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# Do numerical mind and intelligence games reduce mathematics teaching anxiety? Evidence from pre-service primary teachers

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**Abstract**
While existing literature focuses on pre-service teachers' opinions, there is a lack of experimental research on the effectiveness of numerical mind and intelligence games. This study aims to investigate the impact of numerical mind and intelligence games on pre-service teachers' arithmetic and higher-order thinking skills, while also addressing their mathematics teaching anxiety. This study examined the effect of numerical mind and intelligence games training on the mathematics teaching competencies and anxieties of 34 third-grade pre-service primary school teachers. The explanatory design of the mixed method was utilized, with the quantitative part employing a pre- and post-test experimental design without a control group, and the qualitative part utilizing a case study. The study utilized a mathematics teaching competency scale, an anxiety scale, and a semi-structured interview tool. Numerical mind and intelligence games training reduced pre-service primary school teachers' anxiety about teaching mathematics, which is a sub-dimension of their mathematics teaching anxiety, but did not change their anxiety about mathematics self-efficacy and subject knowledge. In addition, it has been determined that numerical mind and intelligence games training does not change pre-service primary school teachers' mathematics teaching competence. To increase pre-service primary school teachers' self-efficacy in teaching mathematics and reduce their anxiety, numerical mind and intelligence games can be introduced at the beginner level, and the difficulty level of the numerical mind and intelligence games can be increased according to the pre-service primary school teachers' levels. The effects of the study, which investigated the impact on pre-service teachers' mathematics teaching self-efficacy and anxieties, on their mathematics teaching motivation and attitudes can be investigated.

**Keywords:** Mathematics teaching anxiety; Numerical intelligence games; Pre-service primary school teacher; Teaching competence

## 1. Introduction

Pre-service primary school teachers who teach mathematics using numerical reasoning and intelligence games should be monitored for changes in their self-efficacy in mathematics teaching and their anxiety levels.Pre-service teachers' competence in teaching mathematics is attempted to be developed through basic mathematics, mathematics teaching courses, and teaching practice during their undergraduate education. Pre-service teachers associate mathematics teaching with games, mazes, and machine metaphors (Tarim et al., 2017) and believe that the use of games in mathematics teaching is necessary and beneficial (Usta et al., 2016). Therefore, it is necessary to find new games and investigate their effects in order to achieve learning objectives in the mathematics teaching process (Vankúš, 2008).

Among the games that can be considered are numerical intelligence games, which are a type of intelligence game. Intelligence games are effective in both utilizing free time (Esentaş, 2021) and improving mental skills such as students' problem-solving abilities (Leso et al., 2017). It is believed that Numerical mind and intelligence games [NMIG], which are a type of intelligence game, will be effective in increasing pre-service teachers' mathematics teaching self-efficacies. Despite the acknowledged benefits of intelligence games in mathematics education (Alyanak & Özkaya, 2024), there is a notable gap in the literature regarding the specific application and effectiveness of NMIG in teacher training programs. While pre-service teachers hold positive attitudes toward using games (Gür & Kobak Demir, 2016), they often lack the practical experience and specialized competence to integrate structured numerical games into the curriculum. This creates a disconnect between theoretical belief and classroom practice. Therefore, it is essential to investigate the impact of NMIG on pre-service teachers' skills and anxiety levels. This study is justified by the need to provide evidence-based strategies that bridge this gap, ensuring that future teachers can move beyond metaphors and effectively employ NMIG to enhance their students' higher-order thinking and arithmetic performance.

### 1.1. Mathematics Teaching Self-Efficacy

Mathematics teaching self-efficacy is defined as teachers' perceptions of their ability to perform mathematics teaching duties (Zuya et al., 2016). Teachers' competence in teaching mathematics is important for students' success and for reducing their negative beliefs and anxieties about mathematics (Blazar & Kraft, 2017). This is because teachers with high mathematics teaching self-efficacy are open to innovation (Tschannen-Moran & Woolfolk Hoy, 2001). They engage in small group activities in their lessons and encourage their students to question through open-ended questions (Gavora, 2010). They are more interested in mathematics teaching and spend more time with students who are not skilled in mathematics in their lessons (Ross & Bruce, 2007; Tschannen-Moram & Hoy, 2001). In fact, teachers with high teaching efficacy beliefs devote ample time to academic activities in the classroom and provide guidance to students who encounter difficulties in order to improve their academic performance and ensure their success. Teachers with low teaching efficacy beliefs devote excessive time to non-academic activities and are more likely to give up on struggling students, often attributing failure to students rather than instructional factors (Tschannen-Moran & Woolfolk Hoy, 2001). It has been found that pre-service teachers have high levels of competence in mathematics teaching and therefore expect their students to perform well in mathematics (Giles et al., 2016).

However, some studies have found that pre-service primary school teachers' self-efficacy in teaching mathematics is close to average, that gender and grade level do not create significant differences in self-efficacy in teaching mathematics, and that their self-efficacy in teaching mathematics is predicted by their mathematical literacy (Karalı, 2022). Furthermore, it has been determined that pre-service primary school teachers' mathematics literacy self-efficacy is below average, and that male teacher candidates have higher self-efficacy than female candidates, and those with a positive attitude have higher self-efficacy than those without (Ayvaz Can, 2019). These individual and academic factors are also highlighted in recent international studies. For instance, in a contemporary study conducted with primary school teachers, statistically significant relationships were identified between gender, mathematics achievement, readiness to teach, and personal efficacy or outcome expectancy or both (Twohill et al., 2023). Moreover, international research conducted by Lau (2021) underlines that mathematical beliefs, mathematical self-efficacy, and mathematics teaching efficacy play distinct and crucial roles in explaining pre-service teachers' broader conceptions of teaching and learning. As the teaching competencies of pre-service primary school teachers in mathematics increase, their anxiety about teaching mathematics decreases, or conversely, as teaching anxiety increases, teaching competence decreases (Deringöl, 2018).

### 1.2. Anxiety about Teaching Mathematics

Mathematics teaching anxiety, which is commonly encountered among pre-service teachers, is defined as the tension and fear that arise when teaching mathematical concepts, formulas, and theorems (Levine, 1993). The foundations of mathematics teaching anxiety are based on the education received during university years (Baki, 2008). However, it is emphasized in the literature that the roots of this anxiety can be traced back to the negative past student experiences of pre-service teachers (Gresham, 2017). Pre-service teachers’ lack of subject knowledge, failure to provide the necessary support during internships, the perception that teaching mathematics is difficult, lack of self-confidence, and negative experiences in the classroom also result in mathematics teaching anxiety (Bekdemir, 2010; Hoşşirin Elmas, 2010; Kurbanoğlu & Takunyuacı, 2012). Additionally, environmental factors such as societal prejudices and high achievement expectations can also trigger this anxiety process (Hembree, 1990).

Students' lack of interest in the course and difficulties in motivating them, insufficient course outcomes, teachers' inability to use sufficient methods and techniques in class and their assessment errors, other teachers' reactions, reluctance to enter the class, the rush to finish the lesson quickly, and their focus on solved problems also negatively affect teachers' mathematics teaching anxiety (Sarı, 2014). Research has also determined that pre-service teachers experience mathematics and mathematics teaching anxiety (Delgado-Monge et al., 2025; Jackson, 2008; Ryan et al., 2025). Teachers who experience mathematics teaching anxiety tend to use more traditional methods in their classrooms and focus on teaching basic skills rather than concepts (Gresham, 2010). In fact, the anxiety of teachers who experience mathematics teaching anxiety is increasing, resulting in negative outcomes such as making mistakes in assessment, avoiding the reactions of peers, students not taking the lesson seriously, and not being motivated to attend class (Sarı, 2014). It has been observed that pre-service primary school teachers who take the mathematics teaching course overcome feelings such as fear, dread, and agitation that they experienced before taking the course, and experience increased self-confidence (Hoşşirin Elmas, 2010). In this sense, it is understood that anxiety is closely related to teachers' perceptions of professional competence (Gresham, 2008; Peker, 2009). Teachers' sufficient subject knowledge, pedagogical knowledge, and practical experience ensure more effective mathematics teaching (Bilgiç, 2022). In other words, having developed mathematics teaching competence facilitates the reflection of teaching belief in classroom practices, resulting in a decrease in anxiety about the teaching process (Peker & Ulu, 2018).

### 1.3. Numerical Mind and Intelligence Games

Intelligence games are classified as reasoning and processing requiring reasoning skills, intelligence questions, geometric and mechanical, memory, strategy, and verbal games (Ministry of National Education [MoNE], 2013). NMIG, which are a type of mind and intelligence game, consist of games such as number riddles, number change, box erasing, target boards, kendoku, inequalities, pyramids, kakuro, and multiplication are games that individuals must solve using skills such as the four operations, thinking, and problem solving (Özkan, 2023). Intelligence games support the development of individuals' higher-level thinking skills, such as reasoning, problem-solving, analytical thinking, critical thinking, and decision-making (Baş et al., 2020). In addition, they provide individuals with a sense of winning and losing, socialization, empathy, self-confidence, and strategies for solving problems they encounter (Esentaş, 2021), and strengthen their cooperation and communication skills (Earp et al., 2014). Intelligence games that attract students' interest lead to students having fun (Ekiçi et al., 2017). Intelligence games that provide an enriched learning environment (Romero et al., 2015). Additionally, mind and intelligence games may enhance students' mathematical reasoning ability (Reiter et al., 2014), problem-solving and reasoning skills (Demirel & Karakus-Yılmaz, 2019), level of geometric thinking (Dokumacı-Sütçü, 2018), learning the topic of area measurement and the concept of area conservation (Fiangga, 2014). In addition, they increase students' motivation in mathematics lessons and reduce anxiety and negative attitudes toward mathematics (Bragg, 2012).

Mind and intelligence games support students' metacognitive awareness, creative thinking, social skills, and attention development, but they fall short in sustaining their lasting effects on metacognitive awareness and social skills (Ayar & Çavaş, 2024). In fact, students who are defeated in mind and intelligence games experience a sense of failure over time (Kula, 2019). Therefore, for the process of mind and intelligence games to be effective, the difficulty level of the games should be appropriate to the students' level of preparation (Demirel & Karakuş-Yılmaz, 2019). The time spent on mind and intelligence games, the number and variety of rules to be remembered, the ability to create a pattern or strategy suitable for the game, and whether or not manipulation of the number, shape, or object to be remembered is performed must be reviewed (Saygı & Alkaş Ulusoy, 2019).

Workshop environments must be created for the implementation of mind and intelligence games at every level of education (Epçaçan & Bahçeci, 2023). In mathematics lessons, psycho-motor skills, attention and memory power, spatial thinking ability, and mental strategies must be carried out together with mathematical skills (Erdoğan et al., 2017). Furthermore, limitations such as the fact that mind and intelligence games take a lot of time, it is not easy to prepare a game for each achievement, and they are difficult to use in crowded classrooms make it difficult to use them in mathematics teaching (Özata & Coşkuntuncel, 2019). Therefore, in order for students to develop a positive attitude towards mathematics and succeed in the subject, teachers must organize the classroom environment, teach logic and intelligence games, support students in developing strategies while playing games, integrate these into mathematics learning outcomes, and ensure students have self-efficacy to manage the process positively when they fail or lose. This way, students can be prevented from worrying about how to teach mind and intelligence games in math class.

## 2. Literature Review

It has been found that pre-service primary school teachers have high self-efficacy in teaching mathematics (Ural, 2015). In contrast, studies focusing on primary school teachers indicate deficiencies in conceptual areas such as place value, fraction operations, decimals, percentages, and measurement (Thanheiser, 2009). It has been observed that there is a difference in the mathematical teaching self-efficacy of pre-service primary school teachers between the first and last years of their undergraduate education. It has been determined that the self-efficacy of pre-service primary school teachers in teaching mathematics increases during the internship period in the final years of undergraduate education (Segarra et al., 2021). This increase is often attributed to mediated field experiences, where structured teaching opportunities allow pre-service teachers to bridge the gap between theoretical knowledge and classroom practice (Gresham, 2021). Because it has concluded that there is a relationship between attitudes toward mathematics and teachers' perceptions and self-confidence when teaching this subject (Delgado-Monge et al., 2024). The beliefs of pre-service primary school teachers regarding teaching mathematics have a positive impact on their practices (Hughes et al., 2019). In addition, it has been found that as pre-service primary school teachers' self-efficacy in teaching mathematics increases, their anxiety about teaching mathematics decreases (Deringöl, 2018; Ural, 2015). Anxiety about teaching mathematics negatively affects pre-service primary school teachers' self-efficacy in teaching effectiveness and effective teaching (Peker, 2016). When comparing pre-service primary school teachers with pre-service mathematics teachers in terms of mathematics teaching anxiety, it was found that pre-service primary school teachers were more anxious about mathematics lessons, while primary school mathematics teachers were more anxious about mathematics teaching (Karaman & Çil, 2021). However, it has been demonstrated that the learning and teaching process designed with GeoGebra software reduces mathematics pre-service teachers' mathematics teaching anxiety (Zengin, 2017). Studies conducted with pre-service primary school teachers were aimed at determining their self-efficacy and anxiety in teaching mathematics or identifying the relationship between the two, but no studies were found that examined the effect of any teaching process on developing their self-efficacy in teaching mathematics or reducing their anxiety. In this sense, providing pre-service primary school teachers with training in NMIG that develop their skills in the four operations, problem solving, reasoning, and decision making may increase their self-efficacy in teaching mathematics and reduce their anxiety. This is because studies conducted with pre-service teachers have demonstrated the effectiveness of mind and intelligence games.

Gamification had a significant positive effect on students' academic achievement (Marín-Díaz et al., 2020). Intelligence games support pre-service teachers' lower cognitive areas such as memory, comprehension, and application, as well as higher cognitive areas such as analysis, evaluation, and creativity (Yükseltürk et al., 2022). Intelligence games are metaphorically perceived by pre-service teachers as development and versatility, while intelligence games are most often expressed with the words *wheel* and *key* (Güneş, 2023). Pre-service social studies teachers believe that the use of intelligence games in educational settings is beneficial (Ekiçi et al., 2017). In addition, pre-service teachers stated that mind and intelligence games support the development of planned movement, attention skills, and versatile thinking abilities, as well as students' socialization and acquisition of group consciousness (Güneş & Güneş, 2024). Pre-service science teachers have stated that mind and intelligence games contribute to basic mathematical skills and science and mathematics education, activate students, and strengthen their mental and manual skills (Çetin & Özbuğutu, 2020).

### 2.1. The Importance and Aim of the Study

A review of existing studies in the literature reveals a broad descriptive data set focusing on determining You had better use pre-service primary school teacher [PPST] in the firts appearance, then just use PPST for all terms for these teachers, such as candidates, future teachers etc.' self-efficacy and anxiety levels regarding mathematics instruction. However, this accumulation of data has not gone beyond identifying existing problems; it has been insufficient in offering practical and intervention-based solutions, particularly those that would break the cycle of low self-efficacy and high anxiety. Most existing studies have merely described the situation and neglected experimental processes that would directly transform the pedagogical skills of prospective classroom teachers. This study is of critical importance as it aims to fill the methodological and practical gap in the literature. The NMIG training used in the study offers a hybrid solution that intervenes in both the cognitive and affective domains of PPST simultaneously, unlike traditional theoretical courses. Through this process, PPST will experience the four operations, logical reasoning, and problem-solving skills in a game-based environment, transforming the perception of mathematics teaching from abstract and difficult to concrete and manageable, thereby increasing their professional competence. Future students will benefit from teachers with reduced anxiety and increased self-efficacy, who will use more innovative and student-centered methods in their classrooms, thereby contributing to the development of a generation that is not afraid of mathematics. In conclusion, this study aims not only to examine the relationship between PPST' anxiety and competence levels but also to experimentally demonstrate that numerical reasoning and intelligence games offer a concrete solution to these issues as a systematic teaching tool. In this respect, the study will meet an important need in the field by proposing an alternative and effective model that can be integrated into teacher education curricula.

This study examined the effect of NMIG on the mathematics teaching competencies and anxieties of PPST. To this end, the study sought answers to the following questions:

RQ 1) Is there a statistically significant difference between the pretest and posttest scores of PPST who received training in NMIG in terms of their mathematics teaching anxiety?

RQ 2) Is there a statistically significant difference between the pretest and posttest scores of PPST who received training in NMIG in terms of their mathematics teaching self-efficacy?

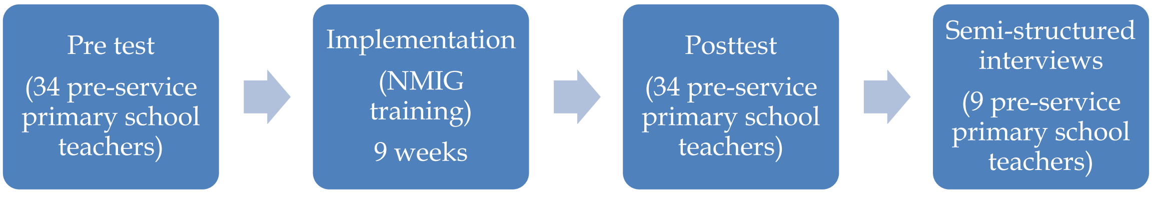
RQ 3) What are the views of PPST on mathematics teaching with NMIG?

## 3. Method

### 3.1. Research Design

In this study, the explanatory design of the mixed method was used. In the explanatory design of the mixed method, qualitative data is collected after quantitative methods are used to collect and analyze data (see Figure 1).

Figure 1
*Research Process*




In the quantitative section of this study, a pre and post-test experimental (simple) design without a control group was used, while in the qualitative section, a case study design was employed. The simple experimental design is used when there is no control group and random assignment is not possible (Shadish et al., 2002). In a case study, an opportunity is provided to examine a problem in detail and in depth, and the researcher is given the opportunity to focus on a specific situation or topic (Creswell & Poth, 2018). The choice of a case study design in this research is particularly appropriate for seeking answers to the questions of "how" and "why" NMIG were effective in the mathematics teaching self-efficacy and anxiety levels of PPST; as this design provides an in-depth understanding of the fundamental processes that experimental designs may overlook.

## 3.2. Study Group

The study was conducted with 34 PPST (30 female, 4 male) selected through convenience sampling from the 3rd grade of the Faculty of Education, Department of Primary School Teacher Education at a university in the Central Anatolia Region of Turkey. Convenience sampling is used when it is easy to access the sample group in order to speed up the study (Creswell, 2014). Convenience sampling was used because the researcher was teaching Mathematics Education I in the classroom. Additionally, semi-structured interviews were conducted with 9 randomly selected pre-service teachers from the study group regarding the effect of NMIG on mathematics teaching anxiety and competence. A random selection was made from among the volunteer PPST participating in the experimental process who agreed to participate in semi-structured interviews. Interviews with 9 PPST were terminated due to repetition in the responses given by the pre-service teachers to the interview questions. Random sampling was used to select pre-service teachers with positive or negative views on mathematics education in an unbiased manner. Six of the pre-service teachers interviewed were female and three were male.

## 3.3. Data Collection Tools

### *3.3.1. Mathematics Teaching Self-Efficacy Scale (Pre-service Teacher)*

The scale developed by Şahinkaya (2008) consists of a total of 21 items. The scale, which consists of the dimensions of self-efficacy, outcome expectancy, and competence, is organized in a Likert-type format with five options (Strongly Agree, Agree, Undecided, Disagree, Strongly Disagree). The scale has subdimensions of self-efficacy (13 items) and outcome expectancy. The self-efficacy subscale includes items such as "I constantly find better ways to teach math," "I generally cannot teach math effectively," etc. The outcome expectancy subscale includes items such as "A student's lack of prior knowledge in math can be remedied with good teaching," "Students' success in math is directly related to the effectiveness of their teachers' math instruction," etc. The scale contains 11 negative and 10 positive items, and the scale's reliability coefficient is .80. The self-efficacy subscale Cronbach Alpha ($\alpha$) value is .79, and the outcome expectation $\alpha$ value is .73.

### *3.3.2. Mathematics Teaching Anxiety*

The scale developed by Sarı (2014) is three-dimensional (anxiety related to teaching, subject knowledge, and self-efficacy) and consists of 23 questions. The reliability coefficient of the scale is .89. The exploratory factor analysis conducted for the scale revealed that Bartlett's sphericity test was statistically significant ($p < .001$) and the KMO value was 0.918. Scale; anxiety related to the teaching process (the thought of not being able to motivate students who are reluctant to take math classes bothers me; the thought of how I can teach math topics according to the students' levels makes me uneasy, ...), anxiety related to subject knowledge (I eagerly await recess when I have math classes; knowing that the next class is math makes me uneasy. ...) and anxiety related to self-efficacy (I feel nervous when other people, such as candidate (trainee) teachers, come to observe math classes, I worry about not being able to find the answer to a math question immediately in math teaching, ...). The total Cronbach Alpha ($\alpha$) value of the scale is .89, while the anxiety dimension related to the teaching process (11 items) ($\alpha$) value is .89, the anxiety dimension related to subject knowledge (6 items) ($\alpha$) value is .77, and the anxiety dimension related to self-efficacy (6 items) ($\alpha$) value is .72.

### 3.3.3. Semi-structured interview

When creating the semi-structured interview form to be used with pre-service teacher, studies in the literature related to NMIG were first reviewed. Then, three questions were prepared in line with the purpose of the study and in a way that would support the experimental results. The prepared questions were sent to experts in the fields of mathematics education, classroom education, and assessment and evaluation for their opinions. Subsequently, a pilot interview was conducted with four pre-service mathematics teachers who had received training in NMIG but were not included in the study, and the final version was finalized.

In semi-structured interviews, three questions were asked to determine students' views on mathematics teaching using NMIG. The questions were: "Which subject do you find the most difficult to teach, and why?; What are your thoughts on mathematics education supported by NMIG?; What are your thoughts on the benefits of mathematics education supported by NMIG for students?" The semi-structured interview form was developed to provide a deeper understanding of the quantitative findings regarding pre-service teachers' mathematics teaching efficacy and anxiety. The decision-making process for the interview questions was based on the "explanatory sequential design" of the study, which aims to clarify how and why Numerical Mind and Intelligence Games influenced these variables. The first question ("Which subject do you find the most difficult to teach?") was designed to establish a baseline for the participants' perceived pedagogical challenges. This allowed the researcher to observe whether NMIG provided a specific pedagogical solution to previously difficult topics. The second and third questions focused on the participants' personal experiences and perceived student benefits. These questions were specifically formulated to elaborate on the quantitative shifts observed in the *Teaching Efficacy Scale* and *Mathematics Teaching Anxiety Scale*. For instance, while quantitative data showed a decrease in anxiety, the interview questions aimed to uncover the specific mechanisms (e.g., increased confidence, gamification) that led to this reduction.

## 3.4. Data Collection

In this study, the mathematics teaching self-efficacy scale and mathematics teaching anxiety scales were used as pre-tests to determine the mathematics teaching anxiety and competence of PPST. The scales were administered to PPST before they received training in NMIG. Subsequently, a 9-week training program on numerical reasoning and intelligence games was conducted, followed by the administration of the Mathematics Teaching Self-Efficacy Scale and Mathematics Teaching Anxiety Scales as post-tests, which had been administered as pre-tests. Teacher candidates were given 40 minutes to complete the scales. After analyzing the post-tests, semi-structured interviews were conducted with volunteer PPST to determine how NMIG affected their mathematics teaching self-efficacy and anxiety. Interviews with each teacher candidate were conducted in a quiet environment. Each interview, lasting an average of 15 minutes, was recorded with a voice recorder. The interviews, which lasted a total of 120-150 minutes, were transcribed on a computer. The qualitative data obtained were analyzed separately by each researcher. After the NMIG training, the mathematics teaching anxiety and self-efficacy scale was administered to the PPST as a final test. After the quantitative data was collected, semi-structured interviews were conducted with nine randomly selected PPST about the effect of NMIG on mathematics teaching competence and anxiety.

## 3.5. Data Analysis

To determine the effect of NMIG training on PPST' anxiety and self-efficacy in teaching mathematics, the normality of the difference between the pre- and post-test scores was checked before performing statistical operations. Additionally, even if the distribution does not show normality, the dependent t-test yields acceptable results when the sample size exceeds 30 (Green & Salking, 2008). Since the study was conducted with 34 PPST and the difference between the post-test and pre-test scores showed a normal distribution, the effect of NMIG on the PPST' mathematics teaching anxiety and self-efficacy was analyzed using a dependent *t*-test

(Mathematics teaching anxiety skewness value .18, kurtosis value −.13; mathematics teaching self-efficacy skewness value -.64, kurtosis value .36). The qualitative data obtained from semi-structured interviews were analyzed using descriptive analysis. Descriptive analysis is an analysis based on questions or topics included in data collection tools such as interviews, observations, and documents used in the research process (Creswell, 2014). Descriptive analysis was used because the PPST' views on NMIG were coded based on the research questions.

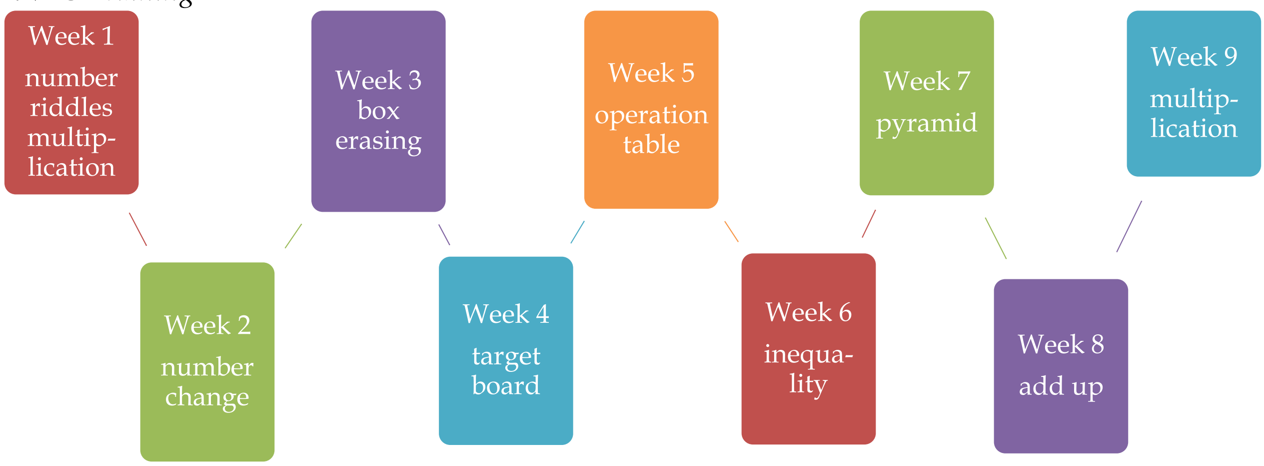
The semi-structured interviews with the PPST were recorded with a voice recorder, transcribed, and analyzed and coded separately by the researchers. The PPST expressed multiple opinions on each of the interview questions. The agreement between the researchers' codings was calculated according to the Miles and Huberman (1994) formula. The agreement between the researcher codes was 93%. Codes that could not be agreed upon were discussed by the researchers and a consensus was reached. In addition, pre-service teachers participated in the study group on a voluntary basis, and codes such as P1, P2, ... were used instead of their real names.

### 3.6. Implementation

NMIG (number riddles, number change, box erasing, target board, operation table, inequality, pyramid, add up, and multiplication) were administered once a week during a 50-minute lesson. NMIG were included in the study because they support the development of skills such as the four operations and establishing relationships between numbers, which are part of the primary school school mathematics curriculum. In addition, NMIG were selected to develop the higher-order thinking skills of PPST, such as reasoning, judgment, problem solving, and decision making, as well as to support their pedagogical knowledge of how to teach NMIG to develop the higher-order thinking skills of students. While teaching NMIG, the researcher solved the sample question in Level 1 and the next question from the NMIG in Halıcı's (2019) intelligence games training workbook and explained the rules of the game and the researcher's solving strategies. The researcher told the PPST that they could also develop their own solving strategies. Later, in the classroom environment, the pre-service teachers were asked to solve the questions in Levels 1 and 2. Questions that could not be solved were explained by the students who solved the question or by the researcher and solved on the board. The questions in Level 3 were given to the pre-service teachers as homework to solve. Questions that the pre-service teachers could not solve in Level 3 were explained and solved at the beginning of the next week's training. Only the multiplication game was taught to the PPST using questions from Özkan's (2023) book. The practice continued for 9 weeks.

The distribution of NMIG training given to PPST by week is presented in Figure 2.

Figure 2
*NMIG Training*




In practice, PPST were given NMIG from Halıcı's (2019) book on mind and intelligence games. First, the rules of the relevant game, which were projected onto the board by the researcher, were explained by solving the first game in the first stage. Then, PPST were given time to solve questions related to numerical mind and intelligence games. Each classroom teacher was given the opportunity to progress at their own pace. Those who could easily solve the numerical mind and intelligence games were allowed to progress, while those who had difficulty solving them were given explanations by the researcher. The games that the PPST had difficulty solving were solved and demonstrated on the board by the researcher or a volunteer student who could solve them. The application continued with one numerical reasoning and intelligence game taught each week.

## 4. Findings

In this section of the study, the results of the descriptive analysis of the PPST' mathematics teaching anxiety and self-efficacy before and after the NMIG training, as well as the results of the statistical analysis conducted to examine the effect of NMIG on mathematics teaching anxiety and efficacy, are presented (see Figure 3).

Figure 3
*Order of presentation of findings*


The results of the descriptive analysis of PPST' mathematics teaching anxiety and self-efficacy before and after NMIG training are shown in Table 1.

Table 1
*Descriptive Analysis Results of Mathematics Teaching Anxiety and Self-Efficacy*

| *Tests* | *N* | *M* | *SD* | *Skewness* | *Kurtosis* |
|---|---|---|---|---|---|
| Mathematics teaching anxiety | | | | | |
| Pre-test | 34 | 2.49 | .63 | .18 | −.13 |
| Post-test | 34 | 2.31 | .69 | | |
| Mathematics teaching self-efficacy | | | | | |
| Pre-test | 34 | 3.54 | .31 | −.64 | .36 |
| Post-test | 34 | 3.57 | .25 | | |

The descriptive analysis results presented in Table 1 indicate a descriptive decrease in the mathematics teaching anxiety scores of pre-service teachers following the intervention. While the pre-test mean score for anxiety was $M$ = 2.49 ($SD$ = .63), it declined to $M$ = 2.31 ($SD$ = .69) in the post-test. Conversely, a slight increase was observed in mathematics teaching self-efficacy scores, rising from a pre-test mean of $M$ = 3.54 ($SD$ = .31) to a post-test mean of $M$ = 3.57 ($SD$ = .25). The Skewness and Kurtosis values for both scales ranged between −1 and +1, suggesting that the data followed a normal distribution, which justified the use of parametric tests for further analysis.

The change in mathematics teaching anxiety of each pre-service primary school teacher caused by NMIG is shown in Figure 4. According to Figure 4, it is observed that the mathematics teaching anxiety of 22 of the PPST decreased as a result of NMIG training, while that of 12 increased.

The statistical significance of NMIG on PPST′ mathematics teaching anxiety was analyzed using a dependent $t$-test, and the results are shown in Table 2.

Figure 4
*Change in mathematics teaching anxiety among PPST*

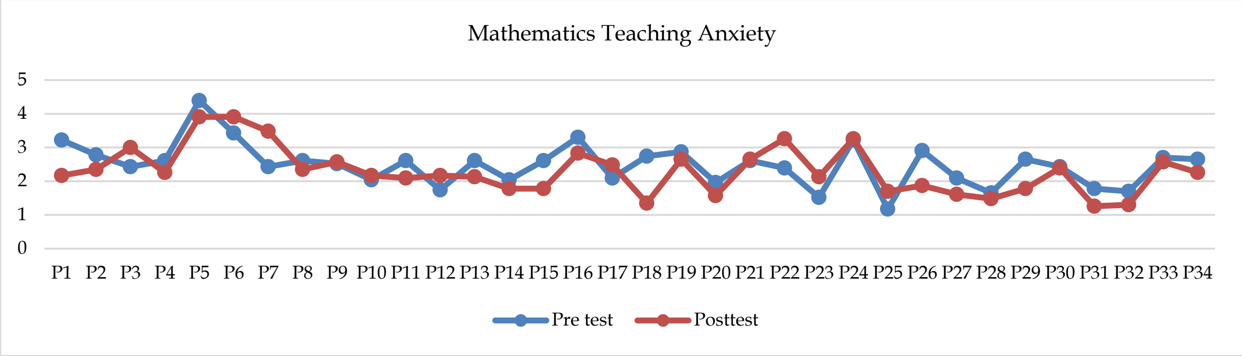
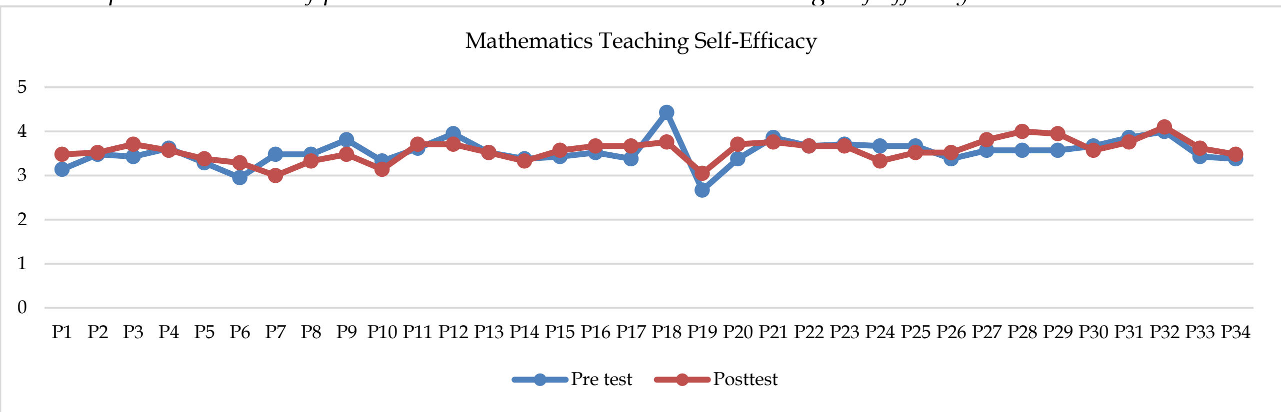



Table 2
*Dependent t-test results for PPST' mathematics teaching anxiety*

| *Mathematics Teaching Anxiety* | *Test* | *N* | *M* | *SD* | *df* | *t* | *p* |
|---|---|---|---|---|---|---|---|
| Related to teaching | | | | | | | |
| Pre-test | | 34 | 3.33 | .75 | 33 | 2.22 | .03 |
| Post-test | | 34 | 3.00 | .83 | | | |
| Related to subject knowledge | | | | | | | |
| Pre-test | | 34 | 1.43 | .81 | 33 | −.80 | .43 |
| Post-test | | 34 | 1.51 | .92 | | | |
| Related to self-efficacy | | | | | | | |
| Pre-test | | 34 | 1.99 | .80 | 33 | 1.25 | .22 |
| Post-test | | 34 | 1.84 | .85 | | | |
| Total | | | | | | | |
| Pre-test | | 34 | 2.49 | .63 | 33 | 1.84 | .08 |
| Post-test | | 34 | 2.31 | .69 | | | |

The results of the paired samples t-test conducted to determine the effect of NMIG on mathematics teaching anxiety are presented in Table 2. A statistically significant decrease was observed in the related to teaching dimension [$t(33) = 2.22$, $p < .05$]. The mean score for this dimension dropped from $M = 3.33$ to $M = 3.00$, indicating that NMIG training effectively reduced the anxiety pre-service teachers felt regarding the instructional process. However, no significant differences were found in the dimensions of related to subject knowledge [$t(33) = -0.80$, $p>.05$] and related to self-efficacy [$t(33) = 1.25$, $p > .05$]. While the total anxiety scores showed a descriptive decrease from $M = 2.49$ to $M = 2.31$, this change did not reach statistical significance [$t(33) = 1.84$, $p = .08$]. These findings suggest that the intervention primarily impacts the pedagogical aspect of anxiety rather than theoretical subject knowledge. The changes in the mathematical teaching competence of each pre-service primary school teacher created by NMIG are shown in Figure 5.

Figure 5
*Pre- and post-test scores of pre-service teachers' mathematics teaching self-efficacy*



According to Figure 5, it is observed that the mathematical teaching self-efficacy of 14 of the PPST decreased as a result of NMIG training, while that of 18 increased and that of 2 remained unchanged.

The statistical significance of NMIG on PPST' mathematics teaching self-efficacy was analyzed using a dependent *t*-test, and the results are shown in Table 3.

Table 3
*Dependent t-test results for pre-service teachers' mathematics teaching self-efficacy*

| *Test* | *N* | *M* | *SD* | *df* | *t* | *p* |
|---|---|---|---|---|---|---|
| Self-competence | | | | | | |
| Pre | 34 | 3.92 | .42 | 33 | −.60 | .55 |
| Post | 34 | 3.95 | .42 | | | |
| Outcome | | | | | | |
| Pre | 34 | 2.92 | .23 | 33 | −.51 | .62 |
| Post | 34 | 2.95 | .25 | | | |
| Total | | | | | | |
| Pre | 34 | 3.54 | .31 | 33 | −.73 | .47 |
| Post | 34 | 3.57 | .25 | | | |

Table 3 presents the paired samples t-test results regarding the change in pre-service teachers' mathematics teaching self-efficacy scores. According to the analysis, no statistically significant difference was found between the pre-test and post-test scores for the self-efficacy dimension [$t(33) = -0.60$, $p > .05$] or the outcome expectancy dimension [$t(33) = -0.51$, $p > .05$]. Similarly, the total self-efficacy scores showed a very slight descriptive increase (from $M = 3.54$ to $M = 3.57$), but this improvement was not statistically significant [$t(33) = -0.73$, $p = .47$]. These results suggest that while NMIG training had a positive descriptive effect on self-efficacy, it did not lead to a fundamental shift in participants' perceived professional competence within the intervention period.

.The findings obtained from semi-structured interviews with 9 PPST regarding the effect of NMIG on mathematics teaching anxiety and self-efficacy are presented in Tables 4, 5, 6, and 7. Information about the subjects that PPST liked, found easy to teach, and enjoyed teaching the most is presented in Table 4.

Table 4
*Information about Pre-Service Teachers Who Participated in the Interviews*

| *Pre-service Teachers* | *Favorite Lesson* | *Lesson he thinks is easy to teach* | *Lesson he most enjoys teaching* |
|---|---|---|---|
| P1 | Literature (for high school) | Turkish | Mathematics |
| P2 | Literature | Life Sciences | Mathematics |
| P3 | Mathematics | Turkish | Mathematics |
| P4 | Mathematics | Life Sciences | Sports |
| P5 | Mathematics | Life Sciences | Mathematics |
| P6 | Mathematics | Turkish | Life Sciences |
| P7 | Turkish | Visual Arts | Life Sciences |
| P8 | Literature (for high school) | Life Sciences | Life Sciences |
| P9 | Literature (for high school) | Life Sciences | Science |

According to Table 4, four of the PPST who participated in the semi-structured interviews liked literature, while three liked mathematics. Five of the PPST indicated that life skills were the easiest subject to teach, while none of the PPST thought that mathematics was easy to teach. However, four PPST stated that they liked teaching mathematics.

The PPST who participated in the semi-structured interviews were asked which lesson they found most difficult to teach and the reasons why, and the data obtained are shown in Table 5.

Table 5
*The most difficult lesson to teach according to pre-service teachers*

| *Lesson* | *f* | *Cause* | *Pre-service Teachers* | *f* |
|---|---|---|---|---|
| Mathematics | 8 (P1, P2, P4, P5, P6, P7, P8, P9) | It is an abstract lesson. | P1, P5, P6, P8, P9 | 5 |
| | | It has a spiral structure. | P2, P7 | 2 |
| | | Teaching it is costly and requires special effort. | P4, P9 | 2 |
| | | It requires advanced thinking skills. | P6 | 1 |
| | | Students do not have the same level of readiness. | P6 | 1 |
| | | The student has preconceived notions about the lesson. | P8 | 1 |
| | | The student has difficulty learning in their student life. | P8 | 1 |
| Science | 2 (P3, P8) | Negative experiences in student life. | P3, P8 | 2 |
| | | Requiring teaching without materials and experiments | P3, P8 | 1 |

According to Table 5, eight of the PPST stated that mathematics was the most difficult subject to teach, while two stated that it was science. Five of the PPST pointed to the abstract nature of the lesson as the reason for the difficulty of teaching mathematics, while two pointed to the spiral structure of the subject. PPST who thought that science was difficult to teach cited the difficulty of understanding the lesson without materials and experiments as the reason for its difficulty, and pointed to their own negative experiences in learning the subject as students. Pre-service teacher P8, who finds both mathematics and science difficult to teach, expressed their thoughts on the lesson as follows: "I think mathematics and science are difficult to teach. I think mathematics is a lesson that students are prejudiced against, and it is a more abstract lesson than other lessons. I think that science lessons cannot be fully understood without the necessary materials and methods such as experiments. I think this way because these were the two lessons I struggled with during my student years." Meanwhile, student P7, who believes that teaching mathematics is difficult, expressed their thoughts as follows: "Teaching mathematics is difficult. Because a single achievement that cannot be gained affects the student's entire life. Therefore, the subject must be taught carefully and all students must be made to understand the essence of the lesson."

PPST were asked for their opinions on teaching mathematics with the support of NMIG, and their responses are shown in Table 6.

Table 6
*Opinions on teaching mathematics with the support of NMIG*

| *Teaching* | *Opinions* | *Pre-service Teachers* | *f* |
|---|---|---|---|
| Positive (All pre-service teachers) | Motivates students to participate in class | P1, P2, P3, P4, P5 | 5 |
| | Activates students' higher-order thinking skills | P2, P5, P6, P8 | 4 |
| | Increases students' self-confidence | P1, P3, P7 | 3 |
| | Makes math teaching fun | P5, P8 | 2 |
| | Improves processing speed | P6, P7 | 2 |
| | Facilitates math teaching | P9 | 1 |
| | Encourages active participation in class | P7 | 1 |

According to Table 6, all PPST believe that NMIG would be useful in mathematics teaching. As reasons for the usefulness of mathematics teaching using NMIG, 5 of the PPST believe that the games will motivate students to attend class, 4 believe that they will activate students' higher-order thinking skills, and 3 believe that they will increase students' confidence in mathematics. Pre-service teacher P5, who believes that mathematics teaching supported by NMIG is useful, expresses his views on the subject as follows: "I think it is useful for pre-service teachers who will start working in the future to try it out. Doing it before starting teaching motivates students to attend class. My favorite feature is that it encourages students to think mentally in the morning and is fun." Pre-service teacher P2, on the other hand, expressed their views as follows: "These games attract children's attention and make the lesson interesting, developing their practical intelligence. It can be started with examples appropriate to the students' level, and then questions above their level can be given as homework."

The opinions of PPST on the benefits of mathematics teaching supported by NMIG for students are shown in Table 7.

Table 7
*PPST' thoughts on the benefits of mathematics teaching supported by NMIG for students*

| *Opinions* | *Pre-service Teachers* | *f* |
|---|---|---|
| Develops students' higher-order thinking skills. | P2, P3, P6, P7, P8, P9 | 6 |
| Motivates students to participate in class. | P2, P4, P5, P7 | 4 |
| Provides students with opportunities to apply what they have learned. | P5, P6, P7, P8 | 4 |
| Increases motivation in class. | P1, P8 | 2 |
| Boosts students' confidence in class. | P1, P7 | 2 |
| Increases student participation in class. | P2 | 1 |
| Improves academic performance. | P9 | 1 |

According to Table 7, six of the PPST believe that mathematics teaching supported by NMIG is useful in terms of supporting students' higher-order thinking skills, four believe it is useful in terms of motivating students to attend class, and four believe it is useful in terms of providing students with opportunities to apply the knowledge they have learned in class. Regarding the topic, the pre-service primary school teacher with code P8 expressed their thoughts as follows: "NMIG develop students' higher-order thinking skills, motivate students to engage in the lesson, enhance computational skills, and promote quick thinking." Meanwhile, the pre-service primary school teacher with code P9 stated their views on the topic as follows: "They enhance students' creative and analytical thinking skills, as well as their problem-solving abilities. They enable students to be more successful in mathematics lessons."

## 5. Discussion

This study, through the rich perspective offered by a mixed-methods design, has revealed the multidimensional impact of Numerical Mind and Intelligence Games training on PPST' mathematics teaching anxiety and competencies. The quantitative data of the study indicate a significant decrease in overall mathematics teaching anxiety, while the qualitative findings confirm that this decrease is rooted in the games' ability to concretize abstract mathematical concepts and transform problem-solving processes into engaging experiences.

The findings demonstrate that NMIG training has varying effects across the sub-dimensions of mathematics teaching anxiety. While a significant reduction was observed in pre-service teachers' *anxiety regarding the teaching process* no statistically significant change was recorded in their anxiety related to *mathematical self-efficacy* and *subject knowledge.* This result aligns with the findings of Tunç-Pekkan et al. (2023) and Zengin (2017), who reported that different instructional methods and software reduce anxiety. However, within a broader global context, this finding supports the math-pedagogy anxiety framework, which suggests that pedagogical confidence often precedes structural subject-matter confidence in short-term interventions (Finlayson, 2014). As a unique finding of this study, although NMIG supports higher-order cognitive skills (Baş et al., 2020), it was observed that it could not alter deep-seated subject knowledge anxieties within a short period. A plausible reason for this may be that NMIG content focuses on reinforcing existing knowledge rather than providing academic depth for mathematical topics with which pre-service teachers are unfamiliar. This is consistent with Shulman's (1986) Pedagogical content knowledge theory, as games enhance the how-to-teach (pedagogy) more rapidly than the what-to-teach (content knowledge).

The quantitative finding of *no change in teaching competency* can be elucidated by the *implementation challenges* theme derived from the qualitative data. Although participants stated that intelligence games are the most suitable tools for mathematics (Yükseltürk et al., 2022) and keep students active (Çetin & Özbuğutu, 2020), they also highlighted risks such as large class sizes, lack of individual feedback, and the difficulty of selecting games appropriate for cognitive levels (Earp et al., 2014; Ekiçi et al., 2017). Therefore, while pre-service teachers believe in the theoretical benefits of these games, the persistence of their pedagogical concerns regarding the application phase can be considered the primary reason for the stagnation in competency scores. This suggests that the thesis of *increased self-confidence through pedagogical education* proposed by Hoşşirin Elmas (2015) may be hindered when practical limitations arise.

One of the most striking outputs of the research is the relationship between pre-service teachers' perception of mathematics as the *most difficult subject to teach* and the potential of NMIG to overcome this difficulty. Pre-service teachers carry intense professional worry as they lack sufficient opportunities to apply instructional methods during their undergraduate education (Yurtbakan, 2025). In contrast, both the qualitative findings of this study and similar studies in the literature (Çetin & Özbuğutu, 2020; Güneş & Güneş, 2024) indicate that NMIG can break this perception of *difficulty* by developing attention, reasoning, and association skills. Internationally, this supports the use of game-based learning as a bridge to mitigate the performance pressure typical of traditional mathematics instruction (Plass et al., 2015). By gamifying the curriculum, the difficulty of mathematics is reframed as a challenge to be solved, shifting the emotional response from fear to curiosity (Connolly et al., 2012).

Consequently, when the quantitative and qualitative data obtained from the research are evaluated holistically; it is understood that NMIG training is an effective tool in overcoming the affective barriers (anxiety) of pre-service teachers toward mathematics teaching. However, it is evident that more long-term interventions that consider individual differences are needed to transform structural beliefs such as professional competency and subject matter knowledge. Following the principles of Bandura’s (1997) Social Cognitive Theory, long-term mastery experiences are essential to translate temporary anxiety reduction into permanent professional self-efficacy. Future teacher-training policies should therefore prioritize longitudinal exposure to NMIG-like tools across the entire pedagogical curriculum.

## 6. Limitations

The study used only NMIG that could be played with pen and paper. In addition, the study was conducted using nine NMIG covering limited mathematical topics such as the four operations and equations, including number puzzles, number swapping, box erasing, target boards, operation tables, inequalities, pyramids, add-up, and multiplication. When selecting the NMIG, the readiness level of the pre-service teachers regarding the games was not determined. Although the NMIG progressed from easy to difficult, due to the large number of students, it was not possible to monitor whether each student could solve every question. When students indicated they could not solve a problem, the solution was explained to the entire class on the board.

## 7. Suggestions

This study was conducted with 34 PPSTs. Future research could strengthen the evidence base by involving a larger and more diverse group of PPSTs who can provide richer feedback on numerical intelligence game solutions. With broader participation, researchers could examine changes in pre-service teachers’ mathematics teaching self-efficacy and anxiety more robustly and explore how these outcomes vary across different backgrounds and prior experiences.

To increase pre-service teachers’ self-efficacy effectively and address subject-matter anxiety, NMIG training should be designed through a scaffolding approach. Beginning with introductory games and gradually increasing difficulty in line with participants’ individual mathematical readiness can support confidence-building before moving to more complex operations. Such progression may prevent early frustration and allow participants to experience incremental success, which is central to developing stronger efficacy beliefs.

Given the finding that NMIG training significantly reduces pedagogical anxiety, integrating these games into mathematics teaching methods courses or Teaching Practice I–II within Faculties of Education may be especially beneficial. Embedding NMIG activities in these courses can provide pre-service teachers with structured opportunities to rehearse instructional decision-making, anticipate classroom challenges, and experience a supportive environment for experimentation and reflection.

Participants' emphasis on how games help concretize abstract concepts suggests the value of developing NMIG resource libraries in both digital and physical formats. Curating accessible collections of games categorized by mathematical topics (e.g., fractions, geometry, operations) would make it easier for teachers to locate and implement suitable activities, while also promoting sustained and systematic use of game-based resources in instructional planning.

Because this study focused on nine pen-and-paper NMIGs (e.g., number puzzles, pyramids, operation tables), future studies could expand the range of mathematical topics and game types examined. Incorporating tactile and strategy-based board games such as Mangala, Corridor, or Topla Topla may offer additional insights into how different game mechanics influence mathematics teaching anxiety and engagement, potentially revealing which features are most supportive for teacher learning.

A key consideration for future interventions is determining participants' readiness levels regarding intelligence games in advance. Assessing entry-level skills and mathematical preparedness prior to training would allow researchers to tailor both the type and difficulty of games to participants' needs. This alignment may lead to more meaningful improvements in self-efficacy and perceived competence, particularly for those who begin the intervention with higher levels of anxiety or lower confidence.

Large group sizes limited individual monitoring in the present study. Future research conducted with smaller focus groups, or supported by multiple facilitators, could enable more detailed observation of how each participant navigates the problem-solving process. Closer monitoring may also help identify common obstacles, effective facilitation strategies, and the moments in which shifts in confidence or anxiety occur.

To better understand the "why" behind quantitative results, fully qualitative studies are also recommended. In-depth qualitative designs could investigate the underlying reasons some pre-service teachers feel inadequate when engaging with NMIG, including prior learning experiences, beliefs about mathematical ability, perceptions of evaluation, and the emotional dynamics triggered during problem solving.

Finally, a promising direction for future research is comparing the effectiveness of physical tabletop games with digital/online versions. Such comparisons could examine not only differences in self-efficacy and anxiety outcomes, but also their potential contributions to pre-service teachers' technological pedagogical content knowledge. This would provide a more comprehensive understanding of how game-based approaches can support contemporary mathematics education in both traditional and technology-enhanced environments.

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**Data Availability:** Data is available upon reasonable request.

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## References


Alyanak, M., & Özkaya, A. (2024). The effect of intelligence games on 5th grade students' mathematics attitudes and academic achievement. *Scientific Educational Studies, 8*(1), 20-40. https://doi.org/10.31798/ses.1462049

Ayar, A., & Çavaş, P. (2024). The effects of mind and intelligence games in primary school: an ın-depth analysis. *Western Anatolia Journal of Educational Sciences, 15*(3), 3360-3386. https://doi.org/10.51460/baebd.1588159

Ayvaz Can, A. (2019). Investigation of mathematics literacy self-efficacy levels of pre-service primary teachers. *Bolu Abant Izzet Baysal University Journal of Faculty of Education, 19*(3), 753-766. https://doi.org/10.17240/aibuefd.2019.19.49440-542414

Baki, A. (2008). *Kuramdan uygulamaya matematik eğitimi* [Mathematics education from theory to practice] (4th ed.). Harf Education & Publishing.

Bandura, A. (1997). *Self-efficacy: The exercise of control.* W H Freeman/Times Books/ Henry Holt & Co.

Baş, O., Kuzu, O., & Gök, B. (2020). The effects of mind games on higher level thinking skills in gifted students. *Journal of Education and Future, 17*, 1-13. https://doi.org/10.30786/jef.506669

Bekdemir, M. (2010). The pre-service teachers' mathematics anxiety related to depth of negative experiences in mathematics classroom while they were students. *Educational Studies in Mathematics, 75*(3), 311–328. https://doi.org/10.1007/s10649-010- 9260-7

Bilgiç, E. N. Ü. (2022). The relationship between technological pedagogical content knowledge of mathematics teacher candidates and teaching mathematics anxiety. *Journal of Educational Technology & Online Learning (JETOL), 5*(3), 619–635. https://doi.org/10.31681/jetol.1115994

Blazar, D., & Kraft, M. A. (2017). Teacher and teaching effects on students' attitudes and behaviors. *Educational Evaluation and Policy Analysis, 39*(1), 146–170. https://doi.org/10.3102/0162373716670260

Bragg, L. A. (2012). Testing the effectiveness of mathematical games as a pedagogical tool for children's learning. *International Journal of Science and Mathematics Education, 10*(6), 1445–1467. https://doi.org/10.1007/s10763-012-9349-9

Connolly, T. M., Boyle, E. A., MacArthur, E., Hainey, T., & Boyle, J. M. (2012). A systematic literature review of empirical evidence on computer games and serious games. *Computers & Education, 59*(2), 661–686. https://doi.org/10.1016/j.compedu.2012.03.004

Creswell, J. W. (2014). *Research design: Qualitative, quantitative, and mixed methods approaches*. Sage.

Creswell, J. W., & Poth, C. N. (2018). *Qualitative inquiry and research design: Choosing among five approaches* (4th ed.). Sage.

Çetin, A., & Özbuğutu, E. (2020). The opinions of pre-service science teachers about mental-intelligence games. *Dicle University Journal of Ziya Gökalp Faculty of Education, 1*(37), 93-99.

Delgado-Monge, I. C., Espinoza-González, J., Valverde-Soto, G., & Pérez-Tyteca, P. (2024). Math anxiety and math teaching anxiety in primary school teachers in Costa Rica. *Uniciencia*, 38(1), 1-18. https://doi.org/10.15359/ru.38-1.21

Delgado-Monge, I., Perez-Tyteca, P., Garcia-Chaves, K., Villalobos-Morales, K. (2025). Anxiety towards teaching mathematics experienced by pre-service primary teachers. *Uniciencia, 39*(1), 1-18. https://doi.org/10.15359/ru.39-1.26

Demirel, T., & Karakus-Yılmaz, T. (2019). The effects of mind games in math and grammar courses on the achievements and perceived problem-solving skills of secondary school students. *British Journal of Educational Technology, 50*(3), 1482-1494. https://doi.org/10.1111/bjet.12624

Deringöl, Y. (2018). An examination of the mathematics teaching efficacy and the mathematics teaching anxiety of classroom teacher candidates. *Journal of Theoretical Educational Science, 11*(2), 261-278.

Dokumacı-Sütçü, N. (2018). The effect of geometric-mechanical intelligence games on the teacher candidates' geometric thinking levels. *Electronic Journal of Education Sciences, 7*(14), 154-163.

Earp, J., Ott, M., Popescu, M., Romero, M., & Usart, M. (2014). Supporting human capital development with serious games: An analysis of three experiences. *Computers in Human Behavior, 30*, 715-720. https://doi.org/10.1016/j.chb.2013.09.004

Ekiçi, M., Öztürk, F., & Adalar, H. (2017). Prospective social studies teachers' insight on intelligence games. *Researcher: Social Science Studies, 5*(4), 489-502. https://doi.org/10.18301/rss.420

Epçaçan, U., & Bahçeci, F. (2023). The effect of mind games course on problem solving and creative thinking skills. *Anatolian Journal of Educational Leadership and Instruction, 11*(2), 342-361.

Erdoğan, A., Eryılmaz-Çevirgen, A., & Atasay, M. (2017). Games and mathematics teaching: a classification of strategic brain games. *Uşak University Journal of Social Sciences, 10*, 287- 311.

Esentaş, M. (2021). A leisure time educational tool: mind and intelligence games: A leisure time educational tool. *International Journal of Curriculum and Instruction, 13*(2), 1355-1373.

Fiangga, S. (2014). Tangram game activities, helping the students difficulty in understanding the concept of area conservation. In H. Sutrisno, W. Dwandaru, K. Krisnawan, D. Darmawan, E. Priyambodo, E. Yulianti, & S. Nurohman (Eds.), *Proceeding of International Conference on Research, Implementation and Education of Mathematics and Sciences* (pp. 453-460). Yogyakarta State University. https://doi.org/10.13140/RG.2.1.3479.4965

Finlayson, M. (2014). Addressing math anxiety in the classroom. *Improving Schools*, *17*(1), 99–115. https://doi.org/10.1177/1365480214521457

Gavora, P. (2010). Slovak pre-service teacher self-efficacy: Theoretical and research considerations. *New Educational Review, 21*(2), 17–30. https://doi.org/10.15804/tner.10.21.2.01

Giles, R., Byrd, K., & Bendolph, A. (2016). An investigation of elementary preservice teachers' self-efficacy for teaching mathematics. *Cogent Education,* *3*(1), 1160523. https://doi.org/10.1080/2331186X.2016.1160523

Green, S. B., & Salkind, N. J. (2008). *Using SPSS for windows and macintosh: Analyzing and understanding data (5th ed.)*. Pearson Prentice Hall.

Gresham, G. (2008). Mathematics anxiety and mathematics teacher efficacy in elementary pre-service teachers. *Teaching Education, 19*(3), 171-184. https://doi.org/10.1080/10476210802250133

Gresham, G. (2010). A study exploring exceptional education pre-service teachers' mathematics anxiety. *IUMPST: The Journal, 4,* 1-14.

Gresham, G. (2017). Preservice to inservice: does mathematics anxiety change with teaching experience? *Journal of Teacher Education, 69*(1), 90-107. https://doi.org/10.1177/0022487117702580

Gresham, G. (2021). Exploring exceptional education preservice teachers' mathematics anxiety. *International Journal for the Scholarship of Teaching and Learning*, *15*(2), 13. https://doi.org/10.20429/ijsotl.2021.150213

Güneş, A. M. (2023). Metaphorical perceptions of teacher candidates towards mind and intelligence games. *MANAS Journal of Social Studies, 12*(2), 424-435. https://doi.org/10.33206/mjss.1217646

Güneş A. M., & Güneş D. (2024). Teacher candidates' experiences regarding mind and intelligence games. *Journal of Turkic Civilization Studies, 5*(1), 107-128.

Gür, H., & Kobak Demir, M. (2016). The views of the teacher candidates about the project of game based mathematics learning laboratory. *Necatibey Faculty of Education Electronic Journal of Science and Mathematics Education*, 10(1), 415-438. https://doi.org/10.17522/nefefmed.33834

Halıcı, E. (2019). *Zeka oyunları eğitimi çalışma kitabı* [Intelligence games training workbook]. Ministry of National Education.

Hembree, R. (1990). The nature, effects, and relief of mathematics anxiety. *Journal for Research in Mathematics Education*, *21*(1), 33–46. https://doi.org/10.2307/749455

Hoşşirin Elmas, S. (2010). *The pre-service primary school teachers' mathematics teaching anxiety levels and the reasons which cause this anxiety* (Publication no. 265254) [Master's thesis, Afyon Kocatepe University]. Council of Higher Education Thesis Center.

Hughes, P., Swars Auslander, S., Stinson, D. W., & Fortner, C. K. (2019). Elementary teachers' mathematical beliefs and mathematics anxiety: How do they shape instructional practices? *School Science and Mathematics, 119*(4), 213-222. https://doi.org/10.1111/ssm.12329.

Jackson, E. (2008). Mathematics anxiety in student teachers. *Practitioner Research in Higher Education, 2*(1), 36-42.

Karalı, Y. (2022). Investigation of prospective primary teachers'mathematical literacy and self-efficacy beliefs regarding mathematics teaching. *Kahramanmaraş Sütçü İmam University Journal of Social Sciences, 19*(1), 89-101. https://doi.org/10.33437/ksusbd.1067612

Karaman, İ., & Çil, O. (2021). The relationship between teachers' self-efficacy beliefs of mathematical connection and their anxiety of mathematics and mathematics teaching. *Van YYU Journal of Education Faculty, 18*(1), 1042-1072. https://doi.org/10.33711/yyuefd.957388

Kula, S. S. (2020). The reflections of mind games on primary school students': An action research. *Journal of National Education, 49*(225), 253-282.

Kurbanoglu, N. İ., & Takunyaci, M. (2012). An investigation of the attitudes, anxieties and selfefficacy beliefs towards mathematics lessons high school students' in terms of gender, types of school, and students' grades. *Journal of Human Sciences, 9*(1), 110–130.

Lau, W. W. F. (2021). Predicting pre-service mathematics teachers' teaching and learning conceptions: The role of mathematical beliefs, mathematics self-efficacy, and mathematics teaching efficacy. *International Journal of Science and Mathematics Education*, 19, 1-20. https://doi.org/10.1007/s10763-021-10204-y

Leso, G., Dias, G., Ferreira, J. P., Gama, J., & Couceiro, M. S. (2017). Perception of creativity and game intelligence in soccer. *Creativity Research Journal*, *29*(2), 182–187. https://doi.org/10.1080/10400419.2017.1302779

Levine, G. (1993). *Prior mathematics history, anticipated mathematics teaching style, and anxiety for teaching mathematics among pre-service elementary school teachers* (ED373972). ERIC.

Marín-Díaz, V., Sampedro-Requena, B. E., MuñozGonzalez, J. M., & Jiménez-Fanjul, N. N. (2020). The possibilities of gamifying the mathematical curriculum in the early childhood education stage. *Mathematics, 8*(12), 1–15. https://doi.org/10.3390/math8122215

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis: An expanded sourcebook*. Sage.

Ministry of National Education [MoNE], (2013). *5, 6, 7 ve 8. sınıf zekâ oyunları dersi müfredatı* [Intelligence games curriculum for grades 5, 6, 7, and 8]. Author.

Özata, M., & Coşkuntuncel, O. (2019). Opinions of secondary school mathematics teachers on the use of educational math games in mathematics teaching. *Mersin University Journal of the Faculty of Education, 15*(3), 662-683. https://doi.org/10.17860/mersinefd.619983

Özkan, D. (2023). *Oyuncu beyinler (Seviye 1, 2, 3)* [Gaming brains (Levels 1, 2, 3)]. TAZOF Mind and Intelligence Games Federation.

Peker, M. (2009). The effect of teaching using problem-solving strategies in mathematics on the teaching anxiety levels of preschool teachers. *The New Educational Review, 19*(3-4), 95-114.

Peker, M. (2016). Mathematics teaching anxiety and self-efficacy beliefs toward mathematics teaching: A path analysis. *Educational Research and Reviews*, *11*(3), 97–104. https://doi.org/10.5897/ERR2015.2552

Peker, M., & Ulu, M. (2018). Pre-service mathematics teachers' teaching anxiety and self-efficacy beliefs. *International Journal of Educational Studies, 11*(2), 94-107.

Plass, J. L., Homer, B. D., & Kinzer, C. K. (2015). Foundations of game-based learning. *Educational Psychologist*, *50*(4), 258–283. https://doi.org/10.1080/00461520.2015.1122533

Reiter, H. B., Thornton, J. & Vennebush, G. P. (2014). Using kenken to build reasoning skills. *Mathematics Teacher*, *107*(5), 341-347. https://doi.org/10.5951/mathteacher.107.5.0341

Romero, M., Usart, M., & Ott, M. (2015). Can serious games contribute to developing and sustaining 21st century skills? *Games and Culture, 10*(2), 148-177. https://doi.org/10.1177/1555412014548919

Ross, J., & Bruce, C. (2007). Professional development effects on teacher efficacy: Results of randomized field trial. *The Journal of Educational Research, 101*(1), 50-60. https://doi.org/10.3200/JOER.101.1.50-60

Ryan, M., Fitzmaurice, O., & Johnson, P. (2025). Investigating mathematics anxiety among mature students in service mathematics courses using the mathematics anxiety scale U.K. *International Journal of Mathematıcal Educatıon in Science and Technology*, *56*(1), 4–28. https://doi.org/10.1080/0020739X.2023.2179950

Sarı, M. H. (2014). Developing a mathematics teaching anxiety scale for classroom teachers. *Elementary Education Online, 13*(4), 1296-1310.

Saygı, E & Alkaş Ulusoy Ç. (2019). Views of the pre-service elementary mathematics teachers about memory games and contribution of memory games to mathematics teaching. *Bolu Abant İzzet Baysal University Journal of the Faculty of Education, 19*(1), 331- 345.

Segarra, J., Julià, C., & Valls, C. (2021). Pre-Service teachers' belief about the efficacy of their mathematics teaching: A case study. *European Journal of Science and Mathematics Education*, *9*(4), 199–210. https://doi.org/10.30935/scimath/11236

Shadish, W. R., Cook, T. D., & Campbell, D. T. (2002). *Experimental and quasi-experimental designs for generalized causal inference*. Houghton Mifflin.

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher*, 15(2), 4–14. https://doi.org/10.3102/0013189X015002004

Şahinkaya, N. (2008). *Comparison of class teachers' and preservice teachers? roles in teaching-learning process and self-efficacy beliefs and teacher preparation programs in Turkey and Finland* (Publication no. 218470) [Doctoral dissertation, Gazi University]. Council of Higher Education Thesis Center.

Tarim, K., Özsezer, M. S. B., & Canbazoğlu, H. B. (2017). Pre-service classroom teachers; perceptions of related with mathematics and teaching mathematics. *Ahi Evran University Kırşehir Faculty of Education Journal, 18*(3), 1032-1052.

Thanheiser, E. (2009). Preservice elementary school teachers' conceptual understanding of multidigit whole numbers. *Journal for Research in Mathematics Education, 40*(3), 251–281. https://doi.org/10.5951/jresematheduc.40.3.0251

Tschannen-Moran, M., & Woolfolk Hoy, A. (2001). Teacher efficacy: Capturing an elusive construct. *Teaching and Teacher Education, 17*(7), 783–805. https://doi.org/10.1016/S0742-051X(01)00036-1

Tunc-Pekkan, Zelha, Olmez, I. B., & Taylan, R. D. (2023). An online laboratory school research on pre-service mathematics teachers' experiences and mathematics teaching anxiety. *Education & Information Technologies,* 5739–5761. https://doi.org/10.1007/s10639-022-11404-x

Twohill, A., NicMhuirí, S., Harbison, L. & Karakolidis, A. (2023). Primary preservice teachers' mathematics teaching efficacy beliefs: the role played by mathematics attainment, educational level, preparedness to teach, and gender. *International Journal of Science and Mathematics Education, 21,* 601–622 (2023). https://doi.org/10.1007/s10763-022-10259-5

Ural, A. (2015). The effect of mathematics self-efficacy on anxiety of teaching mathematics. *Journal of Theoretical Educational Science, 8*(2), 173-184. https://doi.org/10.5578/keg.9075

Usta, N., ve Diğerleri (2017). The opinions of pre-service teachers on the usage of games in mathematics teaching. *International Journal of Social Sciences and Education Research, 3*(1), 328-344. https://doi.org/10.24289/ijsser.270771

Vankúš, P. (2008). Games based learning in teaching of mathematics at lower secondary school. *Acta Didactica Universitatis Comenianae Mathematics, 3*, 103-120.

Yurtbakan, E. (2025). Teachers' motivation to teach mathematics scale: A validity and reliability study. . *Trakya Journal of Education 15*(1), 83111. https://doi.org/10.24315/tred.1422025

Yükseltürk, E., İlhan, F., & Altıok, S. (2022). Preservice teachers' views about the use of mind and intelligence games in education. *Participatory Educational Research, 9*(6), 398-417. https://doi.org/10.17275/per.22.145.9.6

Zengin, Y. (2017). The investigation of the effect of Geogebra software on mathematics anxiety and mathematics teaching anxiety. *Van YYU Journal of Education Faculty, 14*(1), 908-939.

Zuya, H., E., Kwalat, S., K., & Attah, B., G. (2016). Pre-service teachers' mathematics selfefficacy and mathematics teaching self-efficacy. *Journal of Education and Practice, 7*(14), 93-98.