



PRE-SERVICE PRIMARY SCHOOL TEACHERS' SELF-EFFICACY AND OUTCOME EXPECTANCY REGARDING THE USE OF CONCRETE MANIPULATIVES IN MATHEMATICS TEACHING

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Abstract

Concrete manipulatives are widely used in primary mathematics education to support students' understanding of abstract mathematical concepts. This study examined pre-service primary school teachers' self-efficacy and outcome expectancy regarding the use of concrete manipulatives and investigated whether these beliefs differed by sex, year of study, and age. The participants were 118 pre-service teachers enrolled in a primary education programme. Data were analysed using descriptive statistics, a paired-samples t test, independent-samples t tests, one-way analyses of variance, and Tukey HSD tests. Mean scores for both self-efficacy and outcome expectancy fell within the agree range established for interpreting the scale. Outcome expectancy scores were significantly higher than self-efficacy scores, indicating that participants expressed stronger beliefs in the instructional benefits of concrete manipulatives than in their ability to use them effectively. No significant differences by sex were found. Both dimensions differed significantly by year of study, with some later-year groups reporting higher scores than earlier-year groups. Age-group differences were found only in self-efficacy; however, this result should be interpreted cautiously because the oldest group included only four participants. The findings indicate an association between year of study and efficacy beliefs but do not establish a causal effect of the teacher education programme. Teacher education programmes should provide sustained, practice-based opportunities for pre-service teachers to select, use, and evaluate concrete manipulatives in classroom settings.

Keywords: concrete manipulatives, mathematics education, outcome expectancy, pre-service teachers, primary school, self-efficacy

Introduction

Mathematics is commonly perceived as a difficult subject. Research also indicates that students may experience difficulties in learning basic mathematical concepts and that these difficulties may persist across different educational levels (Lima et al., 2019; Nelson & Powell, 2018). At the primary-school stage, this problem is especially evident. Concrete manipulatives are among the instructional resources used to support primary school students' understanding of abstract mathematical concepts. However, concrete manipulatives do not facilitate learning automatically. Their instructional effectiveness depends on how teachers integrate them into lessons and connect physical representations to the underlying mathematical concepts (Clements, 2000; Moyer, 2001).

The pedagogical value of concrete manipulatives can be explained partly through theories of cognitive development and representation. Primary school students may benefit from instructional approaches that connect mathematical concepts to observable and manipulable

representations (Piaget, 1971). Bruner (1966) described enactive, iconic, and symbolic modes of representation, emphasising that understanding can develop through connections among action-based, visual, and symbolic forms. Montessori (1967) also drew attention to the contribution of purposeful physical activity and sensory experience to children's cognitive development.

Evidence from previous research broadly supports the use of concrete manipulatives in mathematics teaching. Meta-analyses have reported positive effects on mathematics achievement, but these effects have not been uniform across studies. The benefits appear to depend partly on the instructional context and, more importantly, on how manipulatives are used to represent mathematical ideas (Carbonneau et al., 2013; Sowell, 1989).

Thus, providing manipulatives does not necessarily lead to meaningful learning. Students need support in relating what they do with the materials to the mathematical ideas represented by those actions. Teachers have an important role in establishing this relationship. Their confidence in selecting and using manipulatives may influence the instructional decisions they make, although classroom practice is also shaped by contextual factors such as time, resources, and classroom organisation (Gokmen et al., 2016; Moyer, 2001).

Review and Rationale for the Research

Research has generally shown that teachers recognise the potential benefits of concrete manipulatives. Recognition of these benefits, however, does not necessarily mean that teachers feel prepared to use the materials effectively. Teachers have reported difficulties associated with lesson time, classroom management, content knowledge, and linking manipulatives to the mathematical concepts being taught (Gokmen et al., 2016; Pişkin Tunç et al., 2012). Moyer (2001) also observed that teachers sometimes treated manipulatives as enjoyable classroom activities without making their mathematical purpose sufficiently explicit.

Teachers who regard manipulatives as useful may be more inclined to include them in mathematics lessons (Uribe-Flórez & Wilkins, 2010). Yet the frequency with which a material is used reveals little about the quality of its use. For instance, a manipulative may be present in a lesson without helping students move from physical actions to mathematical representations. This distinction is also relevant to pre-service teachers. Aydoğdu İskenderoğlu et al. (2016) found that favourable efficacy beliefs did not necessarily indicate extensive knowledge of or experience with manipulatives. Pişkin Tunç et al. (2012) similarly reported that pre-service teachers were willing to use these materials but had concerns about classroom management, available lesson time, and content knowledge. Taken together, these studies suggest that recognising the educational value of manipulatives and feeling capable of using them purposefully are connected but distinct aspects of teacher preparation.

Primary school teachers (PSTs) are responsible for supporting students' early mathematical understanding and helping them develop connections among physical representations, mathematical language, and symbolic notation. Pre-service primary school teachers (PPSTs) therefore need not only to understand the potential value of manipulatives but also to develop confidence in selecting and using them for specific instructional purposes. Investigating their self-efficacy (SE) and outcome expectancy (OE) may provide useful information about areas in which additional practice-based support is needed.

Previous studies have examined pre-service teachers' efficacy beliefs concerning mathematics teaching in general (Byrd & Giles, 2023; Segarra & Julià, 2020), as well as teachers' beliefs and practices concerning concrete manipulatives (Quane, 2025; Quigley, 2021). Other research has focused on efficacy beliefs about manipulative use among pre-service mathematics teachers (Aydoğdu İskenderoğlu et al., 2016; Bakkaloğlu, 2007; Pişkin Tunç et al., 2012). Comparatively less attention has been given to both self-efficacy and outcome expectancy regarding manipulative use among pre-service primary school teachers.

Evidence is also limited regarding whether these beliefs differ across years of study in a primary teacher education programme. The present study addresses these gaps by examining both belief dimensions within the same sample and comparing participants across four years of study. Because the study is cross-sectional, these comparisons are interpreted as differences between year groups rather than evidence of individual development or programme effects.

Research Aim and Research Questions

This study aimed to examine PPSTs' SE and OE regarding the use of concrete manipulatives in mathematics teaching and to determine whether their scores differed by sex, year of study, and age. The following research questions guided the study:

Research Question 1: What are the levels of PPSTs' SE and OE regarding the use of concrete manipulatives in mathematics teaching?

Research Question 2: Do PPSTs' SE and OE scores differ significantly by sex, year of study, and age?

Research Methodology

Design

This study used a quantitative cross-sectional survey design. Data were collected at a single point in time during the autumn semester of the 2025–2026 academic year. The design was descriptive because no intervention was introduced and comparative because self-efficacy and outcome expectancy scores were compared by sex, year of study, and age.

The study did not follow the same participants over time. Therefore, differences among the four year-of-study groups were interpreted as cross-sectional group differences rather than evidence of individual development or the causal effect of the teacher education programme.

Participants

Participants were recruited through convenience sampling from the Primary Education Programme in the Department of Basic Education at Çanakkale Onsekiz Mart University. At the time of data collection, approximately 200 PPSTs were enrolled across the four years of the programme. All enrolled students were invited to participate and were provided with the data-collection instruments. Participation was voluntary.

A total of 118 students completed and returned the instruments and were included in the analysis. The final sample comprised 31 first-year, 28 second-year, 41 third-year, and 18 fourth-year students. Differences in group size reflected voluntary participation and questionnaire return rates. The demographic characteristics of the participants are presented in Table 1.

Table 1
Demographic Characteristics of the Participants

Variable	Group	<i>n</i>	%
Sex	Female	100	84.7
	Male	18	15.3
Year of Study	First year	31	26.3
	Second year	28	23.7
	Third year	41	34.8
	Fourth year	18	15.3
Age	18	6	5.1
	19	17	14.4
	20	24	20.3
	21	32	27.1
	22	26	22.0
	23	9	7.6
	24	4	3.4

As shown in Table 1, 100 participants were female (84.7%) and 18 were male (15.3%). Third-year students constituted the largest year group (34.8%), followed by first-year (26.3%), second-year (23.7%), and fourth-year students (15.3%). Participants ranged in age from 18 to 24 years, and the largest age group consisted of 21-year-old participants (27.1%).

Instrument

PPSTs' SE and OE regarding the use of concrete manipulatives in mathematics teaching were measured using the Instrument of Preservice Mathematics Teachers' Efficacy Beliefs about Using Manipulatives (EBMU; Bakkaloğlu, 2007). Bakkaloğlu (2007) developed the EBMU on the basis of the Mathematics Teaching Efficacy Beliefs Instrument (MTEBI; Enochs et al., 2000), adapting its two-dimensional efficacy-belief framework to the use of manipulatives in mathematics teaching. The EBMU assesses two related dimensions: personal efficacy beliefs about manipulative use and outcome expectancy regarding manipulative use. It is a self-report instrument and does not assess participants' mathematical knowledge, practical teaching performance, or observed competence in using manipulatives.

The version administered in the present study consisted of 15 items rated on a five-point Likert-type scale ranging from 1 (strongly disagree) to 5 (strongly agree). The Personal Efficacy Beliefs about Manipulative Use subscale comprised nine items, whereas the Outcome Expectancy Regarding Manipulative Use subscale comprised six items. Six negatively worded items were reverse-scored before the analyses. After reverse scoring, higher mean scores indicated stronger personal efficacy beliefs or more positive OE regarding the use of concrete manipulatives.

Bakkaloğlu (2007) reported Cronbach's alpha coefficients of .81 for SE beliefs about manipulative use and .79 for OE regarding manipulative use. In the present sample, Cronbach's alpha coefficients were .72 for personal efficacy and .70 for outcome expectancy. These values indicated acceptable but modest internal consistency and were lower than those reported by Bakkaloğlu (2007).

The Turkish EBMU developed by Bakkaloğlu (2007) was administered with the developer's permission. For international readers, the authors translated two sample items from the Turkish instrument into English. A sample personal efficacy item was "I believe that I can use concrete manipulatives effectively during mathematics lessons", and a sample outcome expectancy item was "The use of concrete manipulatives in mathematics teaching contributes substantially to student achievement". These translations are provided only to illustrate the content of the subscales. They were not administered to participants and should not be regarded as a validated English version of the instrument. A brief personal information form was also used to collect data on participants' sex, age, and year of study.

Procedure and Ethics

Ethics committee approval was obtained before data collection. Ethical approval was granted by the Çanakkale Onsekiz Mart University Social and Human Sciences Ethics Committee on May 16, 2025 (Decision No. 60/172). The study was supported by TÜBİTAK, the Scientific and Technological Research Council of Türkiye. Data were collected during the autumn semester of the 2025–2026 academic year.

The data-collection instruments were administered outside of regular class hours to prevent any disruption to scheduled teaching activities. Prior to administration, participants were informed about the study's purpose and scope, the voluntary nature of their participation, and the confidentiality of their responses. Informed consent was obtained from all participants, who also confirmed that they were at least 18 years old. The completion of the instruments required approximately 15 minutes.

Data Analysis

The data were analysed using descriptive and inferential statistics. Frequencies and percentages were calculated to describe the participants' demographic characteristics. Means, standard deviations, minimum scores, and maximum scores were calculated for the SE and OE subscales.

Because the two subscales contained different numbers of items, analyses were conducted using mean item scores rather than raw total scores. Negatively worded items were reverse-scored before the subscale means were calculated. Mean scores could range from 1 to 5, with higher scores representing stronger SE or more positive OE.

For descriptive interpretation, mean scores were classified using equal-width intervals: 1.00–1.80 indicated strongly disagree, 1.81–2.60 indicated disagree, 2.61–3.40 indicated neither agree nor disagree, 3.41–4.20 indicated agree, and 4.21–5.00 indicated strongly agree. These categories were used only to support the descriptive interpretation of the mean scores and were not treated as psychometrically established cut-off points.

Before the inferential analyses, the distributions of the subscale scores and the assumptions of the planned statistical tests were examined. Skewness and kurtosis values were within the ± 1.5 range. Levene's tests indicated that the homogeneity-of-variance assumption was met for the sex comparisons in SE, $p = .925$, and OE, $p = .280$.

A paired-samples t-test was performed to compare the mean SE and OE scores of participants. Because the subscales contained different numbers of items, the paired comparison

was based on the mean item score for each subscale. Independent-samples t-tests were employed to investigate differences by sex. One-way analyses of variance were conducted to assess differences by year of study and age. When the omnibus analysis of variance yielded statistical significance, Tukey's honestly significant difference test was applied for pairwise comparisons. The significance level was established at .05, and all tests were two-tailed.

Research Results

Self-Efficacy and Outcome Expectancy Levels

Descriptive statistics for the SE and OE subscales are presented in Table 2. Because the subscales contained different numbers of items, the analyses were based on mean item scores ranging from 1 to 5.

Table 2

Descriptive Statistics and Paired-Samples Comparison of SE and OE

Subscales	N	Minimum	Maximum	M	SD	df	t	p
SE	118	2.78	4.89	3.83	0.46	117	4.39	< .001
OE	118	2.50	5.00	4.04	0.52			

Note. The paired-samples comparison was calculated by subtracting SE scores from OE scores. The analyses were based on mean item scores.

Participants' mean SE score was 3.83 (SD = 0.46), while their mean OE score was 4.04 (SD = 0.52). Based on the predefined descriptive intervals, both means fell within the agree range. A paired-samples t test showed that OE scores were significantly higher than SE scores, $t(117) = 4.39, p < .001$.

Differences by Sex

Independent-samples t tests were conducted to examine whether SE and OE scores differed by sex. The results are presented in Table 3.

Table 3

Comparison of PPSTs' SE and OE by Sex

Subscales	Sex	n	M	SD	df	t	p
SE	Female	100	3.82	0.46	116	-0.52	.604
	Male	18	3.88	0.46			
OE	Female	100	4.04	0.54	116	0.00	.998
	Male	18	4.04	0.42			

Note. M = mean; SD = standard deviation.

No statistically significant difference in SE scores was observed between sexes, $t(116) = -0.52, p = .604$. Similarly, OE scores did not differ significantly by sex, $t(116) = 0.00, p = .998$.

Differences by Year of Study

One-way analyses of variance were conducted to examine whether SE and OE scores differed among the four year-of-study groups. The results are presented in Table 4.

Table 4
Comparison of PPSTs' SE and OE by Year of Study

Subscale	Year of Study	<i>n</i>	<i>M</i>	<i>SD</i>	<i>F</i>	<i>p</i>	Tukey HSD Pairwise Comparisons
SE	1st year	31	3.67	0.42	4.83	.003	Third year >First year Fourth year>First year Fourth year>Second year
	2nd year	28	3.68	0.37			
	3rd year	41	3.96	0.47			
	4th year	18	4.03	0.48			
OE	1st year	31	3.75	0.58	5.02	.003	Third year >First year Fourth year>First year
	2nd year	28	4.05	0.45			
	3rd year	41	4.19	0.48			
	4th year	18	4.16	0.45			

Note. *M* = mean; *SD* = standard deviation. The greater-than symbol indicates that the mean of the preceding group was significantly higher than that of the following group according to the Tukey HSD test.

SE scores differed significantly among year-of-study groups, $F(3, 114) = 4.83, p = .003$. According to Tukey HSD comparisons, SE scores for third-year students were significantly higher than those for first-year students. Additionally, fourth-year students exhibited significantly higher SE scores compared to both first- and second-year students. No other pairwise differences in SE were statistically significant.

OE scores also differed significantly among year-of-study groups, $F(3, 114) = 5.02, p = .003$. Tukey HSD comparisons indicated that third- and fourth-year students had significantly higher OE scores than first-year students. No other pairwise differences in OE were statistically significant.

Differences by Age

One-way analyses of variance were conducted to examine whether SE and OE scores differed among the seven age groups. The results are presented in Table 5.

Table 5
Comparison of PPSTs' SE and OE by Age

Subscale	Age group	<i>n</i>	<i>M</i>	<i>SD</i>	<i>F</i>	<i>p</i>	Tukey HSD Pairwise Comparisons
SE	18	6	3.67	0.47	3.61	.003	
	19	17	3.52	0.43			24 > 18,
	20	24	3.83	0.34			24 > 19
	21	32	3.86	0.49			24 > 20
	22	26	3.90	0.44			24 > 21
	23	9	3.89	0.46			
	24	4	4.56	0.33			
OE	18	6	3.97	0.44	1.11	.360	
	19	17	3.90	0.50			
	20	24	3.87	0.66			
	21	32	4.09	0.44			None
	22	26	4.14	0.50			
	23	9	4.20	0.59			
	24	4	4.25	0.29			

Note. *M* = mean; *SD* = standard deviation. The greater-than symbol indicates that the mean of the preceding age group was significantly higher than that of the following age group according to the Tukey HSD test. Comparisons involving the 24-year-old group should be interpreted cautiously because this group included only four participants.

SE scores differed significantly among age groups, $F(6, 111) = 3.61$, $p = .003$. Tukey HSD comparisons indicated that participants aged 24 had significantly higher SE scores than participants aged 18, 19, 20, and 21. The groups aged 22 and 23 showed no statistically significant differences when compared to the 24-year-old group. The comparisons involving participants aged 24 should be interpreted cautiously because this group included only four participants.

OE scores did not differ significantly among age groups, $F(6, 111) = 1.11$, $p = .360$. Therefore, post hoc comparisons were not interpreted for OE.

Discussion

This study examined PPSTs' SE and OE about using concrete manipulatives in mathematics instruction. It also investigated whether these beliefs differed by sex, year of study, and age. Participants reported mean scores within the *agree* range for both SE and OE. OE scores were significantly higher than SE scores. No significant sex differences were found in either dimension. Both SE and OE differed significantly among year-of-study groups, while age-group differences were significant only for SE.

Self-Efficacy and Outcome Expectancy

The findings pertaining to the first research question indicated that participants held positive beliefs about both their capability to use concrete manipulatives and the instructional benefits of these materials. The mean OE score was, however, significantly higher than the mean SE score. Participants therefore expressed stronger confidence in the instructional value of concrete manipulatives than in their own capability to use them effectively.

This result concerns participants' perceived capabilities rather than their observed teaching competence. The study used a self-report instrument and did not include classroom observations, performance assessments, or evaluations of lesson plans. Consequently, the findings should not be interpreted as evidence that participants were able to select and use manipulatives effectively in classroom practice.

The positive scores in both dimensions are broadly consistent with previous research showing that teachers and pre-service teachers generally recognise the instructional value of manipulatives (Bakkaloğlu, 2007; Gokmen et al., 2016; Pişkin Tunç et al., 2020). However, having optimistic beliefs does not necessarily correspond to extensive knowledge or effective classroom practice. Aydoğdu İskenderoğlu et al. (2016) reported that positive efficacy beliefs among pre-service teachers did not necessarily reflect extensive familiarity with manipulatives. Moyer (2001) similarly found that teachers sometimes used manipulatives as enjoyable classroom activities without adequately connecting them to the intended mathematical concepts. The present findings are compatible with the distinction between recognising the value of manipulatives and feeling personally capable of using them for specific instructional purposes.

Several explanations may account for the difference between OE and SE scores. First, the two subscales require different types of judgement. OE items ask participants to evaluate the likely benefits of manipulatives for students, whereas SE items require them to evaluate their own capability to use these materials. Participants may find it easier to endorse general statements about instructional value than to make equally positive judgements about their own teaching capability.

Second, social desirability may have influenced participants' responses. Because the educational value of concrete manipulatives is likely to be emphasised during teacher education, participants may have perceived positive OE statements as consistent with accepted pedagogical principles. They may therefore have endorsed these statements more strongly than statements requiring an appraisal of their own competence (Paulhus, 1991).

Third, SE is influenced by mastery experiences in which individuals perform relevant tasks and evaluate the outcomes of their actions (Bandura, 1997). Pre-service teachers may understand why manipulatives are valuable before they have sufficient opportunities to select, implement, and evaluate them in realistic teaching situations. This explanation is plausible, but the present study did not directly measure participants' coursework, frequency of manipulative use, microteaching experiences, or classroom practice. It should therefore be regarded as a possible interpretation rather than an explanation established by the data.

Collectively, these findings indicate that belief in the instructional value of manipulatives and confidence in their use should be regarded as distinct constructs. Future studies could examine this distinction by combining self-report measures with observations, interviews, lesson-plan analysis, or performance-based tasks. Such evidence would help determine whether reported efficacy beliefs correspond to the ways in which pre-service teachers use concrete manipulatives during teaching.

Sex Differences

No statistically significant sex differences were found in SE or OE. Female and male participants reported similar mean scores in both dimensions. This result is consistent with Gokmen's (2012) finding that sex did not significantly differentiate teachers' SE and OE beliefs concerning manipulative use. Bakkaloğlu (2007), by contrast, reported no significant sex difference in SE but found a significant difference in OE.

Differences across studies may be associated with variations in participant characteristics, teacher education context, sample composition, or measurement conditions. The present sample consisted entirely of PPSTs enrolled in the same programme, whereas previous studies

included different teacher or pre-service teacher populations. Shared coursework and learning experiences may be one possible reason for the similarity of scores in the present sample. However, the study did not measure the participants' individual experiences in sufficient detail to test this explanation.

The absence of a statistically significant sex difference should be interpreted with caution. The sample included 100 female participants but only 18 male participants. This substantial imbalance may have reduced the precision and statistical power of the sex comparison. The result should therefore be interpreted as indicating that no sex difference was detected in this sample rather than demonstrating the equivalence of female and male pre-service teachers.

Differences by Year of Study

SE and OE scores differed significantly among the four year-of-study groups. Third-year students reported significantly higher SE scores than first-year students, while fourth-year students reported significantly higher SE scores than first- and second-year students. For OE, third- and fourth-year students reported significantly higher scores than first-year students. No other pairwise differences were statistically significant.

These findings indicate that some later-year groups reported stronger efficacy beliefs than some earlier-year groups. They do not, however, demonstrate a uniform increase across every successive year. For example, third- and fourth-year OE means were similar, and the fourth-year mean was slightly lower than the third-year mean. In addition, not every comparison between a later-year and an earlier-year group was statistically significant. The findings should therefore be described as differences among particular year groups rather than as a continuous upward trend.

The higher scores reported by some later-year groups may be related to the learning experiences available at different stages of the programme. Mathematics methods courses, material-design activities, microteaching, and school-based practice can give students opportunities to observe the use of manipulatives, try different instructional approaches, and receive feedback. Earlier studies have also linked practice with concrete models to stronger efficacy beliefs among pre-service teachers (Pişkin Tunç et al., 2020; Ünlü, 2018).

This interpretation cannot be tested directly with the present data because participants' coursework and practical experiences were not measured. Moreover, the study compared separate year groups at one point in time. The differences may therefore be associated with programme experiences, but they may also reflect differences between cohorts or participants' previous experiences and interest in mathematics teaching. Following the same students over time would provide clearer evidence of whether their self-efficacy and outcome expectancy change during the programme.

The comparatively lower scores reported by first-year students may nevertheless have practical implications. Teacher education programmes could consider introducing guided experiences with concrete manipulatives early in the programme and reinforcing them through progressively more demanding teaching tasks. This recommendation is based on the pattern observed in the present sample and relevant theory, not on evidence that a particular component of the programme caused the group differences.

Differences by Age

SE scores differed significantly among age groups, whereas OE scores did not. Tukey HSD comparisons indicated that participants aged 24 reported significantly higher SE scores than participants aged 18, 19, 20, and 21. However, the 24-year-old group did not differ significantly from the groups aged 22 or 23.

This result does not provide evidence of a consistent increase in SE with age. The age-group means did not follow a uniformly increasing pattern, and the statistically significant differences depended on a 24-year-old group containing only four participants. The mean of such a small group can be strongly influenced by the characteristics of individual participants. For this reason, the finding should not be interpreted as evidence of an age or maturity effect.

Age and year of study may also be related in this sample. Older participants may have accumulated more academic or teaching-related experiences, but the present analyses do not separate the possible contribution of age from that of year of study or other experiences. Drawing conclusions about an independent age effect would therefore be inappropriate.

No statistically significant age-group difference was found in OE. Although the means were generally positive across the age groups, the present data do not establish whether this pattern reflects beliefs formed early in teacher education, restricted variability in OE scores, or another factor. Overall, the findings provide insufficient evidence of a systematic relationship between age and either belief dimension. Research with larger and more balanced age groups would be necessary before drawing conclusions about age-related differences in SE or OE.

Summary of the Discussion

The results suggest a distinction between believing that concrete manipulatives support mathematics learning and feeling personally capable of using them effectively. Participants expressed positive beliefs in both dimensions, but their OE scores were higher than their SE scores. Differences were found among particular year-of-study groups, but the cross-sectional design does not demonstrate individual development or a causal programme effect. The sex findings were limited by the unequal group sizes, and the age finding depended on comparisons involving a very small subgroup.

These results support the value of examining SE and OE as separate constructs. They also highlight the need for research that connects self-reported beliefs with actual instructional decisions and classroom practices.

Limitations and Research Implications

Several constraints must be acknowledged when interpreting the findings reported in this study. First, the participants were recruited through convenience sampling from a single teacher education programme. The sample may therefore reflect the characteristics of this particular institutional context and may not represent PPSTs enrolled in other universities, programmes, or national education systems. Future studies should include participants from multiple institutions and use more diverse sampling strategies to improve the generalisability of the findings.

Second, the research utilized a cross-sectional approach to examine various groups of students across the four years of the programme simultaneously. The observed differences among year-of-study groups cannot therefore be interpreted as changes occurring within the same individuals or as evidence that the teacher education programme caused the differences. Cohort characteristics, previous educational experiences, individual interest in mathematics teaching, and other unmeasured factors may have contributed to the observed pattern. Longitudinal research following the same participants across their teacher education programme would provide stronger evidence concerning changes in SE and OE over time.

Third, the findings were based exclusively on self-report data. The instrument measured participants' perceptions of their SE and OE rather than their actual knowledge, instructional decisions, or classroom performance. Self-reported beliefs may be influenced by social desirability, item interpretation, and differences in participants' self-evaluation standards. The

available evidence is insufficient to demonstrate participants' competence in using concrete manipulatives in actual classroom settings. Future research should combine self-report measures with classroom observations, interviews, lesson-plan analyses, microteaching assessments, or performance-based tasks.

Fourth, SE and OE were measured using subscales included in the same instrument and administered at the same time. The difference between the two dimensions may consequently have been influenced partly by the wording and structure of the items or by common method effects. Although both subscales showed satisfactory internal consistency within the current sample, the obtained reliability estimates did not reach the levels documented during the scales' initial validation. Further research could examine the measurement structure of the instrument in larger and more diverse samples and use additional evidence to assess the two constructs.

Fifth, the sizes of the demographic subgroups were unequal. The sample included substantially more female participants than male participants, which limited the precision and statistical power of the sex comparisons. Some age groups were also small, particularly the 24-year-old group, which included only four participants, and the 18-year-old group, which included six. The significant age-group differences in SE depended on comparisons involving the four participants aged 24 and should therefore be interpreted cautiously. Studies using larger and more balanced sex and age groups are needed before firm conclusions can be drawn about demographic differences.

Sixth, the study did not measure participants' exposure to particular programme components, such as mathematics methods courses, material-design activities, microteaching, school-based practice, or previous experience with concrete manipulatives. It is therefore not possible to determine whether the differences among year-of-study groups were associated with these experiences. Future studies should measure the nature, frequency, and quality of participants' practice-based experiences and examine how these factors relate to SE and OE.

Finally, the study examined perceived capability and expected instructional outcomes but did not investigate the relationship between these beliefs and the actual frequency or quality of manipulative use. Future studies could combine longitudinal and mixed-method designs to examine whether efficacy beliefs predict teachers' selection of manipulatives, instructional explanations, transitions between concrete and symbolic representations, or responses to classroom-management challenges.

Conclusions and Implications

This study examined PPSTs' SE and OE concerning the use of concrete manipulatives in mathematics instruction. Participants reported mean scores within the agree range for both dimensions. However, OE scores were significantly higher than SE scores, indicating that participants expressed stronger beliefs in the instructional benefits of concrete manipulatives than in their own capability to use them effectively.

PPSTs' SE and OE scores did not vary significantly by sex. However, both dimensions showed significant variation across different year-of-study groups. Notably, some groups in their third and fourth years reported higher scores compared to those in their first or second years. Rather than showing a continuous upward trend over the course of the programme, the data revealed significant differences only for some comparisons across year levels.

SE also differed among age groups, but the significant pairwise comparisons involved the 24-year-old group, which included only four participants. The age-related observation must be approached with caution, as it does not demonstrate a consistent rise in SE as age advances.

The difference between OE and SE has implications for teacher education. Helping pre-service teachers recognise the instructional value of concrete manipulatives may not be sufficient to develop confidence in using them. Teacher education programmes should provide

repeated opportunities to select manipulatives, explain the mathematical relationships they represent, anticipate possible student responses, and evaluate their instructional use. Lesson planning, microteaching, classroom observation, and supervised teaching may help connect positive beliefs about manipulatives with practical instructional experience.

These implications should be considered within the boundaries of the study. The findings were based on self-reported beliefs and do not demonstrate participants' actual competence in using concrete manipulatives. In addition, the cross-sectional design does not establish that the teacher education programme caused the differences among year-of-study groups. Longitudinal and mixed-method studies that examine participants' perceptions in conjunction with documented practices or demonstrated capabilities are necessary to investigate the temporal evolution of efficacy beliefs and their manifestation in classroom practice.

Declaration of Interest

The authors declare no competing interests.

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