Pedagogical and Content Knowledge (PCK) in Problem Solving of Pre-Service Teachers

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ABSTRACT

This descriptive research aimed to determine the level of pedagogical and content knowledge (PCK) and the least-learned competencies in problem-solving Heuristics. The respondents were the pre-service teachers who have taught mathematics subjects during their practice teaching where purposive sampling was employed. The result showed that BSED math majors have low while the BEED have very low knowledge on problem – solving Heuristics. The most common strategy used by the pre-service teachers in solving problems were algebraic approach or using equation, making an organized list and drawing a diagram. In terms of Pedagogical Content Knowledge, the BSED has low pedagogical knowledge, high content knowledge and average pedagogical content knowledge while the BEED has low pedagogical knowledge, average content knowledge, and low pedagogical content knowledge. As a whole, the pre-service teachers have low pedagogical knowledge, average content knowledge, and low pedagogical content knowledge. Pre-service teachers need to be competent in their ability to teach mathematics subject to various classes of students specifically on problem solving. Knowledge on content and pedagogy has a significant role during the teaching and learning process. Thus, the pre-serve teachers must have deep mathematical understanding and adequate conceptual and procedural knowledge of the different problem-solving Heuristics so that they can transmit this to their students when they are in the field.

Keywords: Pedagogical, Content Knowledge, Problem Solving

INTRODUCTION

Guimaras State College is one of the prestigious State Universities and Colleges (SUC) in Region VI. The college is composed of different departments offering several courses. One of the department is the College of Teacher Education (CTE) offering Bachelor of Secondary Education (BSED) and Bachelor of Elementary Education (BEED). The pre-service teachers are on the job training in the second semester. These pre-service teachers are expected to teach in the basic education of the Department of Education (DepEd). Thus, they are also expected to be equipped with necessary knowledge and skills in terms of content and pedagogy to become more confident and be an effective teacher in the near future. To become an effective teacher is to have a good foundation of the knowledge of the content applying appropriate pedagogies. The Institution for Educational Leadership (2001) declared that “student learning depends first, last, and always on the quality of teachers”.

In the teaching of mathematics, the most common attitude of students is negative towards problem solving. They find problem solving difficult as claimed by most mathematics teachers. This is maybe because they are used to do computations rather than using their analytical and critical thinking. They are more exposed to solve routine problems using equations and algorithm for the solution. They are not familiar with other problem solving strategies known as heuristics. The study of Pescuela (2006) showed that students who used heuristics in problem solving has a better performance than those who used algebraic approach.

Low performance of the students especially in problem solving is a resounding issue in the basic education. The study of Junsay (2015) showed that students have low performance in problem solving and critical thinking. The study of Saylo (2013) also showed that that students have fairly developed problem solving and critical thinking skills. If the teacher has limited knowledge of the content, how could you expect them to teach effectively?

A teacher’s knowledge on content and pedagogy has a significant role during the teaching and learning process.

However, the fact that teachers have sufficient content knowledge on a subject does not mean they can teach this subject effectively (Kahan, Cooper, & Bethea, 2003). Teachers must also have adequate knowledge about how to teach a lesson, how to transmit it to their students and to be aware of level of the students. Thus, adequate content knowledge is not sufficient on its own for effective teaching (Tanisli & Kose, 2013). That's why many researchers have focused on how teachers teach in their own field and reflect their content knowledge during the teaching and learning process in addition to having adequate content knowledge.

When the capabilities of a good teacher are considered, content knowledge comes to the forefront (Appleton, 2003). The selection of effective learning activities depends on many teaching activities such as asking productive questions and assessing the learning of the students, the teacher's knowledge on the subjects he/she will teach the students like a strong content knowledge. Kapyla, Heikkinen, & Asunta (2009) indicated that teachers who have inadequate content knowledge can transmit their deficient knowledge to their students and may fail to change the misconceptions or mistakes of the students and cannot use written sources critically.

Pre-service teachers need to be competent in their ability to teach mathematics subject to various classes of students. However, research has shown that becoming an effective mathematics teacher is a lengthy process. One way to advance pre-service teachers' knowledge of pedagogy and content on problem solving is through exposure to various problem solving strategies. When preparing pre service teacher's we need to identify important content knowledge needed for teaching, how the knowledge needs to be understood and how that knowledge should be learned in the classroom (Ball, 2000).

The main purpose of this research is to determine the pre-service mathematics teachers' pedagogical and content knowledge (PCK) on problem solving heuristics. The result will determine the content standards to be included in the training workshop that could increase the level of their problem solving heuristics knowledge on pedagogy and content of the subject in line with the K to 12 mathematics curriculum. Furthermore, this study also looks forward for the preparation of the pre-service teachers that is parallel to the new curriculum.

Statement of the Problem

This study was conducted to seek answers to the following question:

1. What is the knowledge level on problem solving heuristics of the pre-service teachers of Guimaras State College?
2. What is the level of Pedagogical and Content Knowledge (PCK) on problem solving heuristics of the pre-service teachers of Guimaras State College?
3. What training module can be developed to enhance the PCK on problem solving heuristics of the pre-service teachers of Guimaras State College?

Theoretical Framework of the Study

Social constructivism as theoretical framework shapes the meaning, purpose of research methodologies, and the interpretability of research findings (Crotty, 1998). The most significant base of social constructivism originated from Vygosky's (1978) social development theory and zone of proximal development (ZPD) theory. The major theme of his theories is that social interaction plays a fundamental role in the development of cognition. According to Vygotsky (1978), every function in the child's cultural development appears on the social level and on the individual level. This applies equally to voluntary attention, to logical memory, and to the formation of concepts.

From the social constructivist view, knowledge is not discovered, but constructed within individual minds through social interactions. We are situated within a social context and we share our everyday lives with others. Thus, our knowledge construction is either encouraged or constrained by social interactions, even though the knowledge construction is processed within our minds.

Along this line, teaching as a professional practice is also a social practice in that teachers' work is embedded not only in a specific problem context but also in a specific social setting. Teachers build up a repertoire of context-specific knowledge through social interaction, negotiation, and co-construction of meaning, with

different social contexts providing different inputs into the individual's construction of a personal framework of understanding (Barnett & Hodson, 2000). Thus, the knowledge of teaching that teachers develop is intimately related to the specific social situations, interactions, and communities which have generated, validated, maintained, and used it. In this sense, social interaction with others is a part of the personal and social construction and reconstruction of knowledge of teaching (Bell, 1998).

This theory Pedagogical Content Knowledge (PCK) was imparted to literature by Shulman (1986). PCK has become a research focus of teacher trainers and researchers from many countries in recent years as an approach which defines teachers' effective technology integration knowledge (American Association of Colleges for Teacher Education (AACTE, 2008). Shulman believed that future teachers need more than just a content knowledge and a generalised knowledge of pedagogy in order to become an effective teacher.

Shulman (1986), described PCK as the way content, pedagogy, and knowledge of students are blended into understanding about how particular topics are taught, represented, and adapted to students' characteristics, interests, and abilities. In terms of PCK, teachers must to know how to teach their subject matter in a way that engages students extensively in tasks that require understanding. To achieve this objective, teachers must first learn to identify students' reasoning difficulties in the specific subject matter domain. Second, teachers must know how to plan lessons or didactic materials to explicitly treat these difficulties. Third, teachers need to know how to implement a curriculum that addresses higher-order understanding. Finally, teachers should know that successful implementation involves a considerable change in teachers' roles. The traditional teacher-centred role of acting as a source of knowledge should be replaced by student-centred learning by highlighting the role of initiating and coaching students' inquiries and problem solving (Zohar & Schwartzer, 2005). Such learning principles require self-knowledge and beliefs, motivation, goals, and strategy knowledge, and is indicative of self-regulation in learning.

Conceptual Framework of the Study

Teachers must have various types of knowledge that they need to know different representations of the concepts, allow students to understand the concepts taught in the best way, and also enable them to understand the mistakes that the students make. This knowledge refers to Pedagogical Content Knowledge (PCK) created by Shulman (1986). It is a type of knowledge that includes the different representation of concepts, the strongest analogies, examples, descriptions and explanations that will ensure the understanding of a subject (Shulman, 1986). PCK is among the requirement that teachers must have (Kleickman et al., 2013). Pre-service teachers must have a strong foundation of PCK on problem solving heuristics. The researcher believed that through training module, they may enhance their skills.

There are different problem solving Heuristics suggested by Polya such as drawing a diagram /picture, making an organized lists, looking for a pattern, guess and check, using a model, working backwards, writing an equation, using a formula, and act it out.

The least mastered skills in problem solving heuristics were the main focus of the training module.

Research Paradigm

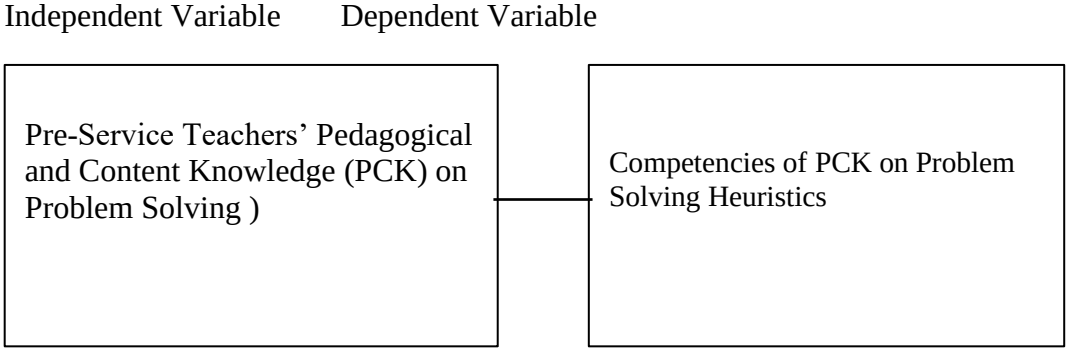

Figure 1. Shows the research paradigm

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METHODOLOGY

Participants

This study was participated by the 13 pre-service teachers taking up Bachelor of Secondary Education major in Mathematics and 11 Bachelor of Elementary Education both in the Salvador Campus and Mosqueda Campus enrolled in the College of Teacher Education.

Instruments

The researcher utilized the researcher-made Problem solving heuristics test and pedagogical and content knowledge (PCK) test. All instruments underwent face and content validation by the panel of experts in the field of mathematics. The mathematics achievement test was pilot tested to the first year BSED major in mathematics and underwent reliability testing.

Problem solving heuristics test. This researcher-made test on problem solving heuristics will be composed of 10 items routine and non-routine problem solving test that will measure the participant's content knowledge of problem solving heuristics. This problems involves solutions using heuristics such as drawing a diagram /picture, making an organized lists, looking for a pattern, guess and check, using a model, working backwards, writing an equation, using a formula, and act it out.

To interpret the scores, the researcher used a problem solving rubric and will utilize the following scales and descriptions:

Scale	Description
48.01 – 6000	Very high knowledge
36.01 – 48.00	High knowledge
24.01 – 36.00	Average knowledge
12.01 – 24.00	Low knowledge
0 – 12.00	Very low knowledge

Pedagogical and Content Knowledge (PCK) Test. This researcher-made test on Pedagogical and Content Knowledge (PCK) was designed to determine the pre-service teachers pedagogical and content knowledge on problem solving heuristics. The final instrument was composed of 30 items multiple choice test categorized into three domains; pedagogical knowledge, content knowledge, and pedagogical and content knowledge. The pedagogical and content knowledge test has reliability coefficient of .834 through Kuder-Richardson (KR20).

To interpret the scores, the researcher utilized the following scales and descriptions:

Scale	Description
8.01 - 10.00	Very high PCK
6.01 - 8.00	High PCK
4.01 – 6.00	Average PCK
2.01 – 6.00	Low PCK
0 – 2.00	Very low PCK

Data Collection Procedure

The researcher first conducted an assessment and determined the level of pre-service teachers PCK on problem solving heuristics. The level of pre-service teachers PCK on problem solving heuristics were the basis of

designing a training module to enhance PCK of the pre-service teachers. A training module will be developed by the researcher as output of this research endeavour.

RESULTS AND DISCUSSIONS

The level of Heuristics knowledge of the pre-service teachers was analysed using the mean score. Data in Table 1 shows that the level of pre-service teachers' Heuristics knowledge was low as a whole. This shows that the pre-service teachers do not have enough knowledge on the different problem-solving strategies. When classified according to course, the BSED math majors have low while the BEED have very low knowledge on problem – solving Heuristics. This result confirms the study of Junsay (2016) and Saylo (2016) that students have low performance in problem solving.

The BSED has a level higher than the BEED maybe because they have more math subjects than the BEED. But still this result shows that they were not much exposed to different problem-solving heuristics.

Out of 13 BSED math majors, 7 or 53.85 % have very low Heuristics knowledge while 6 or 46.15% have low Heuristics knowledge. On the other hand, all 11 or 100% BEED have very low Heuristics knowledge.

The most common strategy used by the pre-service teachers in solving problems were algebraic approach or using equation, making an organized list and drawing a diagram. It shows that the using equation is on the top most maybe because most textbooks or reference books used this strategy.

Table 1. Level of Pre-service Teachers' Heuristics Knowledge

Course	Mean	N	Std. Deviation	Description
BSED	12.31	13	2.95	Low
BEED	4.45	11	2.11	Very Low
Overall	8.71	24	4.74	Low

Scale: 48.01 - 60 (Very High Heuristics Knowledge), 36.01 – 48.00 (High Heuristics Knowledge) 24.01 – 36.00 (Average Heuristics Knowledge), 12.01 – 24.00 (Low Heuristics Knowledge), 0 – 12.00 (Very Low Heuristics Knowledge)

The level of Pedagogical Content Knowledge of problem-solving Heuristics was analysed in terms of pedagogical knowledge, content knowledge, and pedagogical content knowledge. The pedagogical knowledge of problem-solving Heuristics of the BSED pre-service teachers was low. This implies that they have limited knowledge when it comes to how to carry out solutions to a problem. In terms of content knowledge, they have a high content knowledge on problem-solving Heuristics. This shows that they have a high conceptual understanding of different strategies in problem-solving. Moreover, the BSED pre-service mathematics teachers have an average pedagogical content knowledge on problem-solving Heuristics. This means that their conceptual and procedural knowledge on solving problems are at acceptable level.

The pedagogical knowledge on problem-solving Heuristics of the BEED pre-service teachers was low. This means that they have also limited knowledge when it comes to how to solve a problem. In terms of content knowledge, they have average content knowledge on problem-solving Heuristics. This shows that they have an acceptable conceptual understanding of different strategies in problem-solving. The BEED pre-service teachers have a low pedagogical content knowledge on problem-solving Heuristics. This means that their conceptual and procedural knowledge on solving problems are below acceptable level.

As a whole, the pedagogical knowledge on problem-solving Heuristics of the pre-service teachers was low. This implies that their knowledge on how to solve a problem is at lower level. The result further revealed that they have an average content knowledge on problem-solving Heuristics. This shows that they have an acceptable conceptual understanding in problem-solving Heuristics. The pre-service teachers have a low pedagogical

content knowledge on problem-solving Heuristics. This can be deduced that their conceptual and procedural knowledge on solving problems are below acceptable level.

The percentage distribution of the respondent was also analysed. Out of 13 BSED math majors, 1 or 7.69% have high Pedagogical and Content Knowledge, 11 or 84.62% have average Pedagogical and Content Knowledge, while 1 or 7.69% have low Pedagogical and Content Knowledge. On the other hand, out of 11 BEED, 1 or 9.09% have average Pedagogical and Content Knowledge while 10 or 90.91% have low Pedagogical and Content Knowledge.

Table 2. Level of Pre-service Teachers' Pedagogical and Content Knowledge

Course	Mean	SD	Description
BSED *(n=13)*			
Pedagogical Knowledge	4.00	1.00	Low
Content Knowledge	6.31	1.18	High
Pedagogical and Content Knowledge	5.46	1.20	Average
BEED*(n=11)*			
Pedagogical Knowledge	2.64	0.92	Low
Content Knowledge	4.55	0.93	Average
Pedagogical and Content Knowledge	3.64	0.92	Low
Total			
Pedagogical Knowledge	3.38	1.17	Low
Content Knowledge	5.50	1.38	Average
Pedagogical and Content Knowledge	4.63	1.41	Average

Scale: 8.01-10 (Very High PCK), 6.01 – 8.00 (High PCK), 4.01 – 6.00 (Average PCK) 2.01 – 4.00 (Low PCK), 0 – 2.00 (Very Low PCK)

CONCLUSION

Pre-service teachers need to be competent in their ability to teach mathematics subject to various classes of students specifically on problem solving. Teachers who have inadequate content knowledge can transmit their deficient knowledge to their students and may fail to change the misconceptions or mistakes of the students and cannot use written sources critically (Kapyla, Heikkinen, & Asunta, 2009). Ball (2000) stressed that to have better PCK, one need to have a deep mathematical understanding of the concept. Knowledge on content and pedagogy has a significant role during the teaching and learning process. Thus, the pre-serve teachers must have deep mathematical understanding and adequate conceptual and procedural knowledge of the different problem-solving Heuristics so that they can transmit this to their students when they are in the field.

RECOMMENDATIONS

The following are recommended by the researcher:

1. By making use of the results of this research, teacher trainers and researchers in the field of education may develop training programmes for teachers to improve their conceptual and procedural knowledge on problem solving Heuristics.
2. Students are more exposed to solve routine problems using equations and algorithm for the solution. To

develop the students' positive attitude towards problem solving, it is recommended that the teachers may use different problem-solving heuristics.

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