ความพร้อมด้านความรู้ในเนื้อหาผนวกวิธีสอนทางคณิตศาสตร์ของนักศึกษาครู

The Readiness in Mathematics Pedagogical Content Knowledge of Pre-service Teachers

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บทคัดย่อ

นักศึกษาครูคือคนที่จะไปเป็นครูในอนาคต ดังนั้นนักศึกษาครูจึงควรได้รับการพัฒนาความรู้ในด้านเนื้อหาและความรู้ทางด้านวิชาชีพครูอย่างเหมาะสม รวมถึงการบูรณาการความรู้ทั้งสองเพื่อการสอนอย่างมีประสิทธิภาพ การสำรวจความพร้อมด้านความรู้ในเนื้อหาผนวกวิธีสอนทางคณิตศาสตร์ของนักศึกษาครูจะช่วยให้สถาบันผลิตครูได้ทราบความต้องการของนักศึกษาครู เพื่อจะได้ช่วยเหลือนักศึกษาครูก่อนการฝึกประสบการณ์วิชาชีพ ดังนั้นการศึกษานี้มีวัตถุประสงค์เพื่อสำรวจการรับรู้ของนักศึกษาครูเกี่ยวกับความพร้อมด้านความรู้ในเนื้อหาผนวกวิธีสอนทางคณิตศาสตร์ก่อนการฝึกประสบการณ์วิชาชีพ การศึกษานี้เป็นการวิจัยเชิงปริมาณ กลุ่มที่ศึกษาเป็นนักศึกษาครูจำนวน 15 คนที่กำลังศึกษาอยู่ในชั้นปีสุดท้ายก่อนการฝึกประสบการณ์วิชาชีพในสถาบันผลิตครูแห่งหนึ่ง ผู้วิจัยเก็บรวบรวมข้อมูลโดยใช้แบบสอบถามออนไลน์ ที่ถูกพัฒนาให้สอดคล้องกับกรอบความรู้ในเนื้อหาผนวกวิธีสอนทางคณิตศาสตร์ที่นำเสนอโดย Senk และคณะ (2008) การวิเคราะห์ข้อมูลใช้สถิติเชิงพรรณนากับสถิติเชิงเปรียบเทียบ ผลการศึกษาชี้ให้เห็นว่านักศึกษาครูค่อนข้างเห็นด้วยว่านักศึกษาครูมีความพร้อมด้านความรู้ในเนื้อหาผนวกวิธีสอนทางคณิตศาสตร์ก่อนการฝึกประสบการณ์วิชาชีพในทั้งสามด้าน และไม่มีความแตกต่างในเรื่องความพร้อมด้านความรู้ในเนื้อหาผนวกวิธีสอนทางคณิตศาสตร์ก่อนการฝึกประสบการณ์วิชาชีพระหว่างนักศึกษาครูที่เลือกสอนในระดับชั้นที่แตกต่างกัน

คำสำคัญ: ความรู้ในเนื้อหาผนวกวิธีสอนความรู้ในเนื้อหาผนวกวิธีสอนทางคณิตศาสตร์ นักศึกษาครู ความพร้อม

Abstract

Pre-service teachers are expected to be the future teachers. They should be prepared appropriate content knowledge and pedagogical knowledge as well as know how to integrate them for effective teaching. An exploration of pre-service teachers' readiness in mathematics PCK will provide the teacher preparation program information about their need in order for assisting them before taking field experience. Therefore, the purpose of this study is to explore pre-service teachers' perceptions regarding their readiness in mathematics PCK before taking field experience. This study is a quantitative research. The participants of the study were 15 pre-service teachers studying in a mathematics teacher preparation program. They were in the final semester of their coursework before student teaching. An online questionnaire was used to collect the data. Each statement was developed in accordance with mathematical PCK presented by Senk *et al.* (2008). The descriptive and comparative statistics were employed to analyze the data. The findings indicate that the pre-service teachers slightly agree that they have readiness in mathematics PCK before taking field experience in all three sub-domains. Also, there is no significantly difference in readiness in mathematics PCK between pre-service teachers who chose to teach in different levels.

Keywords: pedagogical content knowledge, mathematics pedagogical content knowledge, pre-service teachers, readiness

Introduction

It is widely known that teachers are important to students' learning. Teachers must know the subject they teach, and they must know how to teach it (Ball et al., 2009). Pre-service teachers are expected to be the future teachers. Teacher preparation program should help pre-service teachers gain appropriate contents and assist them to integrate content and pedagogical knowledge for effective teaching (Cooney, 1999). The National Council of Teachers of Mathematics (NCTM) suggests that teacher preparation programs in mathematics must help pre-service teachers develop solid knowledge of content (NCTM, 2000). This expectation includes teaching pre-service teacher not only to understand mathematics contents but also to construct perspectives of pedagogy because "effective teaching requires knowing and understanding mathematics, students as learners, and pedagogical strategies" (NCTM, 2000, p.17). This statement relates to Shulman's (1987) idea about balance and integration between content knowledge and pedagogy which is called "*pedagogical content knowledge (PCK)*". PCK is a salient component of teacher knowledge that should be examined with regard to teacher effectiveness.Senk, Peck, Bankov, and Tatto (2008) divide mathematics PCK into three theoretical sub-domains: mathematical curricular knowledge, knowledge of planning for mathematics teaching and learning, and enacting mathematics for teaching and learning as described in Table 1.

Table 1 *Sub-domains and Aspects of the Sub-domain of Mathematics PCK (Senk et al., 2008, p.5)*

Mathematical curricular knowledge	• Establishing appropriate learning goals • Knowing different assessment formats • Selecting possible pathways and seeing connections within the curriculum • Identifying the key ideas in learning programs • Knowledge of mathematics curriculum
Knowledge of planning for mathematics teaching and learning	• Planning or selecting appropriate activities • Choosing assessment formats • Predicting typical students' responses, including misconceptions • Planning appropriate methods for representing mathematical ideas • Linking didactical methods and instructional designs • Identifying different approaches for solving mathematical problems • Planning mathematical lessons
Enacting mathematics for teaching and learning	• Analyzing or evaluating students' mathematical solutions or arguments • Analyzing the content of students' questions • Diagnosing typical students' responses, including misconceptions • Explaining or representing mathematical concepts or procedures • Generating fruitful questions • Responding to unexpected mathematical issues • Providing appropriate feedback

A common challenge for teacher preparation programs is to prepare teachers to apply knowledge and understanding learned from courses to the real classroom. Field experience provides an opportunity for pre-service teachers to apply theory that they learned to the real-setting situations. Before having field experience, teacher preparation programs need to ensure that the pre-service teachers are well prepared and ready to teach mathematics to students. An exploration of pre-service teachers' readiness in mathematics PCK will help teacher preparation program know pre-service teachers' need before taking field experience and can assist them directly to the point. Therefore, the purpose of this study is to explore pre-service teachers' perceptions regarding their readiness in mathematics PCK before taking field experience. The following research questions are addressed:

(1) Do the pre-service mathematics teachers who are going to take field experience have the readiness in mathematics pedagogical content knowledge?

(2) Are there differencesof pre-service teachers' readiness in mathematics PCK amongthree sub-domains -- mathematical curricular knowledge, knowledge of planning for mathematics teaching and learning, and knowledge of enacting mathematics for teaching and learning?

(3) Are there differences of pre-service teachers' readiness in mathematics PCK among pre-service teachers who chose to teach different levels: lower elementary (Grade 1-3), upper elementary (Grade 4-6), lower secondary (Grade 7-9), and upper secondary level (Grade 10-12)?

Method

Participants

Participants of this study were pre-service teachers in a mathematics teacher preparation program who were in the final semester of coursework and would be enrolled in field experience course in 2014 academic year. As shown in Table 2, there were 15 pre-service mathematics teachers who agreed to participate in this study: one male and fourteen females. Pre-service teachers in this teacher preparation program can choose to teach in a grade level ranged from Grade 1-12 as their interest. There were three pre-service teachers (20%) choosing to teach lower elementary level (Grade 1-3), five pre-service teachers (33.3%) choosing to teach upper elementary level (Grade 4-6), six pre-service teachers (40.0%) choosing to teach lower secondary level (Grade 7-9), and one pre-service teacher (6.7%) choosing to teach lower secondary level (Grade 10-12). Their grade average point ranged from 2.62 to 3.75 (M = 3.31, SD = 0.31).

Table 2 *Demographic Data of Participants*

	N	Percentage
Gender		
Male	1	6.67
Female	14	93.33
Total	**15**	**100.00**

Table 2 *Demographic Data of Participants (ต่อ)*

	N	Percentage		
Teaching level				
Lower elementary (Grade 1-3)	3	20.00		
Upper elementary (Grade 4-6)	5	33.33		
Lower secondary (Grade 7-9)	6	40.00		
Upper secondary (Grade 10-12)	1	6.67		
Total	**15**	**100.00**		
	Min	**Max**	**Mean**	**SD**
Grade Point Average	**2.62**	**3.75**	**3.31**	**0.31**

Procedures

This study is a quantitative research. An online questionnaire was employed as an instrument to explore the pre-service teachers' perception regarding their readiness in mathematics PCK. Researcher sent out an email to request the participants to administrate the questionnaire. The participants had two weeks to complete the questionnaire after it was sent out. The researcher used descriptive and comparative statistics to analyze the data.

Instruments

By exploring the readiness of pre-service teachers about their mathematics PCK before taking field experience, researcher adapted a questionnaire developed by Maluangnont (2012). The questionnaire consists of two parts: readiness of pre-service teachers section, and demographic data section. The first part is a six-level Likert-type scale. There were 24 statements. Each statement was developed in accordance with mathematics PCK presented by Senk et al. (2008). The mathematics PCK was separated into three sub-domains: (1) mathematical curricular knowledge, (2) knowledge of planning for mathematics teaching and learning, and (3) knowledge of enacting mathematics for teaching and learning. The participants were asked to rate their degree of agreement or disagreement in each statement. The data generated from this part were analyzed by using descriptive statistics to examine pre-service teachers' perception regarding their readiness in mathematics PCK. One-way repeated measures ANOVA analysis was used to determine if there was a significant difference in the responses of pre-service teachers among three sub-domains of mathematics PCK and one-way ANOVA analysis was completed to determine if there was a significant difference in the responses between pre-service teachers who chose to teach different levels. The second part aims to explore participants' demographic data which consisted of their gender, grade point average, and the level that they chose to teach in field experience.

Results

To answer the research questions, pre-service mathematics teachers were asked to respond regarding their readiness in mathematics PCK separated into three sub-domains: (1) mathematical curricular knowledge, (2) knowledge of planning for mathematics teaching and learning, and (3) knowledge of

enacting mathematics for teaching and learning. The results were reported related to the research questions.

Research question 1 and 2. Do the pre-service mathematics teachers who are going to take field experience have the readiness in mathematics PCK?, and are there differences of pre-service teachers' readiness in mathematics PCK among three sub-domains of?

Disaggregated data from the questionnaire was analyzed to determine pre-service teachers' perceptions of their readiness in mathematics PCK before taking field experience. Overall, pre-service teachers rated all statements as slightly agree (M = 4.13, SD = 0.47). It meant that they slightly agreed that they have readiness in mathematics pedagogical content knowledge. As shown in Table 3, pre-service teachers also rated that they slightly agreed that they have mathematical curricular knowledge (M = 4.20, SD = 0.57), knowledge of planning for mathematics teaching and learning (M = 4.12, SD=0.54), and knowledge of enacting mathematics for teaching and learning (M = 3.94, SD = 0.42). The results of the one-way repeated measures ANOVA shown in Table 3 did not indicated a statistically significant difference in pre-service teachers' readiness in these three sub – domains (F(1.33,18.60)=2.79, p = 0.10).

Table 3 *Comparison of pre-service teachers' views on Readiness in Three Sub-domains of Mathematics PCK*

Sub-domain of Mathematics PCK	M	SD	F	df	p
Mathematical curricular knowledge	4.20	0.57	2.79	1.33, 18.60	0.10
Knowledge of planning for mathematics teaching and learning	4.12	0.54			
Knowledge of enacting mathematics for teaching and learning	3.94	0.42			

Table 4 provides the pre-service teachers' response to 24 statements regarding their readiness in mathematics pedagogical content knowledge. The pre-service teachers agreed with the statements, "*I have knowledge about mathematics curriculum*", "*I can prepare a lesson plan for a lesson they have to teach"*, and "*I understand about various formats of assessment in mathematics classroom"*. They also slightly agreed with the statements, "*it is difficult to represent mathematical concepts*" and *"it is difficult to respond to unexpected questions of students"*.

Table 4 *Pre-service Teachers' Perception on Readiness in Mathematics PCK*

Item	Frequency (Percentage)						Mean
	Strongly disagree	Disagree	Slightly disagree	Slightly agree	Agree	Strongly agree	
(1) Mathematical Curricular Knowledge							
I have knowledge about mathematics curriculum.	0 (0.0)	0 (0.0)	2 (13.3)	7 (46.7)	3 (20.0)	3 (20.0)	4.47
I can identify key ideas of each lesson.	0 (0.0)	0 (0.0)	1 (6.7)	9 (60.0)	4 (26.7)	1 (6.7)	4.33
It is difficult to establish learning goals of mathematics contents in the curriculum.	1 (6.7)	6 (40.0)	3 (20.0)	3 (20.0)	1 (6.7)	1 (6.7)	3.00
I can see connections between mathematics topics in the curriculum.	0 (0.0)	0 (0.0)	2 (14.3)	9 (64.3)	3 (21.4)	0 (0.0)	4.07
I know about different kinds of assessment formats explained in the curriculum.	0 (0.0)	0 (0.0)	4 (26.7)	7 (46.7)	3 (20.0)	1 (6.7)	4.07
(2) Knowledge of Planning for Mathematics Teaching and Learning							
I can prepare a lesson plan for a lesson I have to teach.	0 (0.0)	0 (0.0)	1 (6.7)	3 (20.0)	7 (46.7)	4 (26.7)	4.93
It is hard to create new mathematics activities by myself.	0 (0.0)	2 (13.3)	5 (33.3)	8 (53.3)	0 (0.0)	0 (0.0)	3.40
I can select appropriate activities to enhance students' learning.	0 (0.0)	0 (0.0)	1 (6.7)	9 (60.0)	5 (33.3)	0 (0.0)	4.27
I do not know how to teach mathematics by using various kinds of activities.	1 (6.7)	5 (33.3)	4 (26.7)	4 (26.7)	1 (6.7)	0 (0.0)	2.93
I have problem in selecting appropriate questions to ask students.	0 (0.0)	6 (40.0)	5 (33.3)	3 (20.0)	1 (6.7)	0 (0.0)	2.93
I cannot predict students' responses to my questions.	1 (6.7)	4 (26.7)	6 (40.0)	2 (13.3)	2 (13.3)	0 (0.0)	3.00
I cannot predict possible misconceptions of students.	1 (6.7)	3 (20.0)	6 (40.0)	4 (26.7)	1 (6.7)	0 (0.0)	3.07
I cannot identify different approaches for solving mathematical problems.	0 (0.0)	6 (40.0)	3 (20.0)	3 (20.0)	3 (20.0)	0 (0.0)	3.20

Table 4 *Pre-service Teachers' Perception on Readiness in Mathematics PCK (ต่อ)*

Item	Frequency (Percentage)						Mean
	Strongly disagree	Disagree	Slightly disagree	Slightly agree	Agree	Strongly agree	
I understand about various formats of assessment in mathematics classroom.	0 (0.0)	0 (0.0)	1 (6.7)	7 (46.7)	6 (40.0)	1 (6.7)	4.47
I can choose appropriate assessment formats.	0 (0.0)	0 (0.0)	1 (6.7)	9 (60.0)	5 (33.3)	0 (0.0)	4.27
It is not easy to use different formats to assess students' learning.	0 (0.0)	5 (33.3)	4 (26.7)	6 (40.0)	0 (0.0)	0 (0.0)	3.07
(3) Knowledge of Enacting Mathematics for Teaching and Learning							
It is difficult to represent mathematical concepts.	0 (0.0)	1 (6.7)	7 (46.7)	5 (33.3)	2 (13.3)	0 (0.0)	3.53
It is easy to explain mathematical procedures.	0 (0.0)	0 (0.0)	5 (33.3)	10 (66.7)	0 (0.0)	0 (0.0)	3.67
I can generate fruitful questions.	0 (0.0)	0 (0.0)	2 (13.3)	12 (80.0)	1 (6.7)	0 (0.0)	3.93
I can analyze content of students' questions.	0 (0.0)	0 (0.0)	3 (20.0)	9 (60.0)	3 (20.0)	0 (0.0)	4.00
It is difficult to respond to unexpected questions of students.	0 (0.0)	3 (20.0)	2 (13.3)	7 (46.7)	3 (20.0)	0 (0.0)	3.67
If I do not have enough time to think, I would not answer students' questions.	7 (46.7)	3 (20.0)	1 (6.7)	2 (13.3)	2 (13.3)	0 (0.0)	2.27
I can diagnose students' misconception in their classroom activity.	0 (0.0)	1 (6.7)	2 (13.3)	9 (60.0)	2 (13.3)	1 (6.7)	4.00
I can evaluate students' mathematical solutions.	0 (0.0)	0 (0.0)	1 (6.7)	8 (53.3)	6 (40.0)	0 (0.0)	4.33

*Percentages within columns appear in parentheses below frequencies

Research questions 3. Are there differences of pre-service teachers' readiness in mathematics PCK among pre-service teachers who chose to teach different levels: lower elementary (Grade 1-3), upper elementary (Grade 4-6), lower secondary (Grade 7-9), and upper secondary level (Grade 10-12)?

As shown in Table 5, the results of the one-way ANOVA did not indicated a statistically significant difference in readiness in mathematics PCK ($F(3,11) = 0.09$, $p = 0.96$)among pre-service teachers who chose to teach lower elementary level ($M=4.05$, $SD = 1.03$), upper elementary level ($M = 4.13$, $SD=0.35$), lower secondary level ($M=4.20$, $SD = 0.31$), and higher secondary level ($M = 3.97$, $SD = 0.00$).

Table 5 *Comparison of Readiness in Mathematics PCK of Pre-service Teachers Who Chose to Teach Different Levels*

Teaching level	N	M	SD	F	df	p
Lower elementary level	3	4.05	1.03	0.09	3,11	0.96
Upper elementary level	5	4.13	0.35			
Lower secondary level	6	4.20	0.31			
Upper secondary level	1	3.97	0.00			

Discussion

This study explored pre-service teachers' perceptions regarding their readiness in mathematics PCK before taking field experience. The quantitative finding of the exploration indicated that the pre-service teachers slightly agreed that they have readiness in mathematics PCK in all three sub-domains before taking field experience. Also, there is no significant difference in readiness in mathematics PCK among pre-service teachers who chose to teach different levels.

Instead of *agree* or *strongly agree*, the pre-service teachers slightly agree that they have readiness in mathematics PCK. There is a body of research indicating that student achievement is directly to teachers' background knowledge (Darling-Hammond & Branford, 2005; Heritage & Vendlinski, 2006). Therefore, a rating of "slightly agree" in terms of readiness in mathematics PCK is concerning. Future research is needed to determine the connection between student achievement and pre-service teachers' perception of their readiness in mathematics PCK.

In addition, the pre-service teachers responded that they slightly agreed in the statement, *"it is difficult to represent mathematical concepts"* and *"it is difficult to respond to unexpected questions of students"*. The pre-service teachers still have had less experience in teaching so they might not be confident in their ability to handle unexpected situations. Therefore, to make the pre-service teachers more confident, the courses before taking field experience that more emphasize and provide them teaching experiences is necessary.

There were some limitations concerning this study. The small sample size of pre-service mathematics teachers who were purposively selected from a teacher preparation program might reduce the generalizability of the results. Furthermore, the data of this study relied on participants' self-perception on their readiness as a proxy to indirectly determine their readiness in mathematics PCK. Therefore, in order to gain more authentic information about their mathematics PCK, other means of data gathering such as classroom observation and interview should be considered in future research studies in this area.

References

Ball, D. L., Thames, M. H., Bass, H., Sleep, L., Lewis, J., and Phelps, G. 2009. **A practice-based theory of mathematical knowledge for teaching.** In M. Tzekaki, M. Kaldrimidou and H.Sakonidis (Eds.) *Proceedings of the 33rd Conference of the International Group for the Psychology of Mathematics Education,* 1, 95-98, Thessaloniki, Greece: PME.

Cooney, T. J. 1999. **Conceptualizing teachers' ways of knowing.** In D. Tirosh (Ed.), Forms of Mathematical Knowledge: Learning and Teaching with Understanding. **Educational Studies in Mathematics**, *38* (1/3), 163-187.

Darling-Hammond, L. and Bransford, J. (Eds.). 2005. **Preparing teachers for a changing world: What teachers should learn and be able to do**. San Francisco: Jossey Bass.

Heritage, M., and Vendlinski, M. 2006. **Measuring Teachers' Mathematical Knowledge. (CSE Technical Report 696)**. In National Center for Research on Evaluation, Standards, and Student Testing (CRESST).

Maluangnont S. 2012. **Readiness in mathematics pedagogical content knowledge of Thai pre-service teachers.** Unpublished manuscript.

National Council of Teachers of Mathematics. 2000. **Principles and standards for school mathematics.** Reston, Virginia: National Council of Teachers of Mathematics.

Senk, S. L., Peck, R., Bankov, K., and M.T. Tatto. 2008. **Conceptualizing and measuring mathematical knowledge for teaching: Issues from TEDS-M, an IEA cross-National study.** Prepared for Topic Study Group 27 (Mathematical knowledge for teaching) of the 11th International Congress on Mathematical Education.

Shulman, L. S. 1987. Knowledge and Teaching: Foundations of the new reform. **Harvard Educational Review**, 57 (1), 1-22.