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Mathematical Content Knowledge and Problem-Solving Skills of Preservice Teachers in the Era of Distance Learning

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A B S T R A C T

This cross-sectional correlational study examined the mathematical content knowledge and problem-solving skills of preservice mathematics teachers in the era of distance learning. The study involved 40 third-year mathematics preservice teachers in one state university in the Philippines, and respondents were selected using stratified random sampling. The findings revealed that most preservice teachers exhibited below-average content knowledge and problem-solving skills. The correlation between content knowledge and problem-solving skills was weak and statistically insignificant. The results highlight the urgent need to address the low levels of content knowledge and problem-solving skills among preservice mathematics teachers. Recommendations include comprehensive training and ongoing professional development opportunities for mathematics education students, focusing on explicit instruction in problem-solving strategies and integrating innovative instructional approaches and technology.

Keywords: preservice mathematics teachers, distance learning, content knowledge, problem-solving skills, mathematics teacher education

Introduction

The rise of the COVID-19 pandemic has disrupted teacher education and shifted to an emergency remote learning modality (Dilling & Vogler, 2022; Pourdavood & Song, 2021; Takunyaci, 2021). The sudden shift in distance learning posed challenges in mathematics pre-service teacher training. A sudden change does not exempt mathematics education from experiencing difficulties, as it traditionally centers on hands-on learning, demonstrations, and collaborative problem-solving (Hine, 2015; Nasution et al., 2022; Rodriguez et al., 2022).

Pre-service teachers utilized blended instruction during this learning modality to complete their core mathematics content courses (Nasution et al., 2022; Pourdavood & Song, 2021). There has been a noticeably significant shift in mathematics instruction from conventional face-to-face instruction. With the absence of face-to-face interactions, teacher candidates have limited opportunities to develop skills in developing content knowledge and problem-solving (Pourdavood & Song, 2021). Interactive problem-solving activities and experiential learning must be taught in person and become challenging to deliver remotely. In addition, most pre-service teachers learned most of their mathematical pedagogical training through distance learning; this highlights the concerns about the possible potential impact on the learning competencies that are fundamental for teaching. The knowledge of mathematical content and problem-solving skills are the springboard of mathematics instruction (Takunyaci, 2021).

Moreover, these skills will gauge pre-service teachers' confidence and readiness to teach mathematics (Hine, 2015). The interplay between mathematical content knowledge and problem-solving can be understated. The knowledge in solving mathematical problems is anchored on the depth and breadth of one's knowledge of mathematical content. The lack of knowledge and understanding of mathematical content can lead to difficulties in problem-solving as it limits one's ability to recognize, understand, and implement the mathematical concepts required to solve a problem (National Council of Teachers of Mathematics, 2000). However, limited research has specifically assessed the long-term effects of distance-focused training on pre-service teachers' mathematical content knowledge and problem-solving skills during the pandemic era.

Addressing this gap is crucial as it could help determine the necessary competencies not learned by pre-service teachers in distance learning that are essential as they enter the classroom. The current research aimed to ascertain the mathematical content knowledge and problem-solving skills of preservice teachers who experienced predominantly distant mathematics courses during their teacher training. The findings will enhance the preparation of new teachers for current and future educational contexts with more technology-mediated learning components.

Methodology

The current research employed a cross-sectional correlational study to ascertain the relationship between mathematical content knowledge and problem-solving skills of preservice mathematics teachers in the era of distance learning (Gall et al., 2006). The study's respondents were 40 third-year preservice

mathematics teachers in the last semesters of their academics at five different campuses in a single-state university in the Philippines. They were selected using stratified random sampling, which allowed for the inclusion of participants from different campuses that provided diverse perspectives among the respondents.

This study utilized two data-gathering instruments: a mathematical content knowledge test and a problem-solving skills test. A 30-item multiple-choice test was developed to assess the level of mathematical content knowledge of preservice teachers. The test consisted of topics on college and advanced algebra, trigonometry, plane and solid geometry, analytic geometry, logic and set theory, statistics and probability, calculus, arithmetic, number theory, and mathematics of investments. Meanwhile, the problem-solving skills test consists of a 30-item multiple-choice test covering various mathematical topics, including geometry, arithmetic, percentages, ratios and proportions, algebraic equations, word problems, and data analysis.

A table of specifications was prepared prior to the construction of the two tests. It underwent validation from panel experts and was pilot-tested with 30 fourth-year Bachelor of Secondary Education majors in Mathematics from different campuses of the same university. Both tests underwent reliability analysis using the KR20 coefficient, which yielded .818 for the mathematical content knowledge test and .904 for the problem-solving skills test, which made the instruments reliable. The original 50-item multiple-choice tests for both variables were trimmed to 30 items after they underwent item analysis.

The collected data were subjected to appropriate descriptive and inferential statistics using the Statistical Package for Social Sciences (SPSS) software.

Results and Discussions

Table 1 presents the distribution of scores among preservice mathematics teachers, who were categorized into five ranges based on their mathematical content knowledge. Most respondents fell to the below-average level, while 30% were at the average level. Furthermore, 15% of the respondents were above average, and only 12.50% had a superior level of mathematical content knowledge.

The mean score and standard deviation (M = 14.45, SD = 5.76) provide additional insight into the respondents' overall level and variability of mathematical content knowledge. The mean score within the range of 13-18 suggests that, on average, the preservice teachers demonstrated an average level of mathematical content knowledge.

The prevalence of below-average and average content knowledge levels among preservice mathematics teachers raises questions about the quality and depth of mathematical content knowledge gained in distance learning.

Table 1

Level of Content Knowledge of Preservice Mathematics Teachers

Range of Score	f	%	Level of Content Knowledge	M	SD
0-6	1	2.50	Poor	14.45	5.76
7-12	16	40.00	Below Average		
13-18	12	30.00	Average		
19-24	6	15.00	Above Average		
25-30	5	12.50	Superior		

Table 2 shows the distribution of scores on problem-solving skills among preservice mathematics teachers, which were categorized into five ranges. The results reveal that 7.5% of the respondents have poor problem-solving skills. Most participants (77.5%) are below-average level, while 15% have average problem-solving skills. There were no participants who achieved scores in the above-average or superior ranges. The mean score (M = 10.03, SD=2.59) shows the average problem-solving skills of preservice mathematics teachers. The result suggests that, as a collective, the group demonstrated a level of problem-solving skills below the average.

These results underscore the need for targeted interventions to enhance the problem-solving skills of these preservice mathematics teachers.

Table 2

Level of Problem-Solving Skills of Preservice Mathematics Teachers

Range of Score	f	%	Level of Problem-Solving Skills	M	SD
0-6	3	7.50	Poor	10.03	2.59
7-12	31	77.50	Below Average		
13-18	6	15.00	Average		

19-24	0	0.00	Above Average
25-30	0	0.00	Superior

Table 3 presents the correlation results showing the relationships between the mathematical content knowledge and problem-solving skills of preservice mathematics teachers. The correlation between mathematical content knowledge and problem-solving skills was positive but weak ($r = .161, n = 40, p = .321$). This suggests a small and non-significant association between preservice mathematical content knowledge and problem-solving skills.

Table 3

Relationship between Preservice Mathematics Teachers' Mathematical Content Knowledge and Problem-Solving Skills

Variables	n	r	p
Content Knowledge and Problem-Solving Skills	40	.161	.321

Conclusions

This research ascertained the mathematical content knowledge and problem-solving skills among preservice mathematics teachers in the era of distance learning. The investigation revealed that most preservice mathematics teachers exhibit below-average mathematical content knowledge and problem-solving skills. This result raises concerns about the quality of mathematics instruction produced in a distance learning setting.

The development of the preservice mathematics teachers' mathematical content knowledge and problem-solving skills may be challenging in a distance learning setting, as evidenced by the prevalence of below-average performance in these areas. There is a pressing need for targeted interventions among these preservice mathematics teachers who were a product of a distance learning modality to enhance their mathematical content knowledge and problem-solving skills.

Furthermore, the relationship is still weak and non-significant despite a positive correlation between mathematical content knowledge and problem-solving skills. This suggests further investigation of additional factors that may influence this result. The findings highlight the necessity of reevaluating and refining approaches to mathematics education, particularly in distance learning modality, to better equip preservice mathematics teachers with the necessary knowledge and skills for effective teaching and learning.

Recommendations

Preservice mathematics teachers with below-average mathematical content knowledge and problem-solving skills due to distance learning are recommended to seek supplemental learning opportunities to strengthen their mastery of mathematical concepts and skills before they take the licensure examinations for teachers. They may consider enrolling in review centers that provide extensive learning activities focusing on mastering mathematics content courses. They may also consider seeking additional learning materials or online sources that help build expertise in their areas of weakness. Preservice mathematics teachers may also consider enrolling in graduate to address any notable competency gaps. This ensures they obtain sufficient mathematics proficiency before delving into teaching.

Teacher education departments may consider reaching out to their graduates to offer free refresher courses on key mathematical concepts and problem-solving strategies to better prepare them for their licensure examinations and teaching in the field. To ensure quality instruction continues in the event of another period of mandatory distance learning, the department may ensure that they have varied online and offline instructional materials suited to diverse learners, conduct regular synchronous class sessions, and provide student support services to help with any technical or academic issues that may arise.

The research community may consider investigating additional factors like self-efficacy and access to resources that may influence preservice teacher development in these areas. They may also examine how instructional approaches, course designs, and distance learning models impact skill acquisition and analyze teacher preparation programs to identify gaps and strengths.

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