities meaningful. They shape students' field of study and associated career pathways (Kelley, Knowles, Holland, & Han, 2020), and their competence to plan, enact, and refine learning experiences is closely tied to the quality of school-based STEM implementation (Delahunty, Prendergast, & Ní Ríordáin, 2021; Ekmekci & Serrano, 2022; Zu & Rauf, 2023). Therefore, professional development is necessary for strengthening teachers' conceptual understanding of STEM education, their orientation toward STEM teaching, and their classroom practice (Boz, 2023; Ghani et al., 2025; Montgomery & Fernández-Cárdenas, 2018; Suebsing & Nuangchalerm, 2021).

Even so, transforming integrated STEM principles into appropriate teaching remains challenging in many contexts. Reported difficulties commonly concern the selection of practical problems, the integration of disciplinary content, the sequence of learning activities, and the assessment and revision of lessons. In Vietnam, STEM education has increasingly received policy and educational attention, yet empirical evidence on elementary teachers' STEM teaching competence is still limited, especially among the specific competence components that can guide targeted professional development. This study, therefore, examines the self-reported STEM teaching competence of elementary in-service teachers in Ho Chi Minh City, Vietnam, to identify areas that may require stronger professional development support.

2. LITERATURE REVIEW

2.1. STEM Teaching

By definition, STEM teaching is generally described as an integrated approach that gathers S, T, E, and M around meaningful problems or contexts rather than treating the four areas as isolated subjects (Bybee, 2010; Sanders, 2009). A central idea is that students learn more purposefully when using cross-disciplinary knowledge in inquiry- or design-oriented activities.

The implementation of STEM teaching involves a range of pedagogical approaches, including project-based, problem-oriented, and phenomenon-driven learning, in addition to the 5E instructional model and the engineering design process (Bybee, 2010; Daugherty et al., 2017; Kennedy & Odell, 2024). Although these approaches differ procedurally, they all help structure interdisciplinary learning around connected activities and practical problems, creating opportunities for critical thinking, problem solving, collaboration, and creativity. Among them, the engineering design process is one possible way of linking STEM disciplines through design-oriented tasks and real-world problems. One illustration is provided by Nguyen, Dang, and Pham (2020), who combined the engineering design process with Kolb's experiential learning cycle in a K–12 STEM context and reported positive effects on students' knowledge development and learning motivation.

At the primary level, however, integration cannot simply replicate models used in secondary education. STEM teaching for young learners needs to be appropriate for their development, closely linked to familiar contexts, and organized so that exploration, design, and problem-solving remain accessible to children. Al-Mutawah, Alghazo, Mahmoud, Preji, and Thomas (2021) similarly argued that primary implementation requires deliberate attention to integrated mathematics–science content and to teaching modules that help teachers translate STEAM/STEM principles into workable classroom activities. Taken together, these studies suggest that STEM teaching is not merely the combination of four subjects, but also the development of coherent learning experiences that connect disciplines, real-world contexts, and active student engagement. This understanding provides the conceptual basis

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for identifying the competencies that elementary in-service teachers need to teach STEM effectively at the primary level.

2.2. Teachers' STEM Teaching Competence

STEM competence has been conceptualized broadly. Generally, it includes not only cognitive resources such as knowledge, skills, and abilities but also non-cognitive elements such as interests and occupational values (Carnevale, Smith, & Melton, 2011). It has also been classified into domains such as working together, problem-solving, working with technology, managing organizational systems, and working with resources (Jang, 2016). These perspectives indicate that STEM competence extends beyond disciplinary mastery alone.

For teachers, STEM competence must be combined with pedagogical competence. Prior work has therefore described teachers' STEM-related competence as involving engineering problem solving and design, digital competence, social competence, and a set of enabling qualities such as creativity, adaptability, communication, collaboration, and willingness to learn (Morze & Strutynska, 2021; Sen, Ay, & Kiray, 2018). On this basis, researchers have proposed several frameworks for STEM teaching competence.

Although these frameworks use different labels, they point to a similar set of competencies. National Academy of Engineering & National Research Council (2014) emphasized disciplinary expertise, lesson design and implementation, collaboration, and assessment. More subject-specific frameworks for pre-service chemistry, physics, and informatics teachers also center on understanding the concept of STEM education, developing integrated themes or lessons, organizing effective teaching, and evaluating student learning outcomes (Nguyen, Tran, Truong, & Nguyen, 2024; Nguyen et al., 2020; Vu, 2024). In the primary education context, Ngo (2024) proposed a comparable framework for elementary in-service teachers. Le, Dang, and Bui (2024), meanwhile, reviewed 60 studies and synthesized the concept, structure, and major competency components of STEM teaching competence. Because this review draws recurrent domains from a broader body of literature, it offers the most suitable point of departure for the present study, while Ngo (2024) helps confirm the relevance of these domains to primary education in Vietnam.

In this study, STEM teaching competence is understood as the capacity of elementary in-service teachers to mobilize disciplinary, pedagogical, and interactional resources to design, implement, assess, and refine STEM learning activities. Despite the differences in terminology and emphasis, the reviewed models concentrate on four domains: understanding STEM education, lesson design, instructional implementation, and assessment/revision. On that basis, the framework developed by Le et al. (2024) is used as the main reference for examining teachers' competence profiles, with Ngo (2024) framework as a contextual support for interpreting these domains in primary schools.

2.3. Assessing and Developing STEM Teaching Competence for Elementary In-Service Teachers

Research on STEM education for elementary teachers has addressed both competence assessment and competence development. In Vietnam, existing research suggests that elementary teachers' STEM teaching competence is uneven across components, with recurring deficiencies in integrated lesson design, classroom implementation, and assessment during instruction (Le et al., 2022; Nguyen et al., 2024). This line of evidence makes competence assessment an important starting point for identifying actual professional development needs.

Once these needs are identified, professional development can be targeted more effectively. Systematic reviews show that programs for teachers commonly focus on strengthening understanding of STEM, lesson design, classroom implementation, and the use of appropriate instructional strategies (Boz, 2023; Ghani et al., 2023). At the same time, these reviews emphasize that professional development is more meaningful when it is sustained, grounded in teachers' practical work, and responsive to clearly identified needs.

This need-based orientation is especially relevant in primary education. STEM teaching at this level must remain developmentally appropriate, feasible within school conditions, and closely connected to learning experiences that

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young children can meaningfully engage with. In this regard, Al-Mutawah et al. (2021) emphasized the importance of strengthening integrated mathematics–science content, modules, and methods in primary STEAM/STEM. Kurup et al. (2019) likewise drew attention to teachers' awareness, beliefs, and professional intentions, while Costa, Domingos, Teodoro, and Vinhas (2022) showed that professional development grounded in authentic real-world contexts can strengthen teachers' STEM-related knowledge base and instructional competencies. These studies suggest that competence development for elementary in-service teachers should focus on domains that can be translated directly into lesson planning, classroom practice, and subsequent instructional improvement.

From this perspective, competence assessment and competence development should be treated as closely connected processes. Evidence on current competence levels helps determine which domains require priority attention, and professional development is likely to be more effective when designed from such evidence. In Vietnam, Diep et al. (2023) proposed a development process that links professional development with assessment tool construction and pre- and post-intervention evaluation. Although that work was conducted with secondary school teachers, it supports the broader argument that STEM teaching competence should be developed based on systematic assessment rather than assumption.

Accordingly, the enhancement of STEM teaching competence for elementary in-service teachers can be approached as a sequence of evidence-based decisions: first, identifying the current competence profile, then locating the weaker domains, and finally using those findings to inform professional development priorities. This sequence provides the rationale for the present study, which examines self-reported STEM teaching competence among elementary in-service teachers in Ho Chi Minh City with the aim of identifying areas that require more targeted professional development support.

2.4. Research Question

Considering the reviewed literature and the empirical gap in the Vietnamese primary education context, the present study addressed the following research question:

RQ: What is the self-reported level of STEM teaching competence among elementary in-service teachers in Ho Chi Minh City, Vietnam?

The study also included inferential analyses to examine whether self-reported STEM teaching competence differed by selected teacher characteristics, specifically gender and teaching experience.

3. RESEARCH METHODS

3.1. Research Design and Approach

The present research adopted a quantitative cross-sectional survey design to investigate elementary in-service teachers' self-reported STEM teaching competence. According to Creswell and Creswell (2023), this is an appropriate approach for collecting statistical data to describe patterns in teachers' perceptions and professional practices. Through a standardized survey, the study analyzed statistical indicators for each competence component and used the results as an empirical basis for identifying areas that may require further professional development.

3.2. Survey Sample and Sampling Method

The required sample size was calculated based on Daniel (2012) formula for proportion-based surveys.

$$n = \frac{Z^2.p(1-p)}{d^2} \quad (1)$$

The calculation was conducted at a confidence level of 95% (Z = 1.96), with a permissible error of 5% (d = 0.05) and an estimated proportion of 0.50. The calculation yielded a minimum required sample size of 385. To reduce the risk of unusable or unreturned questionnaires, 500 survey forms were distributed. Of these, 455 valid responses were retained, corresponding to a response rate of 91% and exceeding the minimum requirement for the planned analyses.

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A multi-stage random sampling was subsequently implemented. In the first stage, seven administrative units were randomly selected from Ho Chi Minh City's districts/counties and Thu Duc City. In the second stage, two to three primary schools were randomly chosen within each selected administrative unit.

This procedure produced a final sample of 15 primary schools distributed across different geographical areas of the city. The names and addresses of these schools are provided in Appendix A. Table 1 summarizes the characteristics of the 455 participating teachers. For descriptive reporting, the original qualification categories in the questionnaire were recoded into three groups: college diploma, bachelor's degree, and postgraduate degree, with the latter combining master's and doctoral qualifications for a small number of cases.

Table 1. Survey results with 455 respondents.

Characteristic	Category	n	%
Gender	Female	405	89.0%
	Male	50	11.0%
Teaching experience	< 5 years	77	16.9%
	From 5 to 10 years	116	25.5%
	> 10 years	262	57.6%
Educational qualification	College diploma	5	1.1%
	Bachelor's degree	442	97.1%
	Postgraduate degree	8	1.8%

Table 2. STEM teaching competence framework for elementary in-service teachers.

Code	Competence component	Indicators
[AK]	Awareness and knowledge of primary STEM education and teaching	[AK1] Core concepts, goals, and educational significance of STEM in primary schooling. [AK2] Features of primary STEM teaching and the rationale for building teachers' STEM teaching competence. [AK3] Use of interdisciplinary knowledge to address authentic problems in STEM lessons.
[DL]	STEM lesson and instructional plan design	[DL1] Selection of authentic problems aligned with curricular content and intended learning outcomes. [DL2] Identification of integrated subject content and intended learning outcomes in STEM lessons. [DL3] Formulation of STEM lesson objectives aligned with integrated content and intended learning outcomes. [DL4] Design of learning sequences and choice of suitable instructional approaches for STEM lessons. [DL5] Identifying and effectively using materials, teaching equipment, and digital resources in STEM lessons. [DL6] Design of assessment criteria for students' participation in learning activities and student products in STEM lessons.
[IL]	Implementation of STEM teaching	[IL1] Facilitation of student participation in planned learning activities to meet lesson objectives. [IL2] Observation and support for students or groups encountering difficulties during learning activities. [IL3] Promotion of discussion, sharing, collaboration, product design, testing, evaluation, and revision during task implementation. [IL4] Organization of student presentation of learning products. [IL5] Facilitation of self-assessment and peer assessment during learning activities. [IL6] Assessment of student participation and learning products using established criteria.
[ER]	Assessment and revision	[ER1] Evaluating the effectiveness of STEM lessons and their teaching outcomes. [ER2] Revising STEM lessons. [ER3] Revising STEM lesson plans.

Note: The four competence components were derived from the framework proposed by Le et al. (2024) and relabeled for this study. The 18 indicators were independently developed by the authors.

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3.3. Instrument Design

The instrument was built on a framework with four components derived from Le et al. (2024). For the present study, the component labels were revised, and 18 indicators were developed by the authors to operationalize the framework in the primary school context. As shown in Table 2, the instrument comprised four competence components: (1) awareness and knowledge of STEM education ([AK]); (2) STEM lesson and instructional plan design ([DL]); (3) teaching implementation ([IL]); and (4) assessment and revision ([ER]). These 18 indicators were then converted into 18 questionnaire items, with one item corresponding to one indicator. Appendix B presents the survey questionnaire used to measure primary school teachers' self-reported STEM teaching competence.

Based on this framework, the study developed 18 questionnaire items (observed variables), each directly measuring one competence indicator. The items used a four-point Likert-type self-assessment scale ranging from (1) Limited to (4) Strong to determine teachers' self-reported level of competence. The four-point scale was selected to eliminate the tendency to choose a neutral option (neutral bias), thereby requiring respondents to provide a more definite self-assessment of their competence (Joshi, Kale, Chandel, & Pal, 2015). At the same time, this number of response categories has been shown to ensure good reliability and discrimination in educational surveys (Lozano, García-Cueto, & Muñiz, 2008).

3.4. Instrument Validation

To ensure content validity, the preliminary pool of questionnaire items and response descriptors was reviewed by six experts in STEM education and educational measurement, with particular attention to the alignment between item content and the indicators, as well as the clarity of wording. Their feedback was used to refine the wording of several items and improve alignment between the questionnaire and the proposed competence structure.

A pilot study with 90 elementary in-service teachers was then conducted to examine preliminary internal consistency before the official survey. As shown in Table 3, Cronbach's alpha coefficients ranged from 0.84 to 0.91 across the four component scales and reached 0.93 for the entire 18-item scale. Corrected item-total correlations fell between 0.48 and 0.84, indicating acceptable preliminary reliability.

Table 3. Cronbach's alpha coefficients for the component scales and the overall scale (pilot survey, N = 90).

Code	Number of items	Corrected item-total correlation	Cronbach's alpha
[AK]	3	0.58–0.72	0.84
[DL]	6	0.48–0.80	0.89
[IL]	6	0.55–0.84	0.91
[ER]	3	0.62–0.78	0.87
Overall scale	18	0.48–0.84	0.93

Note: Cronbach's alpha may increase when the number of items is large and the items are highly correlated. Therefore, the alpha coefficient for the overall scale (0.93) should be interpreted together with the corrected item-total correlations (0.48–0.84).

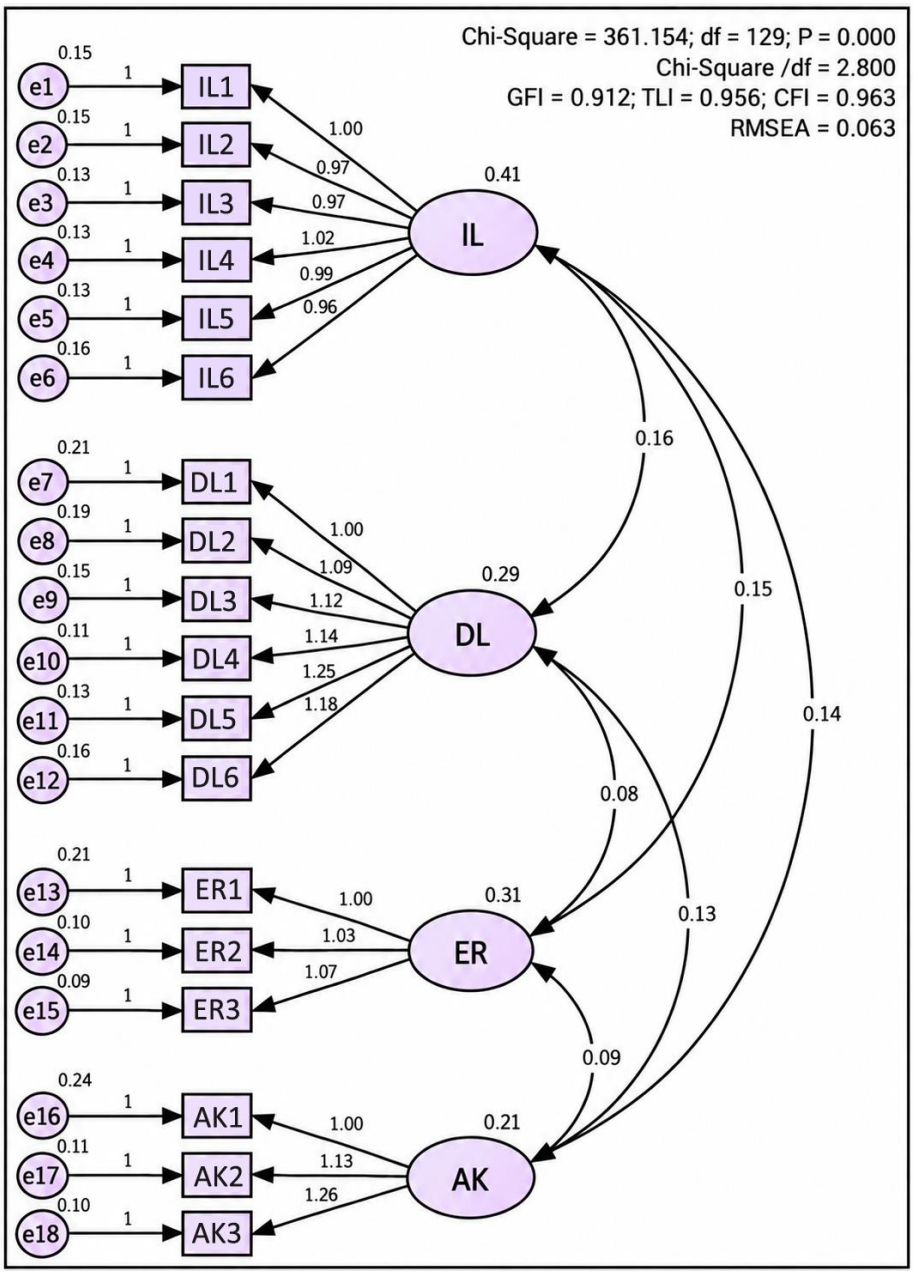
Construct validity was assessed with the official dataset (N = 455) through confirmatory factor analysis (CFA) of the hypothesized four-factor model. The model showed acceptable to good fit, with $\chi^2 = 361.154$, df = 129, $\chi^2/df = 2.800$, GFI = 0.912, TLI = 0.956, CFI = 0.963, and RMSEA = 0.063. Figure 1 presents the CFA measurement model. These results supported the use of the instrument in the official analysis.

3.5. Data Collection

Data collection began after permission had been obtained from the principals of the 15 participating primary schools. Before questionnaire administration, teachers were provided with information regarding the study's purpose, the voluntary nature of participation, their right to decline or withdraw at any time, and the confidentiality of the information they provided. No identifying information was included in the dataset used for analysis.

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The questionnaires were administered directly to generalist elementary in-service teachers in the selected schools. After collection, the responses were screened and cleaned; questionnaires with substantial missing data or clear response patterns were removed. The final dataset included 455 valid questionnaires for quantitative analysis.



Note: The four components of STEM teaching competence are represented as follows: 1 = IL (Teaching Implementation; IL1–IL6); 2 = DL (STEM Lesson and Instructional Plan Design; DL1–DL6); 3 = ER (Assessment and Revision; ER1–ER3); and 4 = AK (Awareness and Knowledge of STEM Education; AK1–AK3).

Figure 1. The CFA results.

3.6. Data Analysis

All valid responses (N = 455) were coded and analyzed using SPSS and AMOS version 26.0. The analysis was carried out in three stages. First, Cronbach's alpha was recalculated on the full dataset, and CFA was used to re-examine the four-factor measurement model. Second, descriptive statistics were computed to summarize the characteristics of the participants and to describe competence scores across the four components and the overall scale. Third, inferential statistics were used to test whether competence scores differed by selected teacher characteristics.

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For descriptive analysis of competency levels, the mean (M) and standard deviation (SD) were calculated for each component and the entire scale. The four-point Likert-type responses were coded as 1 = Limited, 2 = Basic, 3 = Moderate, and 4 = Strong. Following equal-interval conventions on the 1–4 scale, mean scores were interpreted as follows: 1.00–1.75 = Limited; 1.76–2.50 = Basic; 2.51–3.25 = Moderate; and 3.26–4.00 = Strong. These results were used to identify relatively stronger and weaker areas within teachers' self-reported competence profiles.

Group differences were examined using independent-samples t-tests for gender and one-way ANOVA for teaching experience, with effect sizes calculated as Cohen's d for the t-tests and eta squared (η^2) for the ANOVA. Educational qualification was excluded from inferential testing because the subgroups were too small to support meaningful comparison.

4. RESULTS

4.1. Self-Reported Level of Awareness and Knowledge of STEM Education

Table 4 presents teachers' self-reported awareness and knowledge of STEM education. The overall mean fell in the moderate range (M = 2.82; SD = 0.64), with responses concentrated mainly in the moderate category (55.4%), followed by basic (31.1%) and strong (13.5%). Across the three indicators, ⁅AK2⁆ received the highest mean score (M = 2.85; SD = 0.61), whereas ⁅AK3⁆ recorded the lowest (M = 2.80; SD = 0.66).

Table 4. Self-reported level of awareness and knowledge of STEM education (N = 455).

Code	Limited (1)	Basic (2)	Moderate (3)	Strong (4)	M	SD
AK1	0.0%	33.0%	52.3%	14.7%	2.82	0.67
AK2	0.0%	26.8%	60.9%	12.3%	2.85	0.61
AK3	0.0%	33.6%	53.0%	13.4%	2.80	0.66
AK	0.0%	31.1%	55.4%	13.5%	2.82	0.64

Overall, these findings suggested a moderate degree of awareness and conceptual understanding of STEM education, with comparatively weaker confidence in applying interdisciplinary knowledge to real-world problem-solving.

4.2. Self-Reported Level of STEM Lesson and Instructional Plan Design

STEM lesson and instructional plan design also remained generally moderate (M = 2.73; SD = 0.73), yet was one of the weaker competence components. As reported in Table 5, responses were clustered mainly in the basic (44.1%) and moderate (39.1%) categories. The highest mean scores were found for ⁅DL5⁆ (M = 2.76; SD = 0.77) and ⁅DL6⁆ (M = 2.75; SD = 0.76), whereas ⁅DL1⁆ and ⁅DL4⁆ recorded the lowest means (both M = 2.70).

Table 5. Self-reported level of STEM lesson and instructional plan design (N = 455).

Code	Limited (1)	Basic (2)	Moderate (3)	Strong (4)	M	SD
DL1	0.0%	44.6%	40.9%	14.5%	2.70	0.71
DL2	0.0%	44.4%	38.7%	16.9%	2.73	0.73
DL3	0.0%	42.9%	41.1%	16.0%	2.73	0.72
DL4	0.0%	44.0%	42.2%	13.8%	2.70	0.70
DL5	0.0%	44.6%	35.2%	20.2%	2.76	0.77
DL6	0.0%	44.2%	36.7%	19.1%	2.75	0.76
DL	0.0%	44.1%	39.1%	16.8%	2.73	0.73

This result suggests that lesson design was a comparatively weak area, especially in selecting practical problems and sequencing learning activities coherently.

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4.3. Self-Reported Level of Teaching Implementation

Among the four competence components, teaching implementation received the highest overall rating (M = 2.88; SD = 0.74). Table 6 shows that most teachers self-evaluated as moderate (44.2%) or strong (21.6%), while the remaining (34.1%) chose basic. As an indication, [IL4] and [IL5] recorded the highest mean scores (both M = 2.91), whereas [IL2] recorded the lowest (M = 2.83).

Table 6. Self-reported level of teaching implementation (N = 455).

Code	Limited (1)	Basic (2)	Moderate (3)	Strong (4)	M	SD
IL1	0.0%	36.5%	41.8%	21.8%	2.85	0.75
IL2	0.0%	36.7%	43.5%	19.8%	2.83	0.73
IL3	0.0%	33.6%	46.2%	20.2%	2.87	0.72
IL4	0.0%	33.0%	43.1%	24.0%	2.91	0.75
IL5	0.0%	31.6%	46.2%	22.2%	2.91	0.73
IL6	0.0%	33.2%	44.8%	22.0%	2.89	0.74
IL	0.0%	34.1%	44.2%	21.6%	2.88	0.74

Compared with the other components, teachers reported greater confidence in organizing classroom activities, product presentation, and formative peer or self-assessment, but less confidence in monitoring and supporting students who encountered difficulties during learning tasks.

4.4. Self-Reported Level of Assessment and Revision

Assessment and revision were the lowest-rated components, although their mean scores still fell within the moderate range (M = 2.65; SD = 0.68). As shown in Table 7, responses were concentrated mainly in the basic (47.0%) and moderate (41.2%) categories. Among the three indicators, [ER3] received the highest mean score (M = 2.67; SD = 0.67), whereas [ER1] recorded the lowest (M = 2.62; SD = 0.72).

Table 7. Self-reported level of assessment and revision (N = 455).

Code	Limited (1)	Basic (2)	Moderate (3)	Strong (4)	M	SD
ER1	0.0%	52.1%	33.8%	14.1%	2.62	0.72
ER2	0.0%	44.6%	45.3%	10.1%	2.65	0.66
ER3	0.0%	44.4%	44.4%	11.2%	2.67	0.67
ER	0.0%	47.0%	41.2%	11.8%	2.65	0.68

These findings indicate that evaluating STEM lessons and using the results to revise subsequent teaching remained more limited than in the other competence areas.

4.5. Differences in Self-Reported STEM Teaching Competence by Teacher Characteristics

Gender differences in self-reported STEM teaching competence were examined using independent-samples t-tests, with no statistically significant difference observed in overall competence scores between female teachers (M = 2.78, SD = 0.47) and male teachers (M = 2.80, SD = 0.47), $t(453) = -0.347$, $p = .729$, Cohen's $d = 0.052$. The same pattern was found for awareness and knowledge of STEM education, $t(453) = -0.310$, $p = 0.757$, $d = 0.047$; STEM lesson and instructional plan design, $t(453) = -0.117$, $p = .907$, $d = 0.018$; teaching implementation, $t(453) = -0.820$, $p = .413$, $d = 0.123$; and assessment and revision, $t(453) = 0.665$, $p = .507$, $d = 0.100$. Overall, the effect sizes were negligible, indicating a very similar competence profile for female and male teachers in this sample.

A one-way ANOVA was then conducted to examine whether self-reported STEM teaching competence differed across three groups of teaching experience. No statistically significant difference was found in overall competence scores, $F(2, 452) = 0.835$, $p = 0.435$, $\eta^2 = 0.004$. Likewise, the differences were not statistically significant for awareness and knowledge of STEM education, $F(2, 452) = 1.617$, $p = 0.200$, $\eta^2 = 0.007$; STEM lesson and

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instructional plan design, $F(2, 452) = 1.263$, $p = 0.284$, $\eta^2 = 0.006$; teaching implementation, $F(2, 452) = 1.071$, $p = 0.344$, $\eta^2 = 0.005$; or assessment and revision, $F(2, 452) = 1.218$, $p = 0.297$, $\eta^2 = 0.005$. These effect sizes were also very small, suggesting that self-reported STEM teaching competence was broadly stable across teachers with different levels of teaching experience.

5. DISCUSSION

This study examined the self-reported STEM teaching competence of elementary in-service teachers in Ho Chi Minh City, Vietnam, in order to identify competence areas that may require further professional development support. Across the four competence components, teachers reported a moderate level overall. The mean scores followed a consistent pattern: teaching implementation ([IL]) received the highest rating, followed by awareness and knowledge ([AK]), STEM lesson and instructional plan design ([DL]), and assessment and revision ([ER]). This pattern is broadly consistent with previous studies showing that elementary in-service teachers often report a reasonable level of familiarity with STEM education and classroom organization, while experiencing greater difficulty with integrated lesson design and post-instruction evaluation (Boz, 2023; Ghani et al., 2025; Yurchenko et al., 2022).

Another noteworthy result is that no teachers selected the "Limited" category in any of the four competence components. One possible explanation is that STEM education has increasingly received policy attention in Vietnam, especially at the primary level, together with the initial orientation and introductory training activities for teachers (Ministry of Education and Training, 2023). This context may explain why most respondents rated themselves at least at the basic level, despite the clear differences across competence components. At the same time, because the data were self-reported, interpretation of this generally positive response pattern should be done cautiously and not be treated as direct evidence of fully demonstrated classroom competence.

The relatively strong result for [IL] may reflect teachers' greater familiarity with organizing classroom activities in their daily work. In primary education, teachers routinely manage student participation, facilitate interaction, and guide classroom activities, so implementation-related tasks are likely to feel more familiar and manageable. By contrast, the lower scores for [DL] and [ER] point to the demand for more professional judgment involved in high-quality STEM teaching. These include identifying authentic real-world problems, selecting and integrating appropriate content, sequencing learning activities, developing assessment criteria, evaluating lesson effectiveness, and revising lessons based on implementation evidence. Such work requires not only general pedagogical experience but also stronger coordination of curriculum knowledge, pedagogical reasoning, and reflective practice.

Although [ER] recorded the lowest mean score, [DL] can still be regarded as a strategic priority for professional development because lesson design shapes the quality of teaching implementation and revision. In this study, the weakest design-related indicators were those associated with identifying real-world problems and sequencing learning activities. When these aspects remain underdeveloped, STEM lessons are more likely to be carried out procedurally without strong interdisciplinary integration or authentic problem orientation. This interpretation aligns with both foundational and more recent research that identifies lesson design as a key condition for effective STEM teaching in schools (Boz, 2023; National Academy of Engineering & National Research Council, 2014; Wang, Moore, Roehrig, & Park, 2011). Strengthening design competence may also support improvement in assessment and revision, as clearer lesson goals, better-integrated content, and more coherent activity sequences provide a firmer basis for evaluating lesson effectiveness and making instructional adjustments. These findings indicate the need for a dedicated professional development module focusing on STEM lessons and instructional plan design. The module could be structured around three connected strands: (1) theoretical foundations of STEM lessons and instructional plan design; (2) practical design of STEM lessons and instructional plans; and (3) revision and refinement of STEM lessons and instructional plans. This would help teachers move from conceptual understanding to guided application and then to reflexive improvement.

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The inferential findings added to this interpretation. Self-reported STEM teaching competence did not differ significantly by gender, and the corresponding effect sizes were negligible. This suggests that the weaker areas identified in lesson design and assessment/revision were not concentrated in one gender group but reflected broader needs in professional development within the sample. Likewise, no statistically significant differences arose among groups varied by teaching experience. The weaker competence areas identified in the study, therefore, do not appear to be limited to less experienced teachers but may extend across the wider primary teaching workforce. These findings support the view that professional development should address common competence needs rather than assuming that support is required only for specific demographic groups.

The study also adds context-specific evidence from primary education in Ho Chi Minh City. Compared with earlier studies that focused mainly on secondary teachers, pre-service teachers, or broader conceptual discussions of STEM competence (Nguyen et al., 2024; Nguyen et al., 2020; Vu, 2024) the present study provides a more differentiated picture of how elementary in-service teachers rate their competence across distinct components of STEM teaching. This contribution matters because elementary in-service teachers are increasingly expected to integrate content across subjects while adapting learning experiences to the developmental needs of younger learners. Evidence on component-specific strengths and weaknesses is therefore useful not only for describing the current situation but also for identifying more focused directions for teacher professional development.

Several implications follow from these findings. Professional development should give priority to helping teachers design STEM lessons around authentic, real-world problems, identify integrated content and intended learning outcomes, sequence learning activities coherently, develop assessment criteria, and use implementation evidence to revise lessons and instructional plans. Support in these areas should be maintained, practice-based, and closely connected to teachers' actual classroom work rather than limited to general theoretical principles. School-based professional learning communities, collaborative lesson design, peer observation, and reflection on lesson enactment are therefore likely to be useful approaches for strengthening STEM teaching competence at the primary level.

Several limitations of the present study warrant consideration. First, the study relied on self-reported data, which may have been influenced by social desirability or self-evaluation bias. The findings, therefore, reflect perceived competence rather than directly observed classroom performance. Second, the sample was limited to primary schools in Ho Chi Minh City, so the results should not be generalized to elementary in-service teachers in Vietnam. Furthermore, the gender distribution in the study sample is highly uneven, and the results lack gender-specific statistical significance, which should be interpreted with caution. Future research could usefully combine survey data with classroom observation, lesson artifacts, interviews, or intervention-based designs to examine actual competence and the effects of professional development more directly.

6. CONCLUSION

This study examined the self-reported STEM teaching competence of elementary in-service teachers in Ho Chi Minh City, Vietnam. Overall, teachers reported a moderate level across the four competence components, with teaching implementation showing the highest mean score and assessment and revision the lowest. The results nevertheless indicate that STEM lesson and instructional plan design remain strategically important areas because they shape the quality of subsequent implementation and revision.

On this basis, professional development should give priority to strengthening teachers' competence in selecting real-world problems, identifying integrated content and intended outcomes, sequencing learning activities, developing assessment criteria, and using implementation evidence to revise lessons and instructional plans. Practice-oriented professional development, collaborative professional learning communities, and stronger integration of STEM within both pre-service and in-service teacher education may help address these needs.

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These conclusions are directly relevant to primary education in Ho Chi Minh City and may also inform efforts to strengthen primary teacher development in similar educational contexts within and beyond Vietnam.

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Informed Consent Statement: Informed verbal consent was obtained from all participants, and all data were anonymized to protect participant confidentiality.
Transparency: The authors state that the manuscript is honest, truthful, and transparent, that no key aspects of the investigation have been omitted, and that any differences from the study as planned have been clarified. This study followed all writing ethics.
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Appendix A. List of the 15 Participating Primary Schools in Ho Chi Minh City.

No.	Name of Primary school	School address
1	Giong Ong To Primary School	No. 159, Street 6, Binh Trung Ward
2	Pham Van Chinh Primary School	No. 232B, Do Xuan Hop Street, Phuoc Long Ward
3	Tu Duc Primary School	No. 06, Doan Ket Street, Thu Duc Ward
4	Nguyen Van Lich Primary School	No. 66, Street 6, Linh Xuan Ward
5	Truong Thanh Primary School	No. 01, Street 3, Long Phuoc Ward
6	Doan Thi Diem Primary School	No. 140, Nguyen Khoai Street, Vinh Hoi Ward
7	Tran Hung Dao Primary School	No. 250, Tran Hung Dao Street, Cau Ong Lanh Ward
8	Phan Dinh Phung Primary School	No. 491/7, Nguyen Dinh Chieu Street, Ban Co Ward
9	Nguyen Thai Hoc Primary School	No. 71, Tran Hung Dao Street, Ben Thanh Ward
10	Vo Van Tan Primary School	No. 97, Pham Dinh Ho Street, Binh Tay Ward
11	Tran Nguyen Han Primary School	No. 45, Tran Nguyen Han Street, Phu Dinh Ward
12	Nguyen Trai Primary School	No. 170/4A, Chung Thi Minh Street, Tan Thoi Hiep Ward
13	Chi Lang Primary School	No. 645/2, Quang Trung Street, Thong Tay Hoi Ward
14	Doan Thi Diem Primary School	No. 14–16, Tran Van On Street, Tan Son Nhi Ward
15	Vinh Loc B Primary School	No. 2, Street 6, Tan Vinh Loc Commune

Appendix B. Survey questionnaire on the level of STEM teaching competence of primary school teachers.

Dear Teachers,

My name is Le Thi Xinh, and I am a doctoral candidate in Educational Studies at Ho Chi Minh City University of Technology and Education. My research topic is "Developing STEM Teaching Competence for Primary School Teachers."

To identify the practical basis needed for proposing ways to develop STEM teaching competence among primary school teachers, we respectfully invite you to complete this questionnaire on the current level of STEM teaching competence of primary school teachers.

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Please read each item carefully and indicate your response by marking (X) in the appropriate box. Your responses will be highly valuable to the author during the data collection process.

We assure you that the information collected through this questionnaire will be used solely for scientific research purposes and will be kept confidential.

For any comments, please contact: *xinhlt.ncs@hcmute.edu.vn*

I. Personal Information

1. You are currently working at:

Primary school: .....

District/Thu Duc City: .....

2. Gender: Male Female

3. Years of service in education:

Less than 5 years 5–10 years More than 10 years

4. Academic qualifications:

Doctorate Master's Bachelor's College diploma

II. Survey Content

The response levels are defined as follows:

(1): Limited; (2): Basic; (3): Moderate; (4): Strong

1. Competence in awareness and knowledge of STEM education and primary-level STEM teaching

Question 1. Please select the level that best describes your understanding of STEM education (the concepts of STEM and STEM education), and the objectives and role of STEM education at the primary level.

Level	Description	Select
1	Limited understanding of STEM education (the concepts of STEM and STEM education), and of the objectives and role of STEM education at the primary level	
2	Basic understanding of STEM education (the concepts of STEM and STEM education), and of the objectives and role of STEM education at the primary level	
3	Understanding of STEM education (the concepts of STEM and STEM education), and of the objectives and role of STEM education at the primary level	
4	In-depth understanding of STEM education (the concepts of STEM and STEM education), and of the objectives and role of STEM education at the primary level	

Question 2. Please select the level that best describes your understanding of primary-level STEM teaching activities and the need to develop STEM teaching competence among primary school teachers.

Level	Description	Select
1	Limited understanding of primary-level STEM teaching activities and the need to develop STEM teaching competence among primary school teachers	
2	Basic understanding of primary-level STEM teaching activities and the need to develop STEM teaching competence among primary school teachers	
3	Understanding of primary-level STEM teaching activities and the need to develop STEM teaching competence among primary school teachers	
4	In-depth understanding of, and ability to analyze, primary-level STEM teaching activities and the need to develop STEM teaching competence among primary school teachers	

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Question 3. Please select the level that best describes your understanding of how interdisciplinary knowledge is applied to solve real-world problems in STEM lessons.

Level	Description	Select
1	No clear understanding of how interdisciplinary knowledge is applied to solve real-world problems in STEM lessons	
2	Basic understanding of how interdisciplinary knowledge is applied to solve real-world problems in STEM lessons	
3	Understanding of how interdisciplinary knowledge is applied to solve real-world problems in STEM lessons	
4	In-depth understanding of, and ability to analyze, how interdisciplinary knowledge is applied to solve real-world problems in STEM lessons	

2. Competence in designing STEM lesson content and instructional plans for STEM lessons

Question 4. Please select the level that best describes your ability to identify and select real-world problems related to the content and expected learning outcomes of subjects/educational activities in the primary general education curriculum for STEM lesson design.

Level	Description	Select
1	Unable to identify real-world problems related to the content and expected learning outcomes of subjects/educational activities in the primary general education curriculum for STEM lesson design	
2	Able to identify real-world problems related to the content and expected learning outcomes of subjects/educational activities in the primary general education curriculum, but not yet able to use them to design STEM lessons	
3	Able to identify problems related to the content and expected learning outcomes of subjects/educational activities in the primary general education curriculum for STEM lesson design	
4	Able to identify, analyze, and select real-world problems related to the content and expected learning outcomes of subjects/educational activities in the primary general education curriculum for STEM lesson design	

Question 5. Please select the level that best describes your ability to identify the content and expected learning outcomes of subjects/educational activities in the primary general education curriculum integrated into a STEM lesson.

Level	Description	Select
1	Unable to identify the content and expected learning outcomes of subjects/educational activities in the primary general education curriculum integrated into a STEM lesson	
2	Initially able to identify some of the content and expected learning outcomes of subjects/educational activities in the primary general education curriculum integrated into a STEM lesson	
3	Able to identify the content and expected learning outcomes of subjects/educational activities in the primary general education curriculum integrated into a STEM lesson	
4	Able to clearly and comprehensively identify the content and expected learning outcomes of subjects/educational activities in the primary general education curriculum integrated into a STEM lesson	

Question 6. Please select the level that best describes your ability to identify the objectives of a STEM lesson in alignment with the content and expected learning outcomes of subjects/educational activities in the primary general education curriculum.

Level	Description	Select
1	Unable to identify STEM lesson objectives aligned with the content and expected learning outcomes of subjects/educational activities in the primary general education curriculum	
2	Initially able to identify STEM lesson objectives aligned with the content and expected learning outcomes of subjects/educational activities in the primary general education curriculum	
3	Able to clearly identify STEM lesson objectives aligned with the content and expected learning outcomes of subjects/educational activities in the primary general education curriculum	
4	Able to analyze and clearly identify STEM lesson objectives aligned with the content and expected learning outcomes of subjects/educational activities in the primary general education curriculum	

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Question 7. Please select the level that best describes your ability to design the sequence of learning activities and choose appropriate teaching methods for STEM lessons.

Level	Description	Select
1	Able to design the sequence of learning activities, but the teaching methods used in STEM lessons are not yet engaging and do not yet promote students' competencies	
2	Able to design the sequence of learning activities and select teaching methods appropriate to the nature of STEM instruction, helping students develop their competencies	
3	Able to design the sequence of learning activities and select teaching methods appropriate to the nature of STEM instruction that are engaging, motivating, and supportive of students' competency development	
4	Able to design the sequence of learning activities and select teaching methods appropriate to the nature of STEM instruction that are engaging, motivating, differentiated, and suited to the abilities of different groups of students	

Question 8. Please select the level that best describes your ability to identify and use instructional materials and teaching aids for STEM lessons.

Level	Description	Select
1	Able to identify instructional materials and teaching aids and use them in STEM lessons, but selection remains limited, and implementation is still somewhat hesitant	
2	Able to identify instructional materials and teaching aids and use them in STEM lessons	
3	Able to identify instructional materials and teaching aids and use them effectively in STEM lessons	
4	Able to identify and select instructional materials and teaching aids, and use them creatively and appropriately to the school context in order to teach STEM lessons effectively	

Question 9. Please select the level that best describes your ability to develop assessment criteria for students' participation in learning activities and for STEM lesson products.

Level	Description	Select
1	Able to develop assessment criteria for students' participation in learning activities and for STEM lesson products, but the criteria remain broad and insufficiently specific	
2	Able to develop assessment criteria for students' participation in learning activities and for STEM lesson products	
3	Able to develop specific and flexible assessment criteria for students' participation in learning activities and for STEM lesson products	
4	Able to develop specific and flexible assessment criteria for students' participation in learning activities and for STEM lesson products that are highly encouraging and appropriate for different groups of students	

3. Competence in implementing instructional plans for STEM lessons

Question 10. Please select the level that best describes your ability to organize students' participation in learning activities according to the instructional plan to achieve the intended objectives.

Level	Description	Select
1	Able to organize students' participation in learning activities according to the instructional plan, but the activities are not yet lively or engaging	
2	Able to organize students' participation in learning activities according to the instructional plan in a lively and engaging manner, but not yet consistently across all activities	
3	Able to organize students' participation in learning activities according to the instructional plan in a lively and engaging manner	
4	Able to organize students' participation in learning activities according to the instructional plan in a lively and engaging manner, ensuring that all students participate enthusiastically	

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Question 11. Please select the level that best describes your ability to monitor and support students/student groups experiencing difficulties during learning activities.

Level	Description	Select
1	Able to monitor and identify students/student groups experiencing difficulties during learning activities, but not yet all students	
2	Able to monitor and identify all students/student groups experiencing difficulties during learning activities	
3	Able to monitor and identify all students/student groups experiencing difficulties during learning activities and provide appropriate forms of support	
4	Able to monitor and provide timely, appropriate, and encouraging support for all students/student groups experiencing difficulties during learning activities	

Question 12. Please select the level that best describes your ability to encourage and promote students' active discussion, sharing, and collaboration during learning tasks, including jointly designing products, testing them, and evaluating and revising them.

Level	Description	Select
1	Able to organize student discussion, sharing, and collaboration during learning tasks, but the organization does not yet sufficiently promote active participation	
2	Able to apply measures that encourage students to actively discuss, share, and collaborate during learning tasks, but not yet ensure participation from all students	
3	Able to apply measures that encourage students to actively discuss, share, and collaborate during learning tasks, ensuring participation from all students	
4	Able to apply measures that encourage all students to actively discuss, share, and collaborate during learning tasks, jointly design products, test them, and evaluate and revise them	

Question 13. Please select the level that best describes your ability to organize students' presentation of their learning products.

Level	Description	Select
1	Unable to organize students' presentation of their learning products	
2	Able to organize students' presentation of their learning products, but with limited effectiveness	
3	Able to organize students' presentation of their learning products effectively	
4	Able to organize students' presentation of their learning products in a lively, engaging, and effective manner	

Question 14. Please select the level that best describes your ability to organize student self-assessment and peer assessment during learning activities.

Level	Description	Select
1	Unable to organize student self-assessment and peer assessment during learning activities	
2	Able to organize student self-assessment and peer assessment during learning activities for only some students	
3	Able to organize student self-assessment and peer assessment during learning activities for all students	
4	Able to organize student self-assessment and peer assessment during learning activities for all students effectively	

Question 15. Please select the level that best describes your ability to assess students' participation in learning activities and their learning products based on the established criteria.

Level	Description	Select
1	Unable to assess students' participation in learning activities and their learning products according to the established criteria	
2	Able to assess students' participation in learning activities and their learning products according to the established criteria, but not yet fully or accurately	
3	Able to assess students' participation in learning activities and their learning products according to the established criteria fully and accurately	
4	Able to assess students' participation in learning activities and their learning products according to the established criteria fully and accurately, in ways that are highly encouraging and motivating	

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4. Competence in evaluating and revising STEM lesson content and instructional plans for STEM lessons

Question 16. Please select the level that best describes your ability to evaluate the effectiveness of STEM lessons and their instructional outcomes.

Level	Description	Select
1	Unable to evaluate the effectiveness of a STEM lesson and its instructional outcomes	
2	Initially able to evaluate the effectiveness of a STEM lesson and its instructional outcomes	
3	Able to evaluate the effectiveness of a STEM lesson and its instructional outcomes clearly	
4	Able to analyze and evaluate the effectiveness of a STEM lesson and its instructional outcomes clearly and specifically	

Question 17. Please select the level that best describes your ability to revise a STEM lesson.

Level	Description	Select
1	Do not yet know how to revise a STEM lesson	
2	Able to revise a STEM lesson, but not yet effectively	
3	Able to revise a STEM lesson effectively	
4	Able to revise a STEM lesson with a high level of effectiveness	

Question 18. Please select the level that best describes your ability to revise the instructional plan for a STEM lesson.

Level	Description	Select
1	Still uncertain about how to revise the instructional plan for a STEM lesson	
2	Able to revise the instructional plan for a STEM lesson, but not yet effectively	
3	Able to revise the instructional plan for a STEM lesson effectively	
4	Able to revise the instructional plan for a STEM lesson with a high level of effectiveness	

___ Thank you very much for your participation ___

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