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Research Article

Pre-service Science Teachers' Professional Learning Through Content Representations (CoRes) Construction

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Abstract

This study aims to develop preservice science teachers' PCK for teaching science throughout Content representations (CoRes) construction activity of teacher professional development program. Research participants are three 5th year preservice science teachers from department of General Science, faculty of Education, Phuket Rajabhat University. Park and Oliver (2008) PCK conceptualization was used as a theoretical framework in this research. And, Content representations (CoRes) by Loughran et al. (2004) was employed as a research instrument in the lesson preparation process in order to elicit and portray teacher's PCK for teaching science. Data are collected from the first preservice science teachers' CoRes design for teaching a given topic and student grade. Science student teachers are asked to create CoRes for teaching in topic 'Motion in one direction' for 7th grade students. The second CoRes designs are created for teaching their own lesson in school practicum. The development of preservice science teachers' PCK for teaching science represent from the analysis of CoRes design. The instances of preservice science teachers' PCK in aspects of science curriculum and student' s understanding of science is articulated and portrayed during lesson preparation using CoRes design. The resultant CoRes design and discussions indicate that the process of CoRes construction does have potentials for preservice science teachers' PCK development.

Keywords:

Pedagogical content knowledge, preservice science teacher

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Introduction

Pedagogical content knowledge (PCK) is an essential kind of knowledge that teachers have for teaching particular content to particular students for enhance student understanding. Hence, teachers with adequate PCK can give content to their student in the suitable way rather than directly transfer subject matter knowledge to learner. Teacher preparation programs in Thailand aim to enhance teacher professional knowledge in order to enhance quality of education according to the 1999 National Education Act and Amendment (No. 2) of 2002 (ONEC, 2002). Because teacher has crucial influence on student learning, so the development of teacher preparation and teacher education system are key factors for a successful education in Thailand (IPST, 2002). Teacher professional knowledge for teaching has dramatically greatest impact improving student achievement and performance as well as educational system (Knight, 2012). In addition, teacher' s competency for teaching were estimated from many aspects such as teacher' s pedagogy knowledge, teacher' s self-efficacy etc. Teacher educators created the consensus academic construct for applied in teacher professional development.

Pedagogical content knowledge (PCK) was widely accepted and referred as the teacher' s competency in teacher education. The quality of teacher was established from teacher education program and teacher professional development program, so the development of teachers' PCK in order to enhance student academic achievement. The findings of many studies have showed that preservice science teachers have limited level of PCK because of their lack of classroom experience Lederman, Gess-Newsome, & Latz, 1994). Thus, the implementations of PCK notion in science teacher preparation and teacher professional development programs should be emphasized recently (Attakorn, Tayut, Pisitthawat, & Kanokorn, 2014). The conceptualizations of PCK are applied in various educational research contexts as well as in Thailand. Nuangchalerm (2016) investigated preservice science teachers' understanding of PCK from their lesson plans and classroom practices. This study showed that preservice science teachers have adequate content knowledge but they still unable to applied their PCK to create learning objectives, assessment tools, learning activities and scientific content. These results were correlated to the other studies of Thai science teachers that revealed the importance and requirement of promoting preservice teacher' s professional knowledge of teaching in aspects of PCK. In addition, Institution of Promote Science and Technology (IPST) recently promoting teaching and learning science for self-learning, so science teachers are required to have sufficient PCK for teaching science as the subject-specific professional knowledge for teaching in order to transform scientific content knowledge in the understandable form for learners (Yuenyong & Thathong, 2015; Wongsila & Yuenyong, 2019). Loughran et al. (2004, 2006) developed research instrument for capturing science teachers' PCK from lesson preparation and classroom practices that consisting of Content Representations (CoRes) and Pedagogical and Professional-experience Repertoires (PaP-eRs) (Loughran, Mulhall, & Berry, 2004; Loughran, Berry, Mulhall, & Woolnough, 2006). CoRes specifically related to the aspects of PCK and the essential concepts of a specific science topic (e.g., the important science contents, students' alternative conceptions, ways of assessment for student understanding, and ways of teaching to support student learning). PaP-eR offers insights into teachers' knowledge about teaching and learning of specific content in a particular student grade level and portraying teachers' knowledge about science teaching to be more explicit form. However, only PaP-eR does not completely demonstrate the complicated knowledge relevant to a specific content. Thus, a collection of PaP-eRs associated with different aspects of the CoRes design is used to identifying the particular elements of PCK in that field . Several researchers have applied CoRes and PaP-eRs as approaches for analysis of experienced science teachers' PCK to uncover their implicit knowledge about teaching science (Hume & Berry, 2011). A few studies have also used these methods with preservice science teachers (Nilsson & Loughran, 2012). In summary, CoRes is design to portray teachers' possible PCK component and support the development of science teachers' PCK in many studies. Thus, the analysis of the progression in preservice teachers' PCK by involving them in constructing their own CoRes were recently important.

In this study used PCK as the conceptual framework for supporting preservice science teachers' professional learning about teaching science and further improving their teaching practices in school practicum. The objective of this research was to enhance preservice science teachers' PCK for teaching science throughout the construction of CoRes design.

Shulman proposed an academic construct called pedagogical content knowledge (PCK) to embrace the knowledge bases for teaching that teachers possess and how they implement into teaching (Shulman, 1987). PCK is used as an important conceptualization to understand and develop teacher professional knowledge. Kind (2009) described that PCK is very useful for depicting and portraying to teacher educators and other teachers into experienced teachers' classroom practice (Kind, 2009). Teacher educators developed and proposed comprehensible PCK models for subject-specific teaching from the original Shulman' s notion of PCK. The mostly applied PCK model for teaching science was developed by Magnusson as subject-specific PCK clarification that enable teachers to support students' understanding of science (Magnusson, Krajcik, & Borko, 1999; Schneider & Plasman, 2011). PCK model for teaching science is composed of five components including: knowledge of orientation toward science teaching; knowledge and belief about science curriculum; knowledge of students' understanding of science; knowledge of instructional strategies; and knowledge of assessment in science, respectively. Although there is still have contradiction in the literature concerning the nature of PCK and its components. This study adopted the PCK model of Magnusson et al. (1999) for identifying the nature and extent of any PCK development in preservice science teachers. Magnusson et al. described PCK as "the transformation [emphasis in original] of several types of knowledge for teaching" (p.95), including subject matter knowledge, pedagogical knowledge, and knowledge about the context. However, this model doesn't include neither subject matter knowledge nor pedagogical knowledge in this model. They considered these knowledge bases as the sources for the development of PCK, but not the components of PCK. This PCK conceptualization for teaching science has been developed by Park and Oliver and widely used as the theoretical framework for analysis of science teacher's PCK shown in Figure 1 (Park, & Oliver, 2008b).

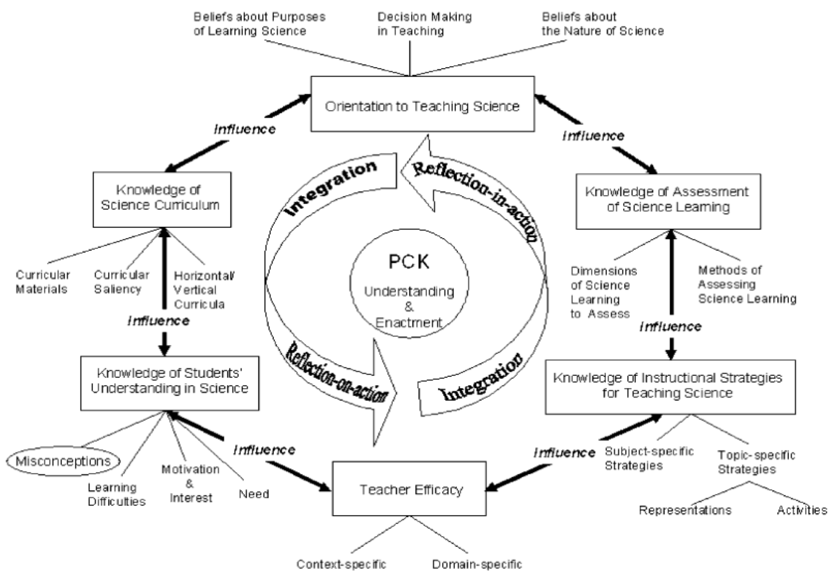

Figure 1.
Hexagon Model of Pedagogical Content Knowledge for Teaching Science

Hexagon model of PCK for teaching science consists of six interacting components of PCK: (1) orientations toward teaching science, (2) knowledge of science curriculum, (3) knowledge of students' understanding of science, (4) knowledge of assessment, (5) knowledge of instructional strategies, and (6) teacher' s efficacy. The latest PCK component is added into this PCK model because of its important influence on teacher competency and further support to the student learning achievement.

However, the internal and tactic nature of PCK required teacher to describe their own professional knowledge, research tools for teachers to reflect about their teaching practice is widely used in teacher education. Teacher educators created and developed research instruments to explore and evaluate teacher' s PCK, for example, Content Representations (CoRes), Inquiry Content Representation (I-CoRe), Pedagogical content knowledge in biology inventory (PCK IBI) etc. (Garritz, Labastida-Piña, Espinosa-Bueno & Padilla, 2010; Großschedl, Welter, & Harms, 2018). CoRes is the effective research instrument that widely applied because this instrument offer way for teacher to carefully consider about their teaching practice during the lesson preparation process.

Method

Participants

Research participants were three 5th year preservice science teacher (PST) from department of General Science, faculty of Education, Phuket Rajabhat University. In this five-year program curriculum preservice teachers study coursework for four years and one-year practical teaching in school. All of participating teachers were female, Sunny, Mary, and Downy (pseudonyms) at age about 21 to 23. Before the school practicum in the fifth year, preservice science teachers were required to complete subject matter courses (e.g., Principle of Physics, Biochemistry, Fundamental Mathematics, Earth Science etc.), general pedagogical courses (e.g., Classroom Management, Curriculum etc.), and subject-specific pedagogical courses (e.g., Methods of Science Teaching, Creating Instructional Media in Science, Science Classroom Action Research etc.). This study conducted the professional development workshop during their first semester of school practicum.

Data Collection

CoRes Construction Activity In Professional Development Workshop

During the school practicum, preservice science teacher attended Teaching Internship Seminar at university, the professional development workshop afterward this seminar was designed according to their problem and needs from their teaching practices. At the beginning of CoRes construction activity, CoRes was introduced to preservice science teachers (PST) as a useful tool for lesson planning. First, researcher explained about Big Idea and pedagogical questions (CoRes prompts) that developed from original CoRes template (Loughran, Berry, Mulhall, & Woolnough, 2006; Adadan & Oner, 2014). Secondly, PSTs created CoRes design for teaching on topic 'Force and Motions' to 7th grade students. For teaching particular science concept, preservice science teachers created the important science concept called Big Ideas and then write down on the top of CoRes template table in Table 1. PSTs completed CoRes prompts about what they considered to be important science concepts for teaching these Big Idea and wrote down in the CoRes template.

The participants responded to the pedagogical prompts in the table form: (1) Why is it important for students to know this concept? (2) What is your knowledge about students' thinking that influences your teaching of this concept? (3) What else do you know about this concept that you do not intend students to know yet? (4) What are some other difficulties (except student thinking) or limitations associated with teaching this concept? (5) What kind of instructional methods or strategies would you use to teach this concept? (6) How would you assess students' understanding of this concept? (7) What are your teaching procedures (focus to the reasons for using these to engage student to inquire this idea)? (8) How would you assess students' understanding of this concept?

Table 1.

Content Representations (CoRes) Framework

Year level for which this CoRes is designed:	**Important science concepts (Big idea)**	
CoRes questions	**Big Idea**	**Big Idea** ....
1. Why is it important for students to know this concept?		
2. What is your knowledge about students' thinking that influences your teaching of this concept?		
3. What else do you know about this concept that you do not intend students to know yet?		
4. What are some other difficulties (except student thinking) or limitations associated with teaching this concept?		
5. What kind of instructional methods or strategies would you use to teach this concept?		

6. Are there any other factors that influence your teaching of this idea?	
7. What are your teaching procedures (focus to the reasons for using these to engage student to inquire this idea)?	
8. How would you assess students' understanding of this concept?	

In the first section of professional development workshop PSTs created CoRes design for teaching the given topic that further collected as the evidence of preservice teachers' initial PCK. The instances of first PST's PCK were portray and elucidated from CoRes design for teaching in their classroom context. Secondly, after PSs completed all CoRes design, then university instructor provided individual feedback and suggestions of their lesson preparation from CoRes design. After the presentation of PSTs' CoRes designs, the group discussion were conducted and analyzed for PSTs' views on CoRes construction activity.

In the last section of CoRes construction activity, PSTs completed the second CoRes design for teaching their own lesson. These CoRes designs were further interpreted for the development of PST' s PCK for science teaching from lesson preparation process.

Data Analysis

Data analysis and data interpretation from the first and second PSTs' CoRes design as well as group discussion were conducted using Content analysis method. PST' s PCK for science teaching were collected from multiple data sources including interview schedule, VDO recording of group discussion, teaching worksheet, and CoRes design. PST' s PCK were qualitatively analyzed according to PCK model for teaching science. The instances of PCK component from PST' s CoRes design and other related data were individually analyzed based on the Hexagon model of PCK for science teaching (Park, & Oliver, 2008b). The five components of PCK for science teaching were including: (1) orientations toward teaching science, (2) knowledge of science curriculum, (3) knowledge of students' understanding of science, (4) knowledge of assessment, (5) and knowledge of instructional strategies were applied as an analytical framework. Data interpretation aimed to explaining of PSTs' PCK development from CoRes construction activity of this professional development workshop.

Results

The examples of Mary, Sunny, and Downy' s possible PCK components represented from their first and second CoRes designs. The instances of each PSTs' PCK for teaching science were described as follow.

The Case of Mary

Mary created Big Ideas in the wrong sequence of subtopics and the mismatch level of scientific concepts that showed her limited knowledge of science curriculum to transfer contents for student understanding. The example of Big Ideas from Mary' s first CoRes design in Table 2.

Table 2.

Mary's Creation of Big Ideas

Big Idea I: Vector quantity	Big Idea II: Scalar quantity	Big Idea III: Force	Big Idea IV: Moving object
a) Magnitude b) Direction c) Velocity d) Displacement	a) Time b) Distance c) Accelerate d) Length	a) Friction force b) Symbol c) Force to object	a) Object moves to the same direction b) Object moves to the opposite direction c) The movement

From the 7th CoRes question of the second CoRes design, Mary designed activity to explain the concepts of Co-ordination of Sun and directions for supporting student understanding. In addition, she also explains the correlation of the related concepts and advance topics. This indicate Marina' s knowledge of science curriculum (PCK component 2).

From the 2nd CoRes question, Mary described a usage of Star map to find direction and navigating and also designed learning activity that related with student everyday life. This indicated Mary's knowledge of student' s understanding of science (PCK component 3) that students can easily understand from the similarity of daily life and scientific knowledge. This result is correlated with the modified worksheet that Mary created for her classroom in Figure 1.

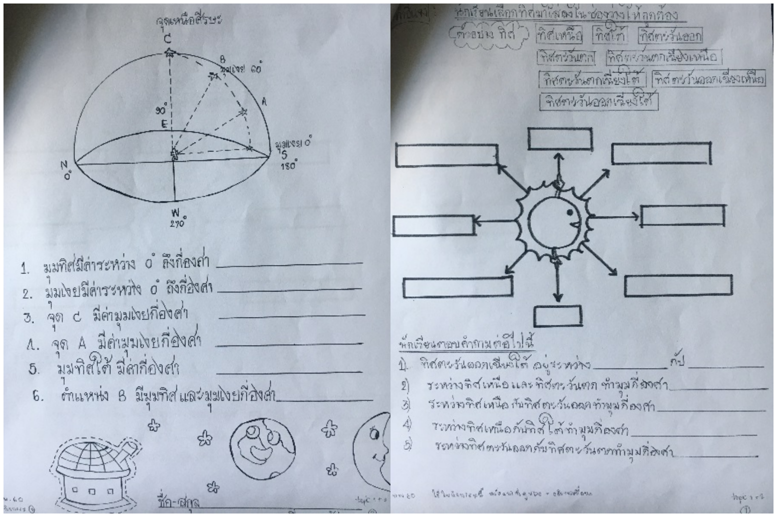

Figure 1.

Mary' s Modified Worksheets for Teaching Directions and Co-ordination of Star

The Case of Sunny

The Big Ideas for teaching Force and Motion are the important science concepts that linked with the more complicated and related advance concepts that student will learn in next grade level called vertical curriculum. This data indicated to Sunny' s knowledge of science curriculum in lesson preparation (PCK component 2).

In the second CoRes design, Sunny arranged four Big Ideas differently from subtopics in science school textbook because this set of important science concepts may support student understanding. During the workshop the development of Sunny' s PCK for teaching science examined from her response CoRes questions. From the 1st CoRes question Sunny explained about the purpose of teaching in topic of the first Big Ideas (Origin and life cycle of Star) was for student to further apply in learning the fourth topics (Color and temperature of Planet). These data represented Sunny' s knowledge of purpose and goals for teaching science (PCK component 1) and knowledge of student' s understanding of science (PCK component 3).

The Case of Downy

In the first CoRes construction, Downy was confronted with the confused hierarchy of science concepts to arrange Big Ideas.

> *At first, I confused about the level of topics which one should teach first and then which topics I should teach after that...which topics were smaller or subset of the other topics. I*

> *tried to listed all related important concepts write it on post-it paper and arrange them into coverage content and sequenced. After I got the correct order I put Big Ideas in linkage like concept mapping and then rewrite Big Ideas. I used different colored pen to grouping these topics into the different level I used red and blue color for main topics and purple for subtopics. (Group discussion)*

This finding showed the development of Downy' s knowledge of science curriculum (PCK component 2) in the creation of Big Ideas.

In the second CoRes design for teaching in topic of Heat energy for grade 7 student, Downy described the relationship between daily life and scientific content in the learning objective of the 2nd CoRes question. She mentions about asking student about the situation of Changing the state of matter (Big Ideas 3) in student daily life. This finding showed Downy' s knowledge of student' s understanding from their experiences in daily life (PCK component 3).

Discussion and Conclusion

From the beginning of this study preservice science teachers had inadequate level of professional knowledge for science teaching. Teacher professional development workshop was created and designed for enhance their PCK for teaching science. All of participating teachers developed their PCK in aspects of science curriculum and student' s understanding of science. In addition, during group discussion preservice science teachers shared their views on the process of CoRes construction, they mentioned about an important of student's prior knowledge and related science concepts of teaching particular content that different from a traditional lesson planning. Several science educators have used CoRes design as a PCK-capturing approach to uncover teachers' implicit knowledge about teaching science (Loughran, Mulhall, & Berry, 2004; Nilsson, & Loughran, 2012).

In summary, the instances of preservice science teachers' PCK for teaching science were captured and analyzed from the development of their CoRes designs. PSTs created Content representation (CoRes) for prepare lesson of the given topic and their own teaching practices that they applied their PCK components about teaching context and student learning. Through multiple data sources, it is examined how preservice science teachers' PCK for teaching science have changed over the CoRes constructions activity, and manifests itself in their classroom practice. In addition, there are the evidences of particular components of PSTs' PCK for science teaching are demonstrated in this study.

Teacher professional workshop offers preservice science teachers to reconsider about their teaching practices and modified teaching procedure and learning activity for their actual classroom. CoRes construction activity with the supportive approach that suitable for preservice science teachers and novice science teachers to improve their PCK for teaching science in a restricted time (Loughran, Mulhall, and Berry, 2008). This approach would allow preservice science teachers to begin accessing and accumulating some of the professional knowledge of experienced science teachers and would enhance their confidence and competence when they begin to build their own knowledge of PCK (Hume & Berry, 2011). In addition, this study is correlated to the other study that enhance innovative thinking of Thai preservice teachers using Six steps of learning activities (Wisetsat & Nuangchalerm, 2019) and content knowledge of Thai novice preservice science teachers (Nuangchalerm, & El Islami, 2018). Furthermore, these results are supported with the important of pedagogical decision in teacher preparation program that required in Educational reform of Thailand (Prachagool, Nuangchalerm, Subramaniam, & Dostál, 2016). The implementation of this study that can be applied as a guideline for design teacher preparation programs and improve preservice teacher professional learning.

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