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Developing a Coding Scheme for Exploring Preservice Science Teachers' Metacognition in a Method Course

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Abstract: Promoting metacognition in preservice science teachers (PSTs) is necessary for effective science teaching. However, metacognition is an abstract attribute that requires in-depth investigations with qualitative methods. This study aimed to express the process utilized to develop a coding scheme of PSTs' metacognition (CSPM). Methods: This study started with a review of the metacognition conceptual framework. Next, the researchers collected data about PSTs' metacognition from a metacognitive self-report (MS) and a metacognition interview protocol (MIP). The participants were 22 third-year PSTs who studied at one public university. All data were analyzed for codes by using content analysis. Results: The CSPM consisted of 177 codes that can be divided into two main components and six subcomponents. The validity of the CSPM was checked by a panel of experts through the item–objective congruence index (IOC) into two different levels: an IOC between codes and components of metacognition, and an IOC between codes and levels of metacognition. The IOCs of the CSPM in the two levels were acceptable. In conclusion, the CPSM was a qualified coding scheme for qualitatively analyzing metacognition in PSTs as well as other types of participants. This study also pointed out an urgent need to develop metacognition in PSTs.

Keywords: metacognition; pre-service science teacher (PST); coding scheme; method course; qualitative research

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1. Introduction

In a global view, the United Nations (UN) [1] announced the "Transforming our world: The 2030 agenda for sustainable development" document, a plan of action for people, the planet, and prosperity. All countries and stakeholders are expected to work collaboratively as partners to implement this agenda. The 2030 agenda for sustainable development consists of 17 sustainable development goals and 169 targets. Goal 4 mentions the aim to "Ensure inclusive and equitable quality education and promote life-long learning opportunities for all" (p. 18). In detail, Goal 4.7 mentions that "By 2030, ensure that all learners acquire the knowledge and skills needed to promote sustainable development, including, among others, through education for sustainable development and sustainable lifestyles, human rights, gender equality, promotion of a culture of peace and non-violence, global citizenship and appreciation of cultural diversity and culture's contribution to sustainable development" (p. 21). Metacognition is one of the important elements of the sustainable development of human beings. It refers to a person's ability to think and reflect on one's thinking process itself, which monitors and controls his or her cognitive ability [2]. There are multiple examples to support the relationship between metacognition and sustainable development, e.g., ref. [3] proposes a metacognitive instruction model for developing EFL speaking competence or skills. They found that Chinese EFL teachers might want to help their students in the sustainable learning of EFL speaking. In relation to [4], drinking-related metacognitive awareness can be improved by metacognitive guidance that directs students to think critically about healthy drinking. Metacognitive guidance holds a significant pedagogical potential to improve sustainable healthy habits among children.

In a national view, Thailand has announced the vision of the National Education Plan of Thailand [5], which states that "All Thais must be able to receive a high quality of education and life-long learning. They must be able to lead a happy life in line with the principle of self-sufficiency economy and changes in the 21st-century world. Intentional learning strategies for lifelong learning requirements of addressing students' need for higher-order abilities in thinking and learning, intentional learning helps students develop the general metacognitive and self-directed learning skills that facilitate autonomous lifelong learning" [6,7]. In being a lifelong learner, an individual person demands metacognitive thinking. In education, to help learners attain metacognition, a teacher must first attain metacognition himself/herself. Additionally, in the case of future teachers as preservice teachers, a teacher preparation program must prepare metacognition in preservice teachers. Metacognition should be set as a desirable attribute of preservice teachers and developed in preservice teachers in a teacher preparation program. In pursuing this, we expect that all preservice teachers will graduate from universities with the required level of metacognition that is sufficient for them to further develop metacognition in the students that they teach.

Metacognition is not new, as it is historically rooted in educational research from about four decades ago. The definition of metacognition was first delivered by Flavell, a developmental psychologist. He defined metacognition as an individual's ability to monitor, regulate, and orchestrate their cognitive processes to attain a particular objective [8,9]. Later this concept was adjusted [7,8,10–12], such that metacognition generally consisted of two main components: (a) metacognitive knowledge and (b) metacognitive regulation. In addition, metacognition is defined as how individuals monitor and control their cognitive processes [13]. Although the definition of metacognition and its components is not universally defined, educators are commonly aware that metacognition is a desirable and important attribute for individuals who aim to be successful and lifelong learners [14].

In the context of science teaching and learning, effective teachers must attain effective teaching skills and deliver efficient teaching [15,16] to help students learn. Teachers with metacognition will be able to understand student learning and achievement in their tasks. Various studies have affirmed that teachers with metacognition could effectively help their students reach the targeted learning objectives. Metacognition, therefore, is related to the development of students' learning processes [8–10,17–21]. The explanation for this is that learners with metacognition are expected to be able to monitor, control, and regulate their learning until achieving learning goals. When learners understand their thinking and can regulate it effectively, they will be better learners.

Metacognition yields several advantages for teachers and students. The authors of [22] stated that teachers' metacognition is essential for teaching students to develop higher-order thinking. To cultivate metacognition in science learners, teachers are required to develop their metacognition first to ensure that they are able to correctly communicate metacognition as well as enhance their students' metacognition. Thus, it is critical to develop metacognition in preservice science teachers (PSTs), who will soon be science teachers serving the nation. In general, there was a lack of integration of metacognition in science classrooms [23]. In addition, science teachers could not explore and facilitate the development of metacognition in their teaching of science [24].

There are two major approaches to exploring metacognition: quantitative and qualitative approaches. From a literature review, there are 12 kinds of quantitative instruments: (1) a metacognitive awareness inventory for use with in-service teachers [25], (2) a metacognitive reading awareness inventory [26], (3) a taxonomy of metacognitive activities [27], (4) a metacognitive awareness of a reading strategies inventory [28], (5) a state metacognitive inventory [29], (6) reading strategy use [30], (7) a meta comprehension strategy index [31], (8) a metacognitive awareness inventory [32], (9) a junior metacognitive awareness inventory [33], (10) a physics metacognition inventory [34], (11) a learning and study strategies inventory [35], and (12) a metacognition scale [36]. However, there are rarely research instruments specifically designed for exploring PSTs' metacognition. It is necessary for metacognition to be included in a series of university activities, such as seminars and classroom action research. Teacher educators should offer approaches, techniques, and methods that help PSTs reflect on their metacognition [37,38]. However, it will be very difficult for teachers to contribute to students' metacognition if they cannot improve their own metacognition [39]. According to [40], a PST program is required to promote teachers' metacognition ability, which will be required as one of the key competencies to be a professional teacher. Therefore, metacognition is proposed as one essential factor for teacher development.

Metacognition is genuinely an abstract attribute in educational research. To study such abstract attributes, several qualitative methods are proposed, such as self-reports, worksheets, interviews, observations, and think-aloud protocols [41]. There was an upward trend in using qualitative data collection methods in research on metacognition. Several science education researchers currently prefer to use qualitative approaches to explore and report their research results. However, there are some concerns with using qualitative data collection methods in research on metacognition. Self-reports and in-depth interviews may rely heavily on participants' writing and speaking abilities, respectively. Science teachers require such qualitative instruments to investigate their students' metacognition.

Although qualitative instruments are important in studying metacognition when deriving data, the qualitative analysis of metacognition is also very difficult. There was a lack of a coding scheme for analyzing data about metacognition. From the literature review, two studies dealt with the coding of metacognition [42,43]. However, no study proposed a coding scheme and the differentiation of metacognitive levels among the codes. This study, therefore, aimed to develop a coding scheme of PSTs' metacognition (CSPM). This study focuses on three research questions:

1. What are codes and their components in the CSPM?
2. What is the quality of the CSPM?
3. What is the quality of the CSPM in differentiating PSTs' levels of metacognition?

2. Methods

This study is qualitative in nature. There were two qualitative research instruments that were used to collect data about metacognition in PSTs: a metacognitive self-report (MS) and a metacognition interview protocol (MIP). The data collected from the MS and MIP were qualitatively analyzed using content analysis. The context of this study was one public university located in the northeast region of Thailand. The duration of this research was from May 2019 until November 2019. The data collection was conducted in a 16-week method course that took 48 h in total (3 h a week). This method course is a three-credit course in a Bachelor of Education (B.Ed.) degree majoring in general science at the Faculty of Education. The method course description is "Principles and theoretical framework of science education, Teaching models and techniques, and Performing micro-teaching of science were integrated with metacognition". The total credits of the B.Ed. curriculum in general science at the Faculty of Education amounted to 173 credits. Overall, the B.Ed. curriculum in general science is divided into three major sections: general courses, required courses, and elective courses. All PSTs are required to take general courses in common. Required courses include both scientific content and pedagogy. PSTs can freely choose elective courses related to their own interests. The method course that was the context of this study was included as one of the required courses. The methodology is shown as the steps to designing the CSPM in Figure 1.

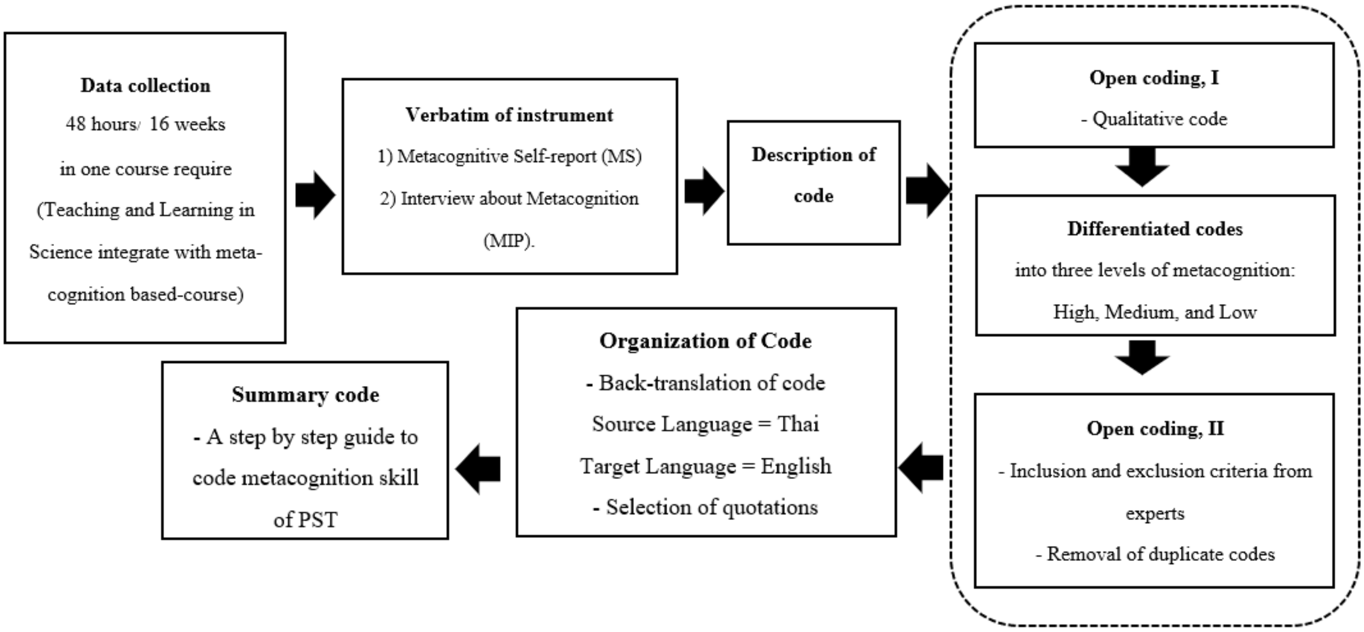

Figure 1. Diagram of the methodology of the CSPM.

2.1. Research Participants

Purpose sampling was used to select participants in the CSPM. The participants were 29 fourth-year PSTs majoring in the general science education program enrolled in the 2019 academic year. There were 16 females and 6 males. The data used for developing CSPM came from 22 PSTs. Seven PSTs were excluded from the data analysis because they did not respond to the MS and attend the MIP. In addition, they participated in the method course lower than 80% of the total hours. This study was submitted to, and the research ethics were reviewed by, the Mahidol University Institutional Review Board (IRB) before the collection of real data.

2.2. Research Process

To answer each research question, the researchers accomplished the following research process.

2.2.1. RQ 1: What Are the Codes and Their Components in the CSPM?

- Review, analyze, and synthesize the theoretical framework of metacognition.
- Apply the theoretical framework of metacognition in coding raw data collected from PSTs in the method course.
- Eliminate the redundant codes and reach the first draft of the CSPM.

2.2.2. RQ 2: What Is the Quality of the CSPM?

The researchers asked five experts to check the correspondence between the codes and components of metacognition. These experts graduated in the fields of science education, educational measurement and evaluation, educational guidance, and psychology education.

- Revise the CSPM according to the experts' comments and reach the second draft of the CSPM.

2.2.3. RQ 3: What Is the Quality of the CSPM in Differentiating PSTs' Levels of Metacognition?

- The researchers developed three groups of codes to differentiate three levels of PSTs' metacognition (high, medium, and low). Then, five experts were asked to check the correspondence between the codes and levels of metacognition.

- Revise the CSPM according to the experts' comments and reach the third draft of the CSPM.
- The researchers conducted back translation by asking two experts in both English and Thai to check the correspondence between the original language (Thai) and the translated language (English).

2.3. Data Collection and Analysis

Two qualitative research instruments, i.e., the MS (Appendix A) and MIP (Appendix B), were used to collect data about PSTs' metacognition. There were four items in the MS (Appendix A) and nine interview questions in the MIP (Appendix B). Raw data about PSTs' metacognition from both instruments were gathered and then coded based on the theoretical framework of metacognition by using content analysis. Content analysis was appropriated in determining the presence of certain words, themes, or concepts within some given qualitative data (i.e., texts). Using content analysis, researchers can quantify and analyze the presence, meanings, and relationships of such certain words, themes, or concepts [44–47]. The final product of content analysis was the CSPM. The validity of the CSPM was evaluated by a panel of five experts in the field of science education, educational measurement and evaluation, educational guidance, and psychology education through the item–objective congruence index (IOC). The IOC of the CSPM was categorized into two different levels: a correspondence of the codes and components of metacognition, and a correspondence of the codes and levels of metacognition. The CSPM was verified by the IOC in two steps: (a) to assure the content validity of the codes and (b) to clarify the quality of the codes.

2.4. Trustworthiness

This study employs methodological triangulation to ensure the external validity of this study. Methodological triangulation involves the use of different methods to collect the same source of data [48]. Methodological triangulation was conducted in this study through the use of different data collection methods to collect the same data, such as the use of the MS (self-report type of data collection) and MIP (interview type of data collection) to collect data about PSTs' metacognition.

3. Results

3.1. RQ 1: What Are the Codes and Their Components in the CSPM?

There were eight steps in developing the CSPM, as shown in Table 1.

Table 1. Steps for developing the CSPM.

Step	Description
Step 1: Determine a theoretical framework of metacognition.	• Review the literature related to metacognition. • Determine the theoretical framework of metacognition.
Step 2: Collect data from PSTs through the MS and MIP.	• Collect data from 22 PSTs by using the MS and MIP throughout the method course.
Step 3: Conduct open coding according to the theoretical framework.	• Conduct open coding with raw data from the MS and MIP. • Conduct axial coding to connect between the main codes into subcategories. • Conduct selective coding to reach a theme of the codes. • Check the meaning of the categories and the accuracy of the codes.
Step 4: Check the IOC of the first version of the CSPM.	• Five experts were asked to check the IOC (Appendix C, Table A1) of the CSPM through the correspondence between the codes and components of metacognition.
Step 5: Revise the CSPM.	• Researchers revised codes according to the experts' suggestions.

Table 1. *Cont.*

Step	Description
Step 6: Differentiate codes in the CSPM into three different levels.	• Researchers differentiated the codes into three levels of metacognition: high, medium, and low.
Step 7: Check the IOC of the second version of the CSPM.	• Five experts were asked to check the IOC (Appendix C, Table A2) of the CSPM through the correspondence between the codes and levels of metacognition.
Step 8: Conduct back translation and reach the final version of the CSPM.	• Two language experts were asked to participate in the back translation process in order to check the clarity and accuracy of the languages used.

From step one: Determine a theoretical framework of metacognition, as in Table 1. Referring to [9], the term "metacognition" referred to an individual's awareness and consideration of his or her own cognitive processes and strategies. Since then, a variety of interpretations have been provided regarding the term "metacognition", which makes this term "fuzzy" [49]. This being the case, metacognition is not universally defined. Based on [8,9,50], metacognition refers to an individual's ability to monitor, regulate, and orchestrate their cognitive processes to attain a particular objective. Metacognition generally consists of two main components: (1) metacognition knowledge (knowledge of cognition) and (2) metacognition regulation (regulation of cognition) [8,10–12].

Referring to [8,51], there are two components of metacognition: (1) Metacognitive knowledge refers to what a person knows about his or her own cognitive processes [8,52–54] or the strategies a person uses to oversee his or her own learning. This component consists of three subcomponents: declarative knowledge, procedural knowledge, and conditional knowledge. In addition, metacognition regulation refers to essential skills/actions that authorize an individual person to control their own learning. This component consists of three subcomponents: planning, monitoring, and evaluating [8–10,32,55].

In summary, Figure 1 represented the theoretical framework of metacognition used in this study for the subsequent coding process. PSTs with metacognition, according to the theoretical framework of metacognition in this study, should possess metacognitive knowledge (MK) and metacognitive regulation (MR). Regarding MK, PSTs should possess declarative knowledge (DK), procedural knowledge (PK), and conditional knowledge (CK). In addition, PSTs should possess MR, which consists of planning, monitoring, and evaluating. The theoretical framework of metacognition, as shown in Figure 2, was then used as a basis to analyze all of the codes derived from the MS and MIP.

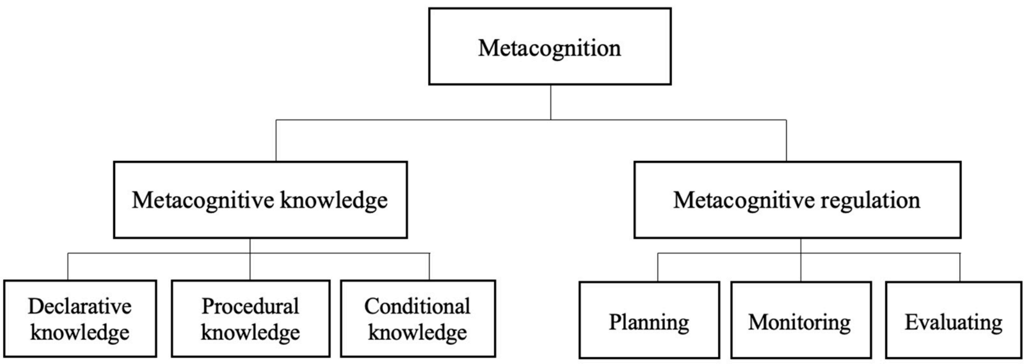

Figure 2. The theoretical framework of metacognition as a basis for analyzing the codes in the CSPM.

The description of each subcomponent of the theoretical framework of metacognition being used as a basis for analyzing the codes in the CSPM in this study are illustrated in Table 2.

Table 2. Descriptions of the subcomponents of the theoretical framework of metacognition.

Subcomponent	Description
Declarative knowledge (MC-DK)	Knowledge about one's own understandings, skills, and wisdoms as a learner, including an awareness of the various factors affecting his/her own learning process.
Procedural knowledge (MC-PK)	Knowledge about various methods or procedures and how to appropriately choose a specific method or procedure for solving a particular problem or accomplishing a particular learning goal.
Conditional knowledge (MC-CK)	Knowledge about the conditions potentially affecting one's learning.
Planning (MR-P)	Regulation of the prediction and preparation for accomplishing a particular learning goal.
Monitoring (MR-M)	Regulation of the monitoring of one's own learning and managing or controlling intellectual processes.
Evaluating (MR-E)	Regulation of collecting data, analyzing, and evaluating one's own learning performance.

3.2. RQ 2: What Is the Quality of the CSPM?

The researchers analyzed raw data obtained from 22 PSTs' MSs and MIPs according to the subcomponents of metacognition shown in Table 2. After that, the frequency of each subcomponent of metacognition was counted and calculated for its percentage. The results of the frequencies of each subcomponent of the CSPM are shown in Table 3.

Table 3. The frequencies of the subcomponents of the CSPM.

Subcomponent	Frequency	%
MC-DK	773	51.26
MC-PK	174	11.54
MC-CK	51	3.38
MR-P	302	20.03
MR-M	140	9.28
MR-E	68	4.51
Total	1508	100.00

There were 1508 codes in total derived from 22 PSTs' MSs and MIPs collected throughout 16 weeks of the method course. The three most frequent subcomponents were MC-DK (51.26%), MR-P (20.03%), and MC-PK (11.54%), respectively. After that, these codes were checked and the redundant codes were excluded until the number of codes was derived, as shown in Table 4.

Table 4. Number of codes after reducing the redundant codes in each subcomponent of the CSPM.

Subcomponent	Frequency	%
MC-DK	75	34.40
MC-PK	23	10.55
MC-CK	14	6.42
MR-P	36	16.51
MR-M	40	18.35
MR-E	30	13.76
Total	218	100.00

For Table 4, the first version of the CSPM consisted of 218 codes that could be allocated into six subcomponents of metacognition. The three most frequent subcomponents were MC-DK (34.40%), MR-M (18.35%), and MR-P (16.51%), in that order. The examples of raw data and how to code them according to each subcomponent of the CSPM are shown in Table 5.

The MC-DK 004 code was very popular for PSTs, it being expressed 99 times by them. The examples of the MC-DK 004 code expressed throughout the method course by PSTs are shown below.

From Table 6, it can be seen that codes of the MC-PK (f = 13), MC-DK (f = 10), and MR-E (f = 6) subcomponents were highly excluded from the second version of the CSPM.

Table 5. Examples of each subcomponent of the CSPM.

Subcomponent	Example of Raw Data	Assigned Code
MC-DK	I realized the importance of my prior knowledge that can hinder or support my learning every week.	MC-DK 004
MC-PK	I learned the way to find the answer to the question I'd like to know or did not understand by myself.	MC-PK 019
MC-CK	I have learned that I can find many solutions, not performing one way until not achieving and then stopping.	MC-CK 010
MR-P	I have learned that well-prepared teaching is very important. We must prepare all tools will be used in teaching beforehand.	MR-P 019
MR-M	During learning, I found that providing an opportunity for learners to conclude knowledge by themselves is an important part of their learning.	MR-M 029
MR-E	I obtain a better understanding of metacognition after I learn in this course.	MR-E 001

The MC-DK 004 code was very popular for PSTs, it being expressed 99 times by them. Examples of the MC-DK 004 code expressed throughout the method course by PSTs are shown below.

MC-DK 004: Realization of the importance of prior knowledge that can hinder or support PSTs' learning every week.

"*After this method course, I think that I am confident in integrating metacognition in my science teaching and learning*."(PST26, week three MS). Note: PST26 stands for PST no. 26.

"*I learned that some activities in science subject require good prior knowledge. What I have learned and experience before can help me learn the subject easier or more difficult or not*."(PST10, week 12 MS).

"*I rely on my prior knowledge and experience in helping me find out the answer of assigned problem*." (PST03, week two MS).

3.3. RQ3: What Is the Quality of the CSPM in Differentiating PSTs' Levels of Metacognition?

The 218 codes expressed in Table 5 were sent to five experts for the validation of their IOCs. After that, 41 codes with low IOCs, which were judged by a panel of experts, were excluded from the second version of the CSPM. Then, the number of codes in the second version of the CSPM was 177, as shown in Table 6.

Table 6. The number of codes in the second version of the CSPM.

Subcomponent	No. of Codes in the First Version of the CSPM	No. of Codes in the Second Version of the CSPM	No. of Codes Being Excluded
MC-DK	75	65	10
MC-PK	23	10	13
MC-CK	14	10	4
MR-P	36	33	3
MR-M	40	35	5
MR-E	30	24	6
Total	218	177	41

After that, the researchers differentiated all the codes in each subcomponent into three different levels of metacognition: high, medium, and low. The description of the codes in each subcomponent are shown in Table 7.

Table 7. Description of the high, medium, and low levels of metacognition in each subcomponent of the CSPM.

Subcomponent	Level	Description
MC-DK	High	The PST explicitly realizes, knows, and understands their own level of knowledge, including factors potentially affecting their development of knowledge and understanding.
	Medium	The PST can judge his/her knowledge and understanding without the realization of factors potentially affecting their development of knowledge and understanding.
	Low	The PST knows and understand things he/she has learned, or he/she knows only content they have learned.
MC-PK	High	The PST can identify a specific method or process as being effective in acquiring knowledge and learning. The PST can also effectively adjust a specific method or process to suit his/her own purpose of learning.
	Medium	The PST can identify a specific method or process to acquire knowledge or learning. He/she may try some methods, but they are not effective enough.
	Low	The PST can identify a specific method to acquire his/her own knowledge or learning.
MC-CK	High	The PST knows their own learning ability, the conditions of knowing and learning, and the conditions of the tasks that will effectively and appropriately lead him/her to knowledge and understanding.
	Medium	The PST knows their own learning ability, the conditions of knowing and learning, and the conditions of tasks; however, he/she cannot utilize these in an effective and appropriate way.
	Low	The PST knows the conditions of a task or strategy to accomplish the task, but is yet to implement it.
MR-P	High	The PST can predict a learning process and possible learning outcomes before performing a task. He/she can design a plan and choose an appropriate strategy for learning.
	Medium	The PST can predict or plan a learning process before performing a task; however, he/she cannot explain it in detail.
	Low	The PST can explain his/her plan that will be implemented in the future, but does not provide any detail.

Table 7. *Cont.*

Subcomponent	Level	Description
MR-M	High	The PST can perceive and judge his/her efficiency in performing a specific task. He/she can also explain his/her own method to monitor, check, and control cognitive or learning processes.
	Medium	The PST can perceive his/her efficiency in performing a specific task; however, he/she cannot clearly explain his/her own method to monitor, check, and control cognitive or learning processes.
	Low	The PST can perceive his/her efficiency in performing a specific task without any clarification.
MR-E	High	At the end of a learning process, the PST can evaluate his/her own success in learning, knowledge gained, and learning outcome achieved according to a specific learning objective, as well as provide supporting reasons.
	Medium	At the end of a learning process, the PST can evaluate his/her own success in learning, knowledge gained, and learning outcome achieved according to a specific learning objective, but he/she cannot provide supporting reasons.
	Low	At the end of a learning process, the PST does not evaluate his/her own learning.

Metacognition, as found in Table 6, was classified from experts' IOC results. There were 177 codes in the recorded data after revisions (excluded from the IOC results). However, MC-DK still had the highest number of codes (n = 65). At the same time, we found that MC-PK dropped rapidly, from n = 23 to n = 10.

The three different levels of codes in the CSPM were validated by a panel of five experts. The codes with low IOCs were excluded from the third version of the CSPM. In total, there were eight codes that were excluded, and the final number of codes in the third version of the CSPM was 169. Table 8 shows the number of codes in each level of metacognition of the CSPM. Of 169 codes, 54 (31.96%), 46 (27.21%), and 69 (40.83%) codes were categorized as high, medium, and low level of metacognition, respectively. Interestingly, the low level of metacognition was dominant among the three different levels of metacognition.

Table 8. The number of codes in each level of metacognition of the CSPM.

Subcomponent	No. of Codes in the Second Version	No. of Codes in the Third Version	No. of Excluded Codes	% of Codes in the Third Version	High Level		Medium Level		Low Level	
					Frequency	%	Frequency	%	Frequency	%
MC-DK	65	62	3	36.69	18	10.65	12	7.10	32	18.93
MC-PK	10	8	2	4.73	4	2.37	1	0.59	3	1.78
MC-CK	10	10	0	5.92	5	2.96	2	1.18	3	1.78
MR-P	33	32	1	18.93	11	6.51	9	5.33	12	7.10
MR-M	35	34	1	20.12	13	7.69	8	4.73	13	7.69
MR-E	24	23	1	13.61	3	1.78	14	8.28	6	3.55
Total	177	169	8	100.00	54	31.96	46	27.21	69	40.83

The detail of codes categorized into three different levels of metacognition in the CSPM can be shown, as in Table 9.

Table 9. Codes categorized into three different levels of metacognition in CSPM.

Subcomponent	High Level of Metacognition	Medium Level of Metacognition	Low Level of Metacognition	Frequency
MC-DK	MC-DK 01, 03, 04, 07, 10, 16, 21, 36, 37, 38, 40, 45, 47, 49, 52, 65, 66, and 69	MC-DK 24, 28, 39, 44, 51, 57, 58, 59, 60, 63, 64, and 70	MC-DK 02, 05, 06, 08, 09, 11, 12, 13, 14, 15, 17, 18, 19, 22, 23, 25, 26, 29, 31, 32, 33, 34, 35, 42, 43, 46, 48, 53, 54, 55, 62, and 68	62
MC-PK	MC-PK 06, 07, 17, and 19	MC-PK 23	MC-PK 01, 02, and 03	8
MC-CK	MC-CK 04, 05, 07, 10, and 12	MC-CK 06, 08	MC-CK 01, 02, and 03	10
MR-P	MR-P 05, 06, 13, 15, 21, 23, 24, 25, 30, 33, and 34	MR-P 03, 04, 09, 10, 14, 17, 18, 19, and 20	MR-P 01, 02, 07, 08, 11, 12, 22, 26, 27, 28, 29, and 32	32
MR-M	MR-M 01, 03, 04, 09, 10, 13, 14, 18, 20, 21, 30, 36, and 37	MR-M 02, 08, 11, 16, 17, 25, 33, and 35	MR-M 06, 07, 12, 15, 19, 22, 23, 26, 27, 28, 29, 31, and 32	34
MR-E	MR-E 07, 08, and 24	MR-E 01, 03, 04, 05, 06, 09, 10, 15, 17, 18, 19, 20, 25, and 26	MR-E 02, 12, 14, 23, 27, and 28	23
Total				169

The example of codes derived from PSTs' MSs and MIPs, which could be differentiated into three levels (high, medium, and low) of metacognition in the CSPM, are shown below.

High Level of Metacognition: MC-PK 019
PST learns to find the answer they did not understand by themselves.

"*I learned by myself until I can understand the content of the lesson. I finally can synthesize it to become my own understanding*." (PST07, week one MS).

"*I went back to my home and tried to resolved what I tied to learn. If I am still unclear, I will find another way to solve that such as asking a teacher, a friend, or searching from Internet*." (PST0, MIP).

Medium of Metacognition: MC-PK 023
PST learns from question and answer.

"*I learned through Q&A among a teacher and my friends in classroom*." (PST14, week one MS).

Low of Metacognition: MC-PK 003
PST learns from explanation and example provided by a teacher.

"*I learned to understand things by listening from explanation from a teacher*." (PST05, week 10 MS).

"*I learned from teacher explaining and giving me an example*." (PST17, week nine MS).

"*I learned from PPT slide that teacher presented*." (PST19, MIP).

The 169 codes of the third version of the CSPM were submitted to two language experts to conduct back translation. At the end, three codes were removed from the 169 codes of the third version of the CSPM because they may lead to the misunderstanding or misinterpretation of metacognition. Therefore, the final version of the CSPM consisted of 165 codes. Four codes were excluded in this process: MC-DK23,58, MR-M02, and MR-P23, as shown in Table 10.

Table 10. Final version of the CSPM.

Subcomponent	Frequency	%
MC-DK	60	36.36
MC-PK	8	4.85
MC-CK	10	6.06
MR-P	32	19.39
MR-M	33	20.00
MR-E	22	13.33
Total	165	100.00

4. Discussions and Conclusions

This study presents eight steps for developing a CSPM that may be useful for other educators or science educators through its application in specific educational contexts and purposes. In particular, in the context of science teacher education, these eight steps are effective in analyzing raw data from qualitative methods until reaching the final code list of the CSPM. The eight steps necessary to construct the CSPM majorly highlight the content validity of the codes. Several techniques are used to check the CSPM's validity, as the IOCs are judged by a panel of experts.

The codes derived from the raw data from PSTs' MSs and MIPs in this study come from an inductive process in nature that is regarded as a basic approach for qualitative data analysis. This may be one characteristic that is different from other coding schemes proposed by other studies that may originate from a deductive approach. In any case, the CSPM was constructed qualitatively (in other word, inductively) from this study; it requires further implementation with the deductive approach, especially in contexts of science education. The deductive approach will verify the CSPM and may provide some useful codes or dimensions of PSTs' metacognition. Through this complete process, the CSPM will be more useful in the context of the development of science teachers.

There is a lack of research instruments used to explore research participants' metacognition, especially in the context of PSTs. The two qualitative data collection methods employed in this study are self-reports, through the MS, and interviews, through the MIP. These two methods work very well in exploring PSTs' metacognitive knowledge and metacognitive regulation aligned with [36]. The MS is suitable for collecting data about metacognition from a person with high writing ability and/or writing preference [55]. On the other side, the MIP is also effective for a more in-depth exploration of PSTs' metacognition by directly asking PSTs about the details of what he/she thinks and how he/she acts in a particular learning context [56]. This study confirms the effectiveness of combining both methods into the same study, especially for collecting raw data about metacognition that are then regarded as a reservoir for constructing a good and valid coding scheme.

The development of PSTs' metacognition and ability to teach science by integrating metacognition is the original passion of this study. Noticeably, the CSPM shows that a majority of the PSTs in this study possess a low level of metacognition. This is a major concern for us as teacher educators, and it is necessary that this is fixed as soon as possible. Science teachers with a low level of metacognition may face difficulties in developing their students' metacognition, which may subsequently affect students' learning and impede the development of students into lifelong learners [57]. This is consistent with [58], who mentioned that various researchers utilize metacognition as a key variable in terms of students' development in learning. In addition, the development of metacognitive knowledge and processes can improve students' conceptual understanding of targeted conceptions [58]. Therefore, PSTs' levels of metacognition can be explored by the CSPM, and this information will be taken into account as a valuable input of PST development throughout the university program. In addition, PSTs may develop their metacognition by learning to think of answering MSs and MIPs about teaching and learning in science by integrating metacognition. In this way, the CSPM may be regarded as one effective tool to help to improve the sustainable development of teaching and learning science.

5. Limitations and Future Research

Researchers who are interested in developing a coding scheme for exploring or measuring research participants' metacognition can apply the eight steps utilized to construct the CSPM in this study in their future research. The utilization of the CSPM in exploring, evaluating, and monitoring PSTs throughout their teacher education programs may be one challenging research question for us as teacher educators. The inclusion of a deductive approach to fulfill the complete picture of the CSPM is also suggested for future research.

The readers of this article should be kindly reminded that generalization is not a focus of this study, as the main research approach is qualitative in nature.

However, increasing the number of participants may help increase the diversity of the codes from PSTs. The unique type of research participants may affect the transferability of the findings of this study. The application of the CSPM in other educational contexts is one recommendation of this study.

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Appendix A. Metacognitive Self-Report (MS)

(Metacognitive knowledge)

Q1: What have you learned in the last week and how much did you understand the content?

(Metacognitive regulation)

Q2: What is your goal for learning this week?

Q3: What are the difficult things this week that you learned? Give an example/explain a case in which you faced the problem.

Q4: From this week, what is an important thing that you should remember?

Appendix B. Metacognition Interview Protocol (MIP)

(Perspective or views in this course)

Q1: How was your experience in this course? Could you explain?

(Metacognitive regulation)

Q2: How did you prepare yourself for study before/during a class? (MR-P)

Q3: Are you knowing yourself when you face any difficulties learning in this course? (MR-M)

(Metacognitive knowledge)

Q4: What are the challenging things in this course? (MC-D)

Q5: How can you pass this? (MC-C)

Q6: How did you study in this course? (MC-D)

Q7: Did you change the strategies to learn or not? If changed, why? (MC-C)

(Metacognitive Regulation)

Q8: Do you have any feedback or suggestion for this course? (MR-E)

Q9: Did you understand more as your own wording from this course? (MR-E)

Appendix C

Table A1. IOCs of the CSPM.

Code	IOC	Result
KC-DK	0.6–1.00	Qualified
KC-PK	1.00	Qualified
KC-CK	0.8–1.00	Qualified
RC-P	0.8–1.00	Qualified
RC-M	0.6–1.00	Qualified
RC-E	0.8–1.00	Qualified

Table A2. IOCs of the CSPM differentiate.

Code	IOC	Result	Excluded (Code)
KC-DK	0.4–1.00	Qualified	3
KC-PK	0.4–1.00	Qualified	2
KC-CK	0.8–1.00	Qualified	0
RC-P	0.4–1.00	Qualified	1
RC-M	0.4–1.00	Qualified	1
RC-E	0.4–1.00	Qualified	1

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