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# Examination of the Games Developed by Pre-service Elemantary Mathematics Teachers Based on The NCTM Content and Process Standards[1]

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**Abstract**: This study aimed to examine the games developed by Pre-service Elementary Mathematics Teachers [PEMT] based on the National Council of Teachers of Mathematics [NCTM] Content and Process Standards. Participants of the study consist of 33 PEMT who participate a selective course of "Mathematics Teaching with Games". Participants were given theoretical knowledge for the first 7 weeks, and then they were asked to develop a game includes one/more acquisitions in the curriculum. PEMT were also asked to develop contactless or online games, taking into account the pandemic process. The data of the study, in which case study method was used, were collected with document analysis. Totally thirteen games developed by PEMT were analyzed descriptively with a codebook developed by Joung and Byun (2020) based on the NCTM Content and Process Standards to evaluate the quality of digital games used in mathematics education. As a result of the study, it was determined that the majority of the games were focused on the Content Standards of Number and Operations, especially for encouraging students to practice compute fluently. On the other hand, no games have been determined with the content of Data Analysis and Proof. In terms of the Process Standards, reasoning and proof was the least observed category.

Keywords: *Games, Mathematics Education, Pre-service Elementary Mathematics Teachers, NCTM Content and Process Standards.*

## 1. INTRODUCTION

Game is the most natural learning environment in which children discover themselves, adapt to the world and prepare for life. Children's study begins with observation, imitation and inquisition, and game is the best activity that can embody children's spirit of learning (Song & Zhang, 2008). Although various definitions have been put forward by different researchers about the game (Pilten et al., 2017; Uğurel & Moralı, 2010), game can be defined as an activity which is done at a certain time and place, which includes prerequisite behaviors and probability, which has winner or winners, and most importantly which is conducted freely and spontaneously (Güneş, 2010). The fact that game has the potential to "learn while having fun" has made it the center of attention in education. In fact, "learning from play" has been emphasized since the era of Confucius, and the principles of all learning activities advocated

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by modern educators can be reflected in the game (Song & Zhang, 2008). Therefore, games have started to be used as a teaching method, learning and assessment tool that teachers can use in the classroom environment rather than just a means of entertainment (Akanca & Sökmen, 2018; Chizary & Farhangi, 2017; Pilten et al., 2017; Uğurel & Moralı, 2010). With the use of games for educational purposes, the concept of educational games has become a current issue (Uğurel & Moralı, 2008), and thus, the definitions related to game have been updated. Educational games can be defined as activities that enable students to actively participate in the process physically, mentally and emotionally, and make them acquire the learning outcomes of the course in an enjoyable and entertaining way (Aykaç & Köğce, 2020). It is beyond doubt to mention the cognitive and emotional contributions of the use of games for educational purposes. For instance, games increase students' motivation and interest (Aykaç & Köğce, 2020; Koç Deniz, 2019) by making the lesson more entertaining (Chizary & Farhangi, 2017; Ibrahim & Jaafar, 2009; Song & Zhang, 2008; Yildirim, 2017), they can eliminate negative attitudes and prejudices towards maths (Koç Deniz, 2019; Yildirim, 2017), they provide an effective learning environment (Durak & Yılmaz, 2019; Song & Zhang, 2008) and thus helping students' learning process (Chizary & Farhangi, 2017; Durak & Yılmaz , 2019; Ibrahim & Jaafar, 2009). Besides, some researchers stressed that the integration of educational mathematics games in mathematics teaching increases students' academic achievement (Özata & Coşkuntuncel, 2019; Yildirim, 2017). Mathematics associated with various signs used for the discovery, perception and understanding of some compounds, patterns and relationships in the world (Chizary & Farhangi, 2017). Games are one of the most effective pursuits for encouraging children to discover the world and life. Even though mathematics and games seem to be the concepts that are far from each other, their interaction areas are much more than are thought (Uğurel & Moralı, 2008). Therefore, numerous studies have been conducted on this subject in the relevant literature (Chizary & Farhangi, 2017; Durak & Yılmaz, 2019; Güneş, 2010; Hacısalihoğlu Karadeniz 2017; Koç, 2019; Özata & Coşkuntuncel, 2019; Pilten et al., 2017; Uğurel & Moralı, 2008, 2010; etc.), and the significance of using games in mathematics teaching has become inevitable. To exemplify, Hacısalihoğlu Karadeniz (2017) concluded that game applications pre-service teachers designed were effective in students' learning mathematics, understanding and making the lesson more enjoyable, and ensuring cognitive, social-emotional and psychomotor development. Likewise, Yildirim (2017) identified that gamification-based teaching practices had a positive effect on students' achievement and their attitudes towards lessons. All these results display that it will be significant and effective for teachers to include games in their mathematics lessons. Teachers can adapt the games to their lessons only if they have knowledge and experience on this subject, namely, it is possible to design games that consider students' readiness and interest in their lessons. Indeed, Pilten et al. (2017) suggested that the effective use of games as an educational tool or teaching method especially focusing on cognitive development is of great paramount and game design must be handled systematically for maximum educational benefit. In this regard, it is considered remarkable for teachers to have knowledge and experience about designing games during the pre-service period and adapting the games they design to the lessons through including practical lessons on the use of games in mathematics teaching in teacher-training undergraduate programs.

However, studies showed that most of the pre-service teachers had little knowledge about educational games (Uğurel & Moralı, 2010). For instance, Pilten et al. (2017) found that pre-service teachers failed at designing satisfactory games in terms of "Game Rules", "Goals and objectives", "Outcomes and feedback" and "Interaction"; while game designs developed by pre-service teachers were partially or completely satisfactory in terms of “Conflict (Competition, challenge, and opposition)” and “Story”. In another study conducted with the pre-service Science and Social Studies teachers, Akcanca and Sömen (2018) found that the participants had difficulties in associating the game with the subject and in designing a game that would ensure active participation. Therefore, pre-service teachers should be provided with opportunities to develop game designs in the teaching courses included in the undergraduate programs (Pilten et al., 2017). Considering that the teachers of the future are today's pre-service teachers, the compatibility of the games with the content and goals of the mathematics curriculum, how much they take into account the skills expected to be developed by the students can also give clues about how they will adapt these games to their lessons in their teaching life. Hence, this study attempts to focus on examining the games designed by the pre-service elementary mathematics teachers.

## 2. LITERATURE REVIEW

Today, a common world culture and norms are required in order to live together in harmony; each society is expected to take into account the common cultural norms and even contribute to this culture along with protecting their own cultural norms; moreover, countries are respected to the extent that they implement practices in accordance with these norms and they take their place in international platforms (Umay et al., 2006). One of the leading authorities on mathematics education is National Council of Teachers of Mathematics [NCTM] (Genç Çopur et al., 2020; Umay et al., 2006).

NCTM has created a system for the perpetual improvement of mathematics education in classrooms, schools and education systems by determining the principles and standards of school mathematics, and this system has been welcomed by many countries (Genç Çopur et al., 2020; Toumasis, 1997). To that end, NCTM (2000) prepared a curriculum outline called "Principles and Standards for School Mathematics" in response to the question of which mathematical content and processes students should know and be able to use at the K-12 level. These standards are presented under two categories as Content Standards and Process Standards. Content standard explicitly defines the 5 content types that students should learn (Numbers and Operations, Algebra, Geometry, Measurement, Data Analysis, and Probability), while the process standard highlights 5 process types that emphasize ways of acquiring and applying content knowledge (Problem Solving, Reasoning, Probability and Proof, Communication, Connections, Representations) (NCTM, 2000). In Turkey, an update was made in 2018 by the Ministry of National Education [MoNE] with the analysis of the curricula that have been renewed and updated in different countries in recent years as well as the academic studies on national and international education and curricula (MoNE, 2018). The new secondary school mathematics curriculum published by MoNE (2018) includes five learning areas: "Numbers and Operations, Algebra, Geometry and Measurement, Data

Processing and Probability". Upon examining the specific objectives of the mathematics course curriculum, 13 goals were identified to emphasize the methods of application that students acquire knowledge such as mathematical literacy, problem solving, reasoning, use of mathematical terminology (communication), making sense of connections through mathematics, using forms of representation, development of thinking skills and affective goals.

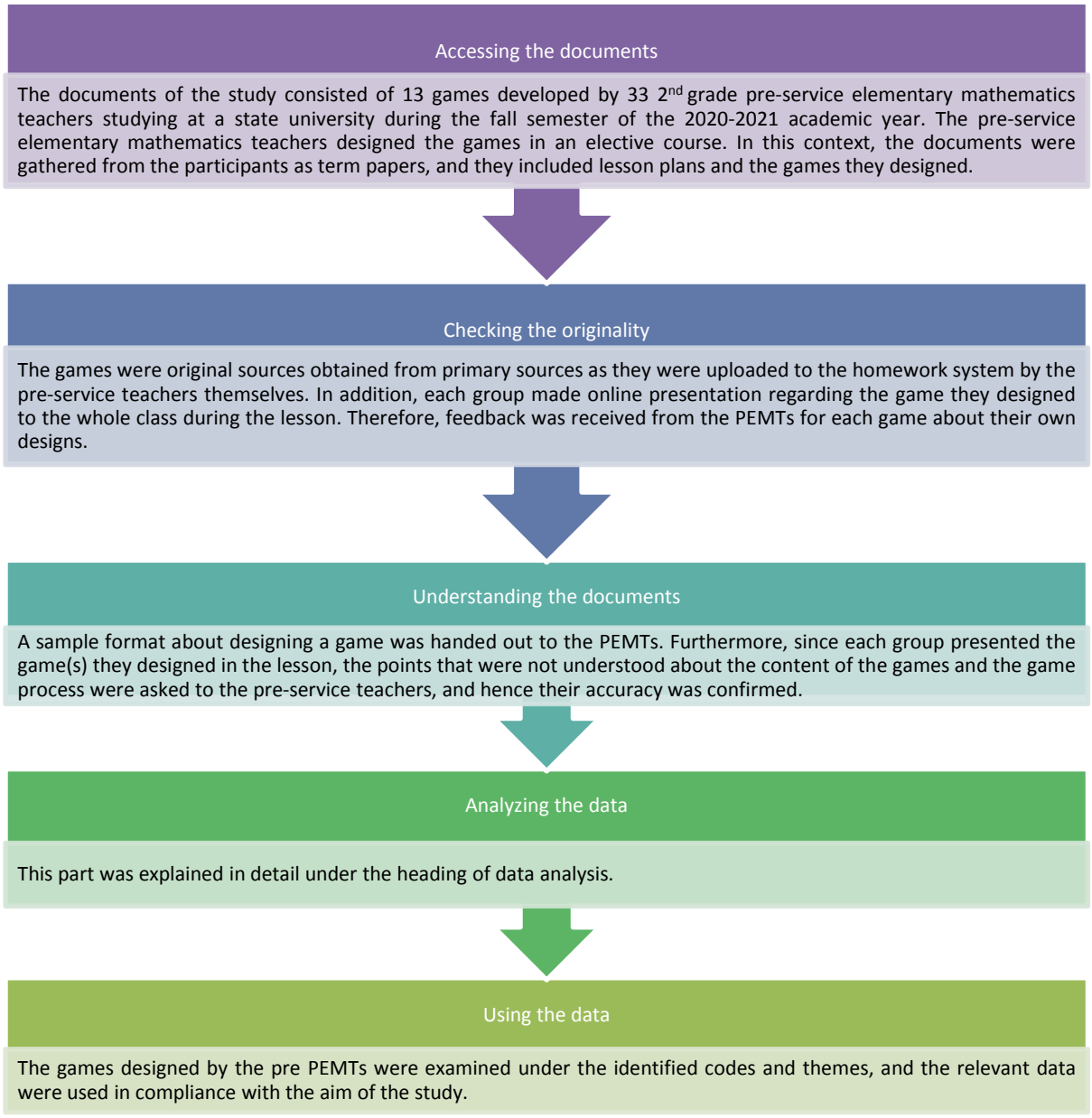
The learning areas in the curriculum and the general objectives of the mathematics course curriculum represent parallelism with the NCTM Process and Content Standards. In this regard, the study aims to examine the games developed by the Pre-service Elementary Mathematics Teachers [PEMT] according to NCTM process and content standards since it reflects the mathematical literacy needs of the society, the values and expectations of teachers, mathematics educators, mathematicians and society (NCTM, 2000) and constitutes a framework for teaching mathematics not only nationally but all over the world (Toumasis, 1997). The relevant literature holds some studies on the examination of games designed by the pre-service teachers and/or game design skills (Akcanca & Sömen, 2018; Hacısalihoğlu Karadeniz, 2017; Pilten et al., 2017; Yıldız Durak & Karaoğlan Yılmaz, 2019). However, there is no such a study specifically published on examining the games designed by pre-service teachers in terms of NCTM process and content standards. The related literature includes only one study (Joung & Byun; 2020) analyzing the games in terms of NCTM process and content standards and constituting the theoretical basis of this study. Still, the related study investigated the games that were used in experimental studies examining the effects of games on students' mathematics learning in previous years and that were still accessible. Thus, this study differs in terms of examining the games designed by the PEMT. In this vein, the study aims to examine the games designed by the PEMT in terms of NCTM Process and Content Standards.

The Covid-19 pandemic, which affected the whole world in 2020, had also impact on the field of education in many countries, as in all other fields, and distance education was carried out in many teaching levels, which led to several changes in the methods and techniques teachers use. The use of some games, especially in classroom environments, have become more difficult due to the transition to distance education or social distance education. Therefore, PEMT were asked to design "online" games that can be used in distance education or "contactless" games in accordance with social distance in the present study. They were free to choose the type of game (online or contactless) they would design. In line with the main aim of the study, answers to the following sub-problems were sought:

1. What is the type of games (online, contactless) designed by PEMT?
2. Which NTCM Content Standards are in rapport with the games designed by PEMT?
3. Which NTCM Process Standards are in rapport with the games designed by PEMT?

## 3. METHODOLOGY

This study employed the qualitative research design as it aims to examine the games designed by PEMT in terms of the NCTM Content and Process Standards. Since the data were obtained through the documents gathered in terms of the NCTM Content and Process Standards for the games designed by the PEMT, the document analysis method was used in the present study. Document analysis can be a research method on its own, or it can also serve as an additional source of information when other qualitative methods are used (Yıldırım & Şimşek, 2013). Yıldırım and Şimşek (2013) indicated that document analysis can be conducted in 5 stages (accessing documents, checking their originality, understanding documents, analyzing data, using data). Thus, this study took the following actions at the relevant stages:




**Graph 1.** *Studies Carried Out Within the Scope of Document Review*

### *3.1. Data Analysis*

Descriptive analysis technique was used during data analysis. With this design, the games designed by the PEMT were analyzed through use of the "Codebook" that Joung and Byun (2020) developed by taking into consideration the NCTM Content and Process Standards. The researchers developed the codebook items based upon the description statements for categories in NCTM Process and Content Standards. To illustrate, with the explanation of NCTM (2000) regarding the "Number and operations" category, they put the following codes under this category by choosing the keywords "Representing numbers, Connections between numbers, Number systems, Meaning of operations, Connection with each other, Calculation and Meaningful estimations" (Joung & Byun, 2020, p. 131):

**Table 1.** *The Items for Number and Operations Category (Joung & Byun, 2020, p. 131)*

| Category | Items |
|---|---|
| Number and operations | 1. This game includes the content related to the numbers, especially ways of representing numbers |
| | 2. This game includes the content related to the numbers, especially relationships among numbers |
| | 3. This game includes the content related to the numbers, especially number systems |
| | 4. This game contains content that shows the meanings of operations |
| | 5. This game contains content that shows how they relate to one another |
| | 6. This game encourages students to practice computing fluently |
| | 7. This game encourages students to make reasonable estimates |

The researchers developed the codes for other categories by following similar processes. They developed a total of 64 items, forty-one items to analyze the game content for the NCTM Content Standards and 23 items to examine the game for the NCTM Process Standards (Joung & Byun, 2020). In addition to the NCTM Standards items, the codebook consisted a total of 65 items as they added an item questioning how to determine the game genre. Researchers used a 5-point Likert scale for coding in all items except for the game type. While the categories such as "Action, Role-playing, Strategy, Adventure, Simulation, Puzzle, and Others" were used as the game type in the related study, the category was grouped under two headings in this study since the PEMT were asked to design contactless or online games. Unlike Joung and Byun (2020), this study identified only whether the relevant code was found in the games instead of using the 5-point Likert scale while analyzing the games. The PEMT designed the games in groups including 3-4 individuals. As a result, 13 games designed by the PEMT were included in the study and the games were coded as G1, G2, G3, ....

### *3.2. Reliability*

Yıldırım and Şimşek (2013) outlined that expertization can be done in two ways:

1. The expert holds an evaluation meeting with the researcher.
2. The researcher sends all the documents related to the design of the research, their analysis and the results together with the raw data to an expert.

An expert review was conducted to ensure credibility in the current study. In this context, the opinion of an expert who was in the field of mathematics education and who was conducting an undergraduate course on teaching mathematics with games at a different university, was sought. 3 random games were evaluated together with the expert, thereby a consensus was reached about the equivalents of the codes in the codebook in the games. Afterwards, the researcher presented the codes that s/he hesitated after coding the other games to the expert opinion and the form got the final version after reaching a consensus.

## 4. FINDINGS

The findings obtained as a result of the analysis of the games designed by the PEMT in terms of the NCTM process and content standards are presented in line with the related sub-problems.

### *4.1. Findings Regarding The Type of Games Designed by The PEMT*

The games designed by the PEMT were examined under two categories, contactless or online, in terms of their types. Table 2 depicts findings regarding the type of games.

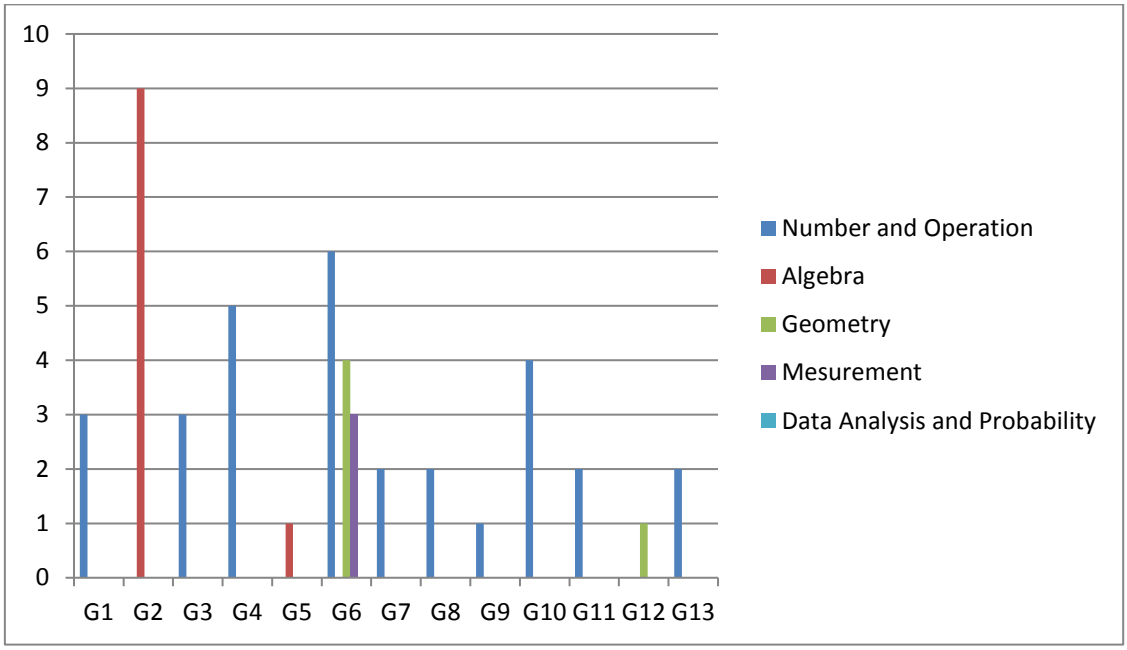
**Table 2.** *The Type of The Games Designed by The PEMT*

| Type of the Game | Code of the Game | f | % |
|---|---|---|---|
| **Contactless Game** | G1, G2, G3, G4, G5, G6, G7, G8, G9, G10, G11, G12, G13 | 13 | 81 |
| **Online Game** | G2, G6, G9 | 3 | 19 |
| **Total** | | 16 | 100 |

Table 2 shows that the majority of the games (81%) was in the contactless game type, and there were only three games in the online game type. As stated in the method section, although a total of 13 games were evaluated, the reason for higher frequency was that the three games coded G2, G6 and G9 were designed as both contactless and online games.

### *4.2. Findings Regarding The Distribution of Games Designed by The PEMT in Terms of NCTM Content Standards*

Graph 1 suggests findings regarding the distribution of each game designed by the participants in terms of the NCTM Content Standards categories.

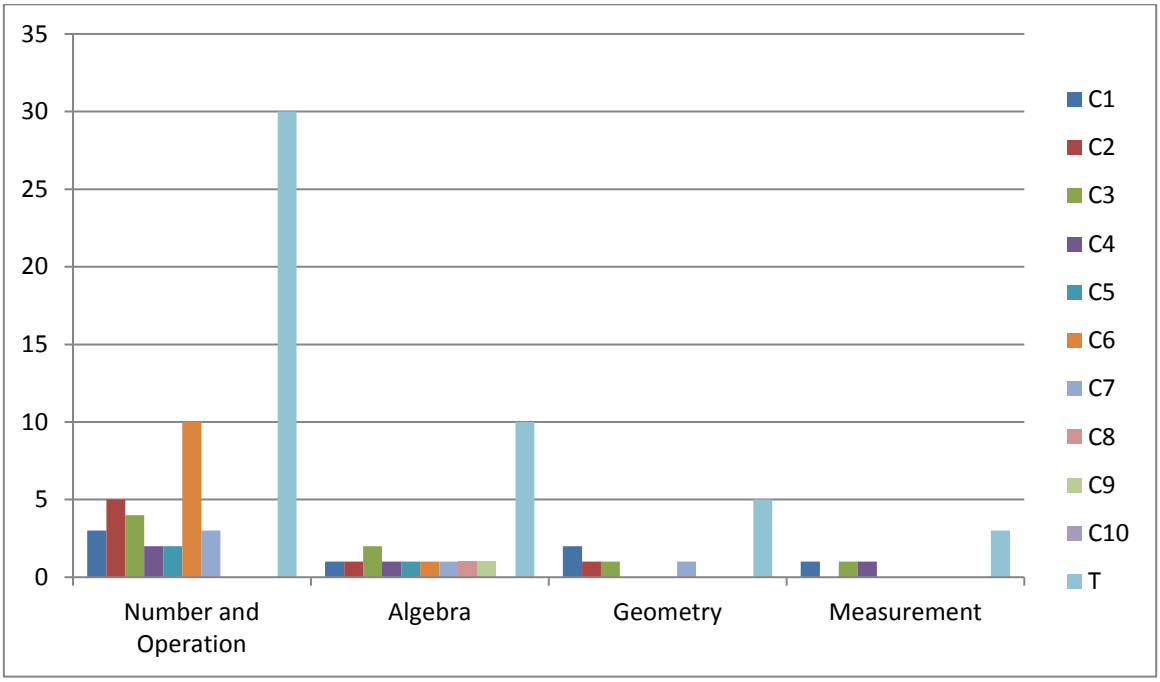



*G1 = Game 1, G2 = Game 2, ..., G13 = Game 13

**Graph 1.** *Distribution of Games Designed by the PEMT in Terms of NCTM Content Standards*

As is seen in Graph 1, all of the games designed by the PEMT were identified to have a single category content taken into account except for the G6 coded game, and all of these contents belonged to the Number and Operation category apart from the G2 and G5 coded games. Only the G2 and G5 coded games were determined to focus on the algebra category, while the G6 coded game on the Number and Operation, Geometry and Measurement categories. Besides, Data Analysis and Probability category was found to have no content. On the other, it is noteworthy that the G5, G9 and G12 coded games focused on merely one category and the content of a single code in this category.

Graph 2 presents the findings about whether the games designed by PEMT include the codes within the context of each NCTM Content Standard.




*C1 = Code 1, C2 = Code 2, ... , C10 = Code 10, T = Total

**Graph 2.** *Distribution of Games Designed by PEMT in the Context of NCTM Content Standards' Codes and Categories*

Among the NCTM Content standards, there were 7 codes in the Number and Process category, 10 codes in the Algebra category, 9 codes in the Geometry category and 4 codes in the Measurement category (See Appendix). In this regard, the expressions C1, C2, ... , C10 in the chart represent the code numbers of the categories. What is more, the Total (T) value was also taken into account in order to evaluate each category holistically. Upon analyzing Graph 2 in terms of total values, the games designed by PEMT were found to mostly in the "numbers and operations" category (T=30) in terms of NCTM Content standards. Even though "Measurement" category was determined as the least mentioned in the chart, no game was found in the "Data Analysis and Probability" category so this category was excluded from the chart.

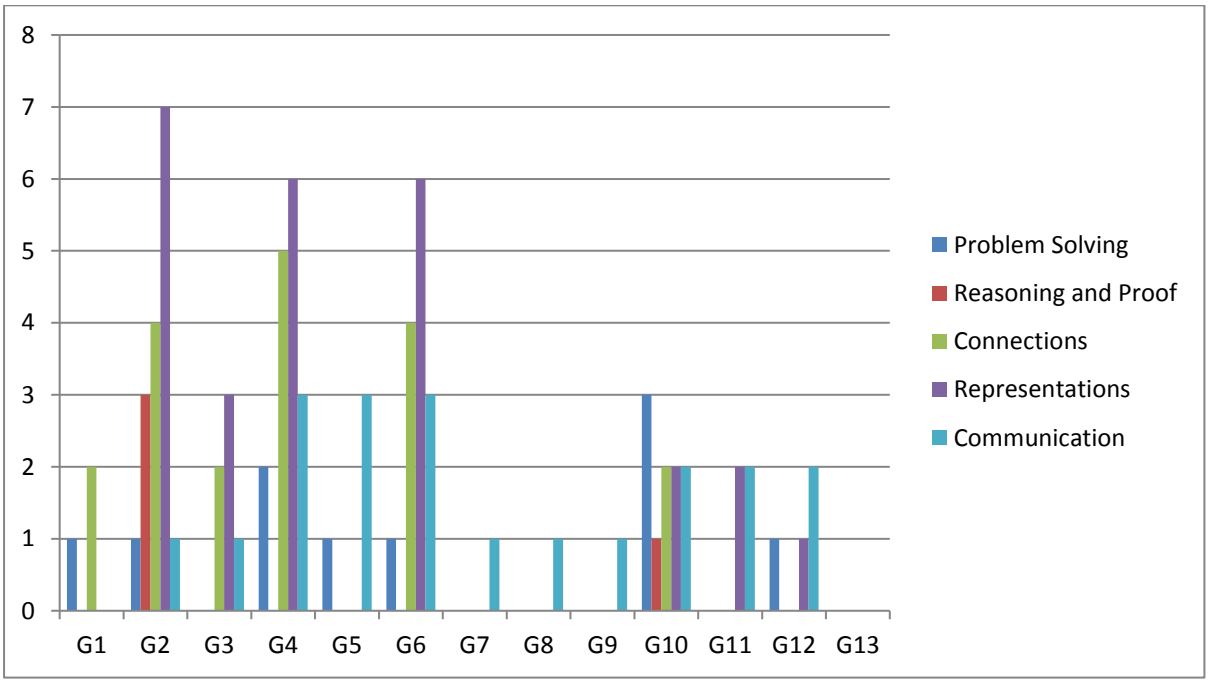
When Graph 2 was examined separately within the context of each category, all the codes in the "number and operation" category were found in the games designed by the PEMT, yet the C6 code stands out the most, meaning that the games especially had a content that would encourage students to practice calculating fluently (C6). The analysis of other categories revealed no prominent code for almost each category, and that the contents of the codes in the games were very few. Considering the algebra category, the contents of 9 codes were also found, still there was only one of each code except for C3.

As for the geometry category, although there were 9 codes in the codebook of this code, only the contents of C1, C2, C3 and C7 codes were identified, but only the C1 code was observed twice. This shows that there were few games belonging to the category of Geometry and that these games did not include content related to the use of spatial reasoning and geometric

modeling to solve problems, to develop students' skills of applying transformations and symmetry to analyze mathematical situations. Even if few games were determined in the measurement category, three of the 4 codes in this category were found to have content.

### *4.3. Findings Regarding the Distribution of Games Designed by the PEMT in Terms of NCTM Process Standards*

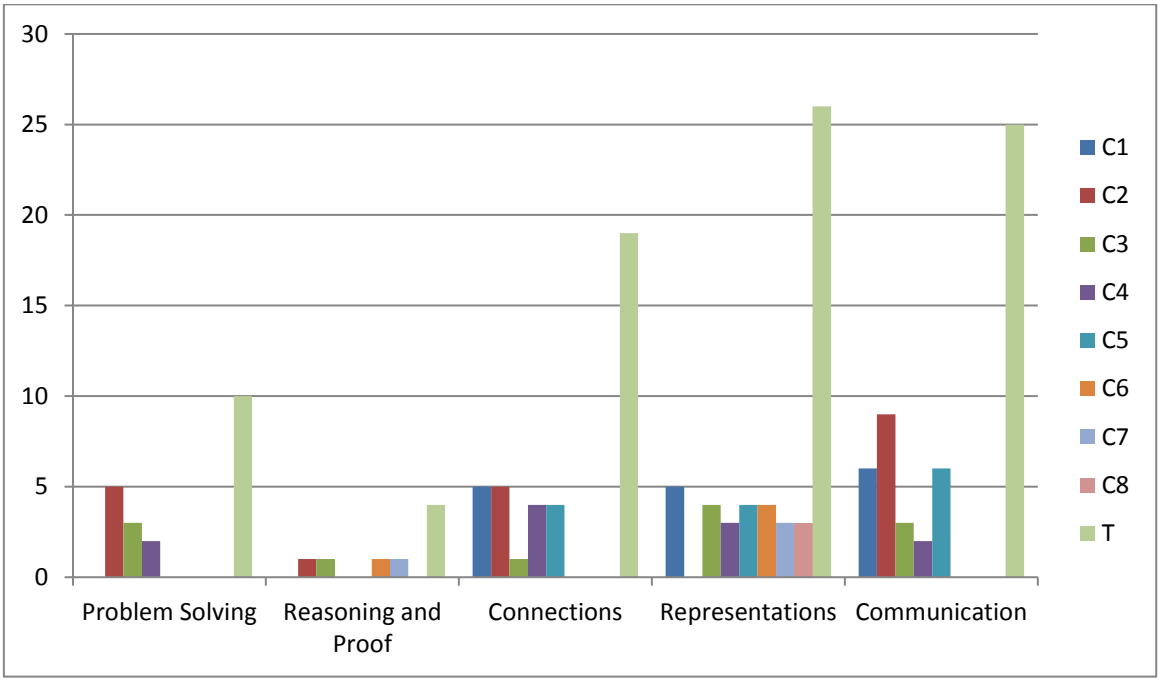
Graph 3 displays findings regarding the distribution of each game designed by the participants in terms of the NCTM Process Standards categories.




**Graph 3.** *Distribution of Games Designed by The PEMT in Terms of NCTM Process Standards*

Graph 3 demonstrates that most of the games designed by PEMT, except for the G7, G8 and G9 coded games, were found to mostly focus on more than one process standard category. In addition, all games had the Communication category, except for the G1 coded game. On the other hand, Problem Solving and Representations categories emerged in 7 of 13 games. Therefore, although Problem Solving and Representations was the second most determined NCTM Process standard in the games designed by PEMT, the Representations category were more remarkable in terms of process standards by taking their frequency into consideration. Reasoning and Proof was identified as the least considered process standard category in games. Indeed, there were only two games (G2 and G10) that take cognizance of this category among the process standards.

Graph 4 shows the findings about whether the games designed by PEMT include the codes within the context of each NCTM Process Standard.




**Graph 4.** *Distribution of Games Designed by the PEMT in the Context of NCTM Process standards' Codes and Categories*

There emerged 4 codes in the Problem solving category, 6 codes in the Reasoning and Proof category, 5 codes in the Connections category, 8 codes in the Representations category and 5 codes in the Communication category among the NCTM Process standards (See Appendix). In this context, the expressions C1, C2, ... , C8 in the chart represent the code numbers of the categories. Besides, the Total (T) value was taken into account in order to evaluate each category holistically. When Graph 2 was examined in terms of total values, the games designed by the PEMT were noted to have the most codes belonging to the category of "Representations" (T=26) and "Reasoning and Proof" (T=4) the least in terms of NCTM Process standards. Though there were 5 codes in the Communication category, it is remarkable that there were almost the same number of codes (T=25) as the Representations category, which had the most codes in the games. Considering the codes belonging to all categories together, the highest number of codes was found in the Communication category (C2). This indicates that PEMT mostly designed process-oriented games that help students explicitly transfer their mathematical ideas to others.

When Graph 4 was analyzed separately within the context of each category, the C1 code in the "problem solving" category was not encountered in the games designed by PEMT candidates, suggesting that no game was found to help students create new mathematical knowledge through problem solving. Besides, games are available for helping students solve problems that arise in mathematics and other contexts, enabling them to monitor and think about the mathematical problem solving process, and providing them with the opportunity to apply and adapt various appropriate strategies to solve problems in terms of Problem Solving process standards.

The Graph also portrays that Reasoning and Proof was the least identified category. Only 4 of the 6 codes were found in this category. All the codes belonging to the Connections category were encountered in the games and all codes were close to each other except for C3. This shows that at least a process for students to understand how mathematical ideas are related to each other is presented in the games within the context of the Connections category. The Representations category signified that all codes, except for C2, emerged in close numbers, indicating the presence of no games to develop students' ability to choose mathematical representations with the aim of solving problems. Having examined in terms of the communication category, all codes were found to be in the games, especially the C2 code. Therefore, games were found to mostly deal with the process that helps students to explicitly transfer their mathematical thoughts to others.

## 5. RESULTS AND DISCUSSION

This study aims to examine the games designed by PEMT in terms of NCTM Content and Process Standards. In service of this aim, PEMT were asked to design online or contactless games. The study results suggested that all of the games designed by the pre-service teachers were in the contactless game type, and only 2 of these games were also designed as online games. This may arise from the inadequacy of PEMT in using technology. In other words, the lack of technological content knowledge (TCK) and technological pedagogical knowledge (TPK) may have caused them to prepare contactless games. The related literature holds various studies (Pamuk et al., 2012; Saltan & Arslan, 2017) revealing that pre-service teachers did not consider themselves sufficient in the use of technology in teaching activities; whereas some studies found vice versa (e.g.; Kent & Giles, 2017; Yurdakul, 2011). The majority of the participants (95%) consisted of the 2nd grade pre-service elementary mathematics teachers studying during the fall semester of academic year. The "Elementary Education Mathematics Teaching Undergraduate Program" published by the Higher Education Council [HEC] stressed that the PEMT did not receive any training on technology, especially the use of technology in teaching, except for the "Information Technologies" course, including this semester. It is likely that PEMT had a lack of knowledge on this subject, which led them to designing contactless games. The samples presented to the PEMT within the scope of the elective course they received included educational math games considered as the adaptation of traditional games to mathematics teaching and other games. Although PEMT were requested to design online or contactless games, the candidates were set free to determine the type of game. Therefore, the samples may be effective in their preference for more contactless games. Because the contactless games included the rules of the games adapted to the pandemic conditions. Another reason may be that it is easier for the pre-service teachers to prepare paper-pencil or educational games that they are used to.

Upon examining the games in terms of NCTM Content Standards, the games were mostly designed for the "Number and Operation" category, and that no games were designed with the "Data Analysis and Probability" content. This may be related to the time allocated to these learning areas in the Secondary School Mathematics Curriculum. When the learning outcomes and time distribution of the units at each grade level were examined in the context

of the MoNE (2018) secondary school mathematics curriculum, the time allocated to the Numbers and Operations learning area was found to be 60%, 57% in the 6th grade, 55% in the 7th grade and 27% in the 8th grade. This distribution unveiled that more than half of the time was allocated to the field of Numbers and Operations for mathematics at all grade levels, except for the 8th grade. Therefore, it is not unlikely that PEMT included more content about this category in the games. Likewise, Joung and Byun (2020) noted that digital games had the highest average in the Number and Operation category. Taking data analysis and probability category into account, the probability learning area was found to be only at the 8th grade level. Regarding the Data Processing learning area, there were three learning outcomes at the 5th grade level, five at the 6th grade level, four at the 7th grade level, and two at the 8th grade level. The rates of the time allocated for learning outcomes to the total time were identified as 6%, 5%, 8% and 14%, respectively (MoNE, 2018), which was quite less compared to the Numbers and Operations learning field.

The results also demonstrated that the games mostly contained Representations and Communication categories of the NCTM Process Standards. The games also illustrate the process that most helps students transfer their mathematical thinking to others. This may be due to the fact that the games are played as a group and that the students need to communicate in order to find the correct answer in group games. As a matter of fact, the lesson plans pointed that the games were mostly designed as group games. In their study, Joung and Byun (2020) could not examine the Communication category as they analyzed digital games with the assumption that the games were played individually. However, the researchers stated that these communication standards can be improved if the teachers play games in the class as a small group. This result is in line with that of this study. Unlike Joung and Byun (2020), the least emerging category in the games was determined as problem solving, reasoning and proof. The questions in the games are those that require more operational knowledge and improve quick calculation. Besides, the pre-service teachers were determined to mostly design the games in order to reinforce the subject. To that end, this result may have arisen from the fact that they included questions that can be solved in a shorter time and that will improve students' quick processing instead of those that may require a long process.

## 6. RECOMMENDATIONS

This study aims to examine only the games designed by the PEMT in terms of NCTM content and process standards, and the data were collected through the lesson plans designed by the participants. Interviews may be conducted with the PEMT to ask questions such as why they chose the learning outcomes, how they determined the questions/problems in their games, and why they preferred these questions/problems in further studies. Thus, the reasons for the emergence of the obtained results can be examined in more detail.

This study revealed that all of the games designed by the PEMT were in the contactless game type, and 3 games were also designed as online games. This may be due to the fact that PEMT felt inadequate in using technology. In further studies, clearer inferences can be made

by interviewing PEMT on the reasons for choosing the game genre. In addition, various studies may be carried out to examine whether PEMT knowledge about the use of technology in education affects their reason for choosing the game type by providing them with a separate training on how to use technology in games.

Both this study and other studies identified that games contained the most Number and Operations, and the least Data Analysis and probability categories in terms of NCTM Content standards. Different studies may focus on especially Data Processing and Probability content, and the design of games can be encouraged in these categories. Thus, it may contribute to the relevant literature in terms of these contents.

## 7. ABOUT THE AUTHOR

She was born in Samsun in 1987. She completed her elementary and high education in Samsun. In 2005, she won Ondokuz Mayıs University, Amasya Education Faculty, Elementary Mathematics Teaching. After graduating in 2009, she started his PhD education in Karadeniz Technical University, Institute of Educational Sciences, Department of Elementary Mathematics Education in the same year. Between 2010 and 2016, she worked as a research assistant at Karadeniz Technical University, Fatih Education Faculty, Department of Elementary Mathematics Education. After completing her doctoral thesis tittled as *"An analysis of the creativity of the students who assigned as gifted and the students who are not assigned as gifted in mathematics: A case study"*, she started to work as Assistant Professor at Istanbul Medipol University in 2017. After working here for one year, she began to work at Düzce University at the same position in 2018 and still working at the same university. Her study fields are mathematical creativity, mathematical giftedness, problem solving, problem posing, mathematical modeling, teacher education. She has some papers and articles published in national and international symposiums and journals.

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# Appendix

## Codebook Items

### Content Standards

Number and operations

1. This game includes the content related to the numbers, especially ways of representing numbers.
2. This game includes the content related to the numbers, especially relationships among numbers.
3. This game includes the content related to the numbers, especially number systems.
4. This game contains content that shows the meanings of operations.
5. This game contains content that shows how they relate to one another.
6. This game encourages students to practice compute fluently.
7. This game encourages students to make reasonable estimates.

Algebra

1. This game helps students understand math content related to patterns.
2. This game helps students understand math content related to relations.
3. This game helps students understand math content related to functions.
4. This game includes the content that develops students' skills to represent mathematical situations using algebraic symbols.
5. This game includes the content that develops students' skills to analyze mathematical situations using algebraic symbols.
6. This game includes the content that develops students' skills to represent mathematical structures using algebraic symbols.
7. This game includes the content that develops students' skills to analyze mathematical structures using algebraic symbols.
8. This game demonstrates mathematical models to represent quantitative relationships.
9. Students can understand quantitative relationships through mathematical models demonstrated in this game.
10. The content of this game helps students develop the skills to analyze change in various contexts.

Geometry

1. Through playing this game students can develop the skills needed to analyze characteristics of two- and three-dimensional geometric shapes.
2. Through playing this game students can develop the skills needed to develop mathematical arguments about geometric relationships.
3. This game includes the content that helps students specify locations using coordinate geometry and other representational systems.
4. This game includes the content that helps students describe spatial relationships using coordinate geometry.
5. Playing this game develops students' skills to apply transformations to analyze mathematical situations.

6. Playing this game develops students' skills to use symmetry to analyze mathematical situations.
7. This game contains the content related to the use of visualization to solve problems.
8. This game contains the content related to the use of spatial reasoning to solve problems.
9. This game contains the content related to the use of geometric modeling to solve problems.

Measurement

1. This game helps students understand measurable attributes of objects, such as the units and systems.
2. This game helps students understand the processes of measurement.
3. This game helps students apply appropriate techniques to determine measurements.
4. This game helps students apply appropriate formulas to determine measurements.

Data analysis and probability

1. This game contains the content related to the formulation of questions that can be addressed with collecting data to answer them.
2. This game contains the content related to the formulation of questions that can be addressed with organizing data to answer them.
3. This game contains the content related to the formulation of questions that can be addressed with displaying relevant data to answer them.
4. This game develops students' skills to select appropriate statistical methods to analyze data.
5. This game develops students' skills to use appropriate statistical methods to analyze data.
6. This game helps students to learn how to develop inferences that are based on data.
7. This game helps students learn how to evaluate inferences that are based on data.
8. This game helps students to learn how to develop predictions that are based on data.
9. This game helps students learn how to evaluate predictions that are based on data.
10. This game helps students understand the basic concepts of probability.
11. This game helps students apply the basic concepts of probability.

**Process Standards**

Problem solving

1. This game assists students to build new mathematical knowledge through problem solving.
2. This game is helpful for students to solve problems that arise in mathematics and in other contexts.
3. This game guides students to apply and adapt a variety of appropriate strategies to solve problems.
4. This game makes students monitor and reflect on the process of mathematical problem solving.

Reasoning and Proof

1. This game provides students with skills that recognize reasoning and proof as fundamental aspects of mathematics.

2. This game provides students with the process that make and investigate mathematical conjectures.
3. This game includes the process that develop mathematical arguments and proofs.
4. This game includes the process that evaluate mathematical arguments and proofs.
5. This game includes the process that select various types of reasoning and methods of proof
6. This game includes the process that use various types of reasoning and methods of proof

Connections

1. Through playing this game, students can recognize connections among mathematical ideas.
2. This game helps students use connections among mathematical ideas
3. This game presents the process for students to understand how mathematical ideas interconnect with one another to produce a coherent whole.
4. By playing this game, students can build skills to recognize mathematics in contexts outside of mathematics.
5. This game helps students apply mathematics in contexts outside of mathematics.

Representations

1. This game helps students create and use representations to organize, record, and communicate mathematical ideas.
2. This game builds students' skills for selecting mathematical representations to solve problems.
3. This game builds students' skills for applying mathematical representations to solve problems.
4. This game builds students' skills in translating mathematical representations to solve problems.
5. This game helps students build the skills for using representations to model.
6. This game helps students build the skills in interpreting physical phenomena.
7. This game helps students build the skills in interpreting social phenomena.
8. This game helps students build the skills in interpreting mathematical phenomena.

Communication

1. This game helps students organize and consolidate their mathematical thinking through communication.
2. This game shows the process that helps students communicate their mathematical thinking clearly to others.
3. This game helps students build the skills for analyzing mathematical thinking and strategies through communication.
4. This game helps students build the skills for evaluating mathematical thinking and strategies through communication.
5. This game shows the process for using the language of mathematics to express mathematical ideas precisely.

Game genre

1. What is the genre of this game?