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The Effects of Pre-service Early Childhood Teachers' Pedagogical Content Knowledge in Mathematics and Constructivist Educational Belief on Mathematics Teaching Efficacy

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Abstract

The purpose of the study was to examine the effects of pre-service early childhood teachers' pedagogical content knowledge in mathematics and constructivist educational belief on mathematics teaching efficacy. The subjects were 187 pre-service early childhood teachers who enrolled in universities majoring early childhood education. We used self-reporting survey questionnaires to measure the major variables and utilized the SPSS 28.0 Program to analyze the collected data. Cronbach's alphas were calculated and the descriptive statistical analysis were conducted. To investigate the research questions, Pearson's correlation analysis and multiple regression analysis were done. As results, the higher the levels of pre-service early childhood teachers' pedagogical content knowledge in mathematics and constructivist educational beliefs, the higher their mathematics teaching efficacy. In addition, both pedagogical content knowledge in mathematics and constructivist educational belief were validated as the predictors of increased mathematics teaching efficacy of pre-service early childhood teachers.

Keywords: Pre-service Early Childhood Teachers, Mathematics Teaching Efficacy, Pedagogical Content Knowledge in Mathematics, Constructivist Educational Belief

1. INTRODUCTION

Early childhood is a critical period for the development of basic mathematical abilities through everyday experiences. Mathematical experiences and learning during early childhood have a significant impact on the subsequent development of mathematical abilities [1]. The 2019 Revised Nuri Curriculum in South Korea reflects the developmental importance of early childhood mathematics education through the category of 'Inquiry in Everyday Life' within the domain of 'Nature Exploration' [2]. Therefore, the role of early

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childhood teachers in providing learning experiences and environments to support the development of young children's mathematical abilities is crucial.

One of the key teacher variables that determine the quality of early childhood mathematics education is mathematics teaching efficacy. Early childhood teachers' mathematics teaching efficacy refers to their confidence in teaching mathematics [3]. The concept of teaching efficacy is based on Bandura's self-efficacy [4]. Self-efficacy is defined as a personal belief in one's capability to organize and execute courses of action required to attain designated types of performances [4]. Ashton applied the concept of self-efficacy to teachers' teaching efficacy [5]. Teaching efficacy is defined as the degree to which teachers believe they have the ability to affect student performance [5]. Among various internal beliefs and attitudes that influence teachers' teaching behaviors, teaching efficacy has been reported to consistently and continuously affect students' academic achievement and motivation as well as teachers' instructional behaviors in the classroom [5-6]. In other words, while teaching efficacy does not directly influence students' learning outcomes, it acts as a cognitive process mediating teachers' overt instructional behaviors, ultimately impacting students' achievement.

Furthermore, Dembo and Gibson proposed two sub-factors of teaching efficacy: general teaching efficacy or outcome expectancy and personal teaching efficacy or ability expectancy [7]. Similarly, early childhood teachers' mathematics teaching efficacy consists of two sub-factors: General mathematics teaching efficacy and personal mathematics teaching efficacy [8]. General mathematics teaching efficacy or outcome expectancy is the belief that appropriate mathematical knowledge and effective teaching methods influence early childhood mathematics education, while personal mathematics teaching efficacy or ability expectancy is the belief in one's ability to effectively guide early childhood mathematics education [8].

According to previous research, early childhood teachers with high mathematics teaching efficacy provide ample mathematical activities, create rich environments, use appropriate teaching strategies in practice, and engage in positive and active interactions with young children [9-10]. Thus, early childhood teachers' mathematics teaching efficacy is an essential factor in providing high-quality mathematical experiences that help develop young children's mathematical abilities. Therefore, it is necessary to investigate which variables would enhance early childhood teachers' mathematics teaching efficacy.

Meanwhile, early childhood teachers' beliefs such as teaching efficacy begin to form even before they become teachers. Generally, what early childhood teachers learn during their training in university significantly influences their future educational activities as teachers. Furthermore, once teaching efficacy as individual belief is formed, it is not easily changed. However, only a few studies have examined pre-service early childhood teachers' mathematics teaching efficacy. Therefore, this study aims to investigate mathematics teaching efficacy by focusing on pre-service early childhood teachers as the research subjects.

Variables influencing early childhood teachers' mathematics teaching efficacy can be broadly categorized into academic and personal factors. A representative academic factor is pedagogical content knowledge in mathematics. Pedagogical content knowledge in mathematics includes the content knowledge of mathematics and the pedagogical knowledge required to apply this knowledge in teaching practice [11]. Teachers' mathematical content knowledge is related to their instructional behaviors and influences teaching practices and students' mathematical achievement [12].

In the field of early childhood education, pedagogical content knowledge in mathematics has also been identified as an important variable influencing the practice of mathematics education. For example, Aubrey reported that early childhood teachers who were confident in their mathematical content knowledge planned and implemented rich and meaningful early childhood mathematics education [13]. Korean studies also found significant results regarding early childhood teachers' pedagogical content knowledge in mathematics and their mathematics teaching efficacy [14-16]. The positive correlations between two variables have been found with pre-service early childhood teachers as the subjects [17-19]. It has also reported that pre-service early childhood teachers' pedagogical content knowledge in mathematics is the significant variable in enhancing mathematics teaching efficacy [18, 19].

A representative personal factor influencing early childhood teachers' mathematics teaching efficacy is constructivist educational belief. Teachers' beliefs on education affect their teaching behaviors. Among early childhood teachers' educational beliefs, constructivist educational belief is noteworthy when considering the goals of the Nuri Curriculum, the national early childhood education curriculum in Korea. The goals of the

Nuri Curriculum are based on constructivism, which posits that children construct knowledge through active experiences with their environment. These goals are well reflected in child-centered and play-based instructional methods [2]. Constructivist educational belief is defined as the fundamental assumptions or belief that teachers holds regarding child development and learning, knowledge construction, teacher roles, and environment composition from a constructivist perspective [20].

Empirical studies have shown that early childhood teachers' constructivist educational beliefs are significantly positively correlated with teaching efficacy [21] and mathematics teaching efficacy [15, 22, 23]. Moreover, constructivist educational belief has been identified as a predictor of mathematics teaching efficacy [16, 23]. Although few study has been conducted on the relationship between pre-service early childhood teachers' constructivist educational belief and mathematics teaching efficacy, Chi and Kim proved a significant positive correlation between early childhood teachers' constructivist educational belief and their teaching efficacy in science which would be regarded as similar domain with mathematics [24]. Thus, this study aims to examine constructivist educational belief as the other variable that affect pre-service early childhood teachers' mathematics teaching efficacy.

Based on the previous studies, we paid attention to the importance of pre-service early childhood teachers' mathematics teaching efficacy and examined the related variable with it. The purpose of the study was to verify the relations between variables and to figure out the effects of pedagogical content knowledge in mathematics and constructivist educational belief on mathematics teaching efficacy. Through the results of the study, we expect to enhance the academic understanding of pre-service early childhood teachers' mathematics teaching efficacy and provide useful information for developing strategies to improve related variables at early childhood teacher training institutions. The specific research questions set for the purpose are as follows.

Research Question 1. What are the correlations of pre-service early childhood teachers' pedagogical content knowledge in mathematics, constructivist educational belief, and mathematics teaching efficacy?

Research Question 2. What are the effects of pre-service early childhood teachers' pedagogical content knowledge in mathematics and constructivist educational belief on mathematics teaching efficacy?

2. RESEARCH METHODS

2.1 Subjects

The subjects of this study were 187 students who enrolled in the department of early childhood education at universities located in Gyeonggi Province and Incheon Metropolitan City. The socio-demographic characteristics of the subjects are as follows. 92.5% ($n = 173$) were female and 7.0% ($n = 4$) were male. Their ages ranged from 18 to 25 years, with an average age of 19.81 years ($SD = 1.48$). The distribution by academic year was as follows: 38.0% ($n = 71$) were freshmen, 34.2% ($n = 64$) were sophomores, 13.4% ($n = 25$) were juniors, and 14.4% ($n = 27$) were seniors

Additionally, 36.9% ($n = 59$) of the subjects had taken or were taking the course 'Early Childhood Mathematics Education.' Furthermore, 17.2% ($n = 32$) had completed or were completing kindergarten practicum, and 42.7% ($n = 80$) had completed or were completing daycare center practicum.

2.2 Instruments

Mathematics Teaching Efficacy (MTE). To measure pre-service early childhood teachers' MTE, MTEBI (Mathematics Teaching Efficacy Belief Instrument) was used [3]. This scale was originally developed by Enochs, Smith, and Huinker for elementary school teachers, modified for early childhood teachers by Yeo, and revised for pre-service early childhood teachers by Kim [3, 8, 21]. The scale consists of 21 items and two subscales: General Mathematics Teaching Efficacy (GMTE) or Mathematics Teaching Outcome Expectancy

(MTOE) (8 items) and Personal Mathematics Teaching Efficacy (GMTE) or Mathematics Teaching Ability Expectancy (MTAE) (13 items). GMET or MTOE assesses whether early childhood teachers' instruction can influence young children's mathematical achievement, while PMTE or MTAE evaluates the degree of belief in their ability to effectively conduct mathematics education [22]. An example item is "If children's mathematical abilities have improved, it is likely due to the teacher's effective teaching methods." The items are rated on a 5-point Likert scale ranging from 1 ('strongly disagree') to 5 ('strongly agree'), with higher average scores indicating higher MTE. The internal consistency reliabilities (Cronbach's alpha) for this study were .79 for GMET or MTOE, .76 for PMTE or MTAE, and .75 overall.

Pedagogical Content Knowledge in Mathematics (PCKM). To measure pre-service early childhood teachers' PCKM, the measure developed and validated by Hong was used [23]. This instrument consists of 45 items and five sub-factors: Curriculum Knowledge (9 items), Content Knowledge (5 items), Instructional Strategies Knowledge (19 items), Learner Knowledge (7 items), and Professional Development Knowledge (4 items) [23]. An example item is "I understand each child's attitude and disposition toward mathematics." The items are rated on a 5-point Likert scale from 1 ('strongly disagree') to 5 ('strongly agree'), with higher average scores indicating higher PCKM. The internal consistency reliabilities (Cronbach's alpha) for this study were .91 for curriculum knowledge, .94 for content knowledge, .96 for instructional strategies knowledge, .94 for learner knowledge, .88 for professional development knowledge, and .97 overall.

Constructivist Educational Belief (CEB). To measure pre-service early childhood teachers' CEB, the Constructivist Educational Belief Scale developed by Lim [17] was used. This scale originally consists of two factors (constructivist-compatible and constructivist-incompatible). We decided to use only constructivist-compatible questions (11 items) because they are directly related to our research purpose. CEB refers to the degree to which pre-service early childhood teachers believe in engaging in educational activities that align with constructivist perspectives. An example item is "Teachers should prioritize supporting children's play." The items are rated on a 5-point Likert scale from 1 ('strongly disagree') to 5 ('strongly agree'), with higher total scores indicating stronger CEB. The internal consistency reliability (Cronbach's alpha) for this study was .75.

2.3 Data Collection Procedure

Prior to the main survey, a preliminary survey was conducted with four randomly selected pre-service early childhood teachers to verify the appropriateness of the survey questions. The preliminary survey confirmed that the items were well understood and the time required to complete the survey was reasonable. The final survey was distributed and collected through major courses at selected universities, including a research consent form and cooperation request. A total of 187 surveys were used in the final analysis, excluding those with significant missing responses.

2.4. Statistical Analysis

The collected data were analyzed using SPSS 28.0. First, Cronbach's alpha coefficients were calculated to verify the reliability of the research instruments. Second, descriptive statistical analyses of frequencies (%) and means (*SD*) were conducted to examine the general characteristics of the research subjects. Third, Pearson's correlation analysis and multiple regression analysis were performed to test the research hypotheses.

3. RESULTS AND DISCUSSION

3-1. Correlations Between Pre-service Early Childhood Teachers' PCKM, CEB, and MTE

The subjects showed a relatively high level of PCKM ($M = 4.19$, $SD = .48$), a relatively high level of CEB ($M = 4.29$, $SD = .39$), and a moderate level of MTE ($M = 3.78$, $SD = .47$). For the first research question, Pearson's correlation analysis was conducted. As shown in Table 1, pre-service early childhood teachers' MTE had a statistically significant positive correlation with PCKM ($r = .47$, $p < .01$) and CEB ($r = .38$, $p < .01$). Pre-

service early childhood teachers' PCKM also had a statistically significant positive correlation with CEB ($r = .42, p < .01$). That is, the higher the levels of pre-service early childhood teachers' PCKM and CEB, the higher their levels of MTE. The results refer to that pre-service early childhood teachers who possess substantial PCKM and hold strong constructivist educational beliefs have higher levels of MTE.

Table 1. Descriptive statistics and correlations between major variables (N = 187)

Variables	①	②	③
① PCKM			
② CEB	.42**	-	
③ MTE	.47**	.38*	-
<i>M (SD)</i>	4.19 (.48)	4.29 (.39)	3.78 (.47)

** $p < .01$

These results support the findings of the previous studies that report the positive correlations between variables. First, the result that pre-service early childhood teachers with higher levels of PCKM exhibited higher levels of MTE supports the results of previous studies conducted on early childhood teachers [14-16] and on pre-service early childhood teachers [17-19]. Second, the results that pre-service early childhood teachers with higher levels of CEB exhibited higher levels of MTE supports the results of previous studies conducted on early childhood teachers [15, 22, 23]. This indicates that pre-service early childhood teachers who perceive a high level of PCKM and CEB show a high level of MTE. The results of this study indicate that it is necessary to systematically teach PCKM from the university level, where pre-service early childhood teachers are trained. Additionally, efforts should be made to develop various teaching methods that strengthen CEB.

3-2. The Effects of Pre-service Early Childhood Teachers' PCKM and CEB on MTE

For the second research question, the analysis of multiple regression was conducted. Since *VIF* (1.21) and tolerance (.83) were within acceptable limits, no multicollinearity was assumed. In order to examine the effects of pre-service early childhood teachers' PCKM and CEB on MTE, the scores of PCKM and CEB on MTE were used as the independent variables of multiple regression analysis (Table 2).

Table 2. Effects of PCKM and CEB on MTE (N = 187)

Independent variables	MTE			
	<i>B</i>	<i>S.E.</i>	β	<i>t</i>
(Constant)	1.11	.37	-	2.98*
PCKM	.38	.07	.38	5.31***
CEB	.25	.09	.21	2.87**
$F = 29.52^{***} (R^2 = .25, Adj. R^2 = .24)$				

** $p < .01$, *** $p < .001$

As shown in Table 2, pre-service early childhood teachers' PCKM and CEB had a statistically significantly positive effect on MTE ($F = 29.52, p < .001$). Both PCKM ($t = 5.31, p < .01$) and CEB ($t = 2.87, p < .001$) had

a statistically significantly positive effect on MTE. In terms of the relative influence on MTE, PCKM ($\beta = .38$) had a greater influence than CEB ($\beta = .21$). These variables were found to explain 24.4% ($Adj. R^2 = .24$) of MTE. Although there has been no previous studies that investigated the effects of these variables of pre-service early childhood teachers, the results of this study are in line with the results of previous studies that used early childhood teachers as the subjects [18, 19, 16, 23].

The results show that pre-service early childhood teachers' PCKM and CEB are variables that would enhance MTE. In addition, it is noteworthy that the perception of pre-service early childhood teachers' PCKM showed a larger influence than CEB on their MTE. The results imply that while CEB are important, pre-service early childhood teachers' confidence in teaching mathematics to young children is enhanced when they possess professional knowledge about mathematics and understand various ways to reconstruct and apply early childhood mathematics curricula based on this knowledge. Therefore, we argue that to improve MTE, which is considered the most critical variable for effective mathematics instruction, it is necessary to have a pre-service early childhood teacher education curriculum that deeply teaches mathematical content knowledge and pedagogical knowledge combined to teach mathematics effectively. In conclusion, to enhance the mathematics teaching expertise of pre-service early childhood teachers, it is necessary to provide teacher education that enhances knowledge of specialized mathematical content and effective teaching and learning methods from the training stage.

4. CONCLUSION

We focused on the importance of MTE among pre-service early childhood teachers and examined the related variables of PCKM and CEB. As research methods, self-report questionnaires were administered to 187 early childhood education majors at universities in the metropolitan area of South Korea, and the variables were measured and statistically analyzed. We conclude that the higher the levels of pre-service early childhood teachers' PCKM and CEB, the higher their MTE. In addition, both PCKM and CEB were validated as predictors of increased MTE among pre-service early childhood teachers. Based on the results, we suggest that in order to train early childhood teachers who support children's mathematical abilities, PCKM and CEB related to enhancing MTE should be sufficiently incorporated into the teacher training curriculum.

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