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Enhancing Early Childhood Students' Computational Thinking Competency Through Digital Game-Based Learning

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Abstract: This study investigated how the computational thinking competencies of students classified in the early childhood category can be developed through digital game-based learning. Computational thinking is a way of thinking that includes problem solving, algorithmic thinking and logical inference skills is considered an important competence that should be acquired at an early age. Digital game-based learning stands out as a powerful tool for developing computational thinking skills while providing a fun and motivating environment by ensuring the active participation of students. Within the scope of the research, the effects of digital game-based learning activities on students' computational thinking skills were examined by experimental method, one of the quantitative research methods. In this study, a 4-week training activity was conducted for the experimental and control groups determined during the research process to develop computational thinking skills in 5-year-old pre-school children. The study group consists of 50 students in the 5-year-old age group studying in the pre-school class of a state institution. In the study, student groups were divided into experimental and control groups. The experimental and control groups consisted of 25 students. The achievement test prepared for the cognitive domain was used as a pre-test and post-test as the data collection tool. In addition to this data collection tool, an evaluation rubric was also used in the study. The findings showed that digital game-based learning methods positively affect the development of computational thinking skills in early childhood. In light of these findings, recommendations were made in the study for the integration of digital games into relevant educational programs and the promotion of computational thinking at an early age.

Keywords: *digital game-based learning, computational thinking, early childhood, experimental method.*

Introduction

The early childhood period, which covers the age range of 0-6, is a critical period in which the cognitive, social and emotional development of individuals is based. Skills acquired during critical periods affect children's future learning processes and academic success. Therefore, it is of great importance to implement such effective learning methods at an early age. During this period, children show rapid change in multiple areas of cognitive development (Bakioglu and Karamustafaoglu, 2022). It is important to organize the educational materials prepared for children in this age group in accordance with their developmental areas in order to create an environment that includes stimuli for learning experiences (Can Yasar and Aral, 2010).

Early childhood is a period in which the brain develops rapidly. During the cognitive development process, children gain skills such as acquiring knowledge, using language appropriately, reasoning, and problem solving (Gardiner and Garner, 2010). According to related research, state that in order to support the cognitive development of children, presenting appropriate content or organizing educational materials in line with the thoughts, hypotheses, and solution suggestions they put forward is of great importance for their cognitive development (Yıldız and Zengin, 2021).

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In another study, it was stated that environmental richness can be created through play to support cognitive development in children (Fisher et al., 2018). Other research emphasizes that games play an important role in the emotional, linguistic, social, physical, and especially cognitive development of children (Yavuzer, 2010).

The 21st century is a period in which digitalization has accelerated and can be called the computer age. In this age, it is becoming increasingly important for individuals to develop the ability to think with computer logic and acquire programming skills. It has developed the computational thinking skill that the logical functioning of computers can also affect humans. Acquiring computational thinking skills and applying them in daily life stands out as a great necessity for individuals. According to related research, states that programming or computer skills are not needed specifically for computer scientists (Wing, 2008). In other research, also define computational thinking as a type of logical thinking that everyone has (Kim et al., 2013). In addition, it is stated that cognitive thinking skills, which are shown among the 21st century skills, include basic competencies such as algorithmic thinking and problem solving expected from individuals (Tezer et al., 2024).

In the century we are in, technological developments have also created radical changes in the game of playing. The proliferation of digital platforms has enabled children to move from traditional games to digital games that they interact with through electronic devices. This process has changed both children's understanding of entertainment and their social relationships. The increasing popularity of digital games in all age groups indicates that they have positive effects on children's development (Talan and Kalınkara, 2020). It is stated that digital games have the potential to provide a more interesting learning environment and support learning by structuring learning processes, as well as having positive effects on cognitive skills such as reasoning, critical thinking, problem solving, and ensuring the permanence of learning (Granic et al., 2014; Guntepe and Donmez, Usta, 2017; Li et al., 2020). According to other research, digital games improve children's skills such as planning, problem solving, observation, mathematical thinking, hypothesizing and testing, creativity, and collaborative learning (Gozum and Kandır, 2021). Another research stated that the correct use of technology by children in the pre-school period can have positive effects, improve their creativity and contribute to their self-confidence (Haugland, 2000).

The concept of computational thinking, first put forward by Wing (2006), includes ways of solving problems, designing systems, and understanding human behavior. Computational development in early childhood includes children's skills in problem solving, logical thinking, decision making, and participation in creative processes. Utilizing common points between digital games and computational thinking can contribute to this development process. That games help children develop problem-solving strategies, support algorithmic thinking skills, and establish logical connections (Bers, 2018).

Computational thinking includes the skills to analyze complex problems, develop solution strategies by breaking these problems into smaller pieces, create algorithms, and optimize solution processes. That the challenges encountered in games are similar to the basic principles of computational thinking, where players systematically take the problem-solving process and try various solutions by (Shute et al., 2017; Wing, 2006), states that overcoming an obstacle encountered in the game requires the player to solve this obstacle by dividing it into smaller sub-parts and establishing relationships between these parts, which is one of the basic principles of computational thinking. Additionally, the repetitive experience and opportunities to learn from failure that games offer are very similar to the trial-and-error processes encountered in computer programming. In this case, computer games can be considered as tools that provide players with the basics of computational thinking in a fun and interactive way.

A quasi-experimental research design with a pretest-posttest control group was used for this study. The study group consisted of sixth-grade middle school students. Lessons were conducted for the experimental group using a BID block-based coding tool. The results show that the experimental group had much higher mathematics achievement than the control group (Top and Arabacıoglu, 2024).

In this study, the Bee-Bot application was preferred for early childhood robotic coding education. Bee-Bot is an educational robot specifically designed to develop preschool children's algorithmic thinking, understanding of directional concepts, problem-solving, and sequencing skills. Its physical structure and ease of programmability support children's learning through concrete experiences. However, the literature also includes other robotic tools that can be used in early childhood education. For example, Doc Robot, developed by the company Clementoni, is another educational robot that similarly aims to enhance children's coding-based thinking skills. In addition to fostering logical thinking, directional awareness, and problem-solving, Doc Robot is designed to teach basic concepts such as letters, numbers, colors, and animals (dikkatatolyesi.com, turascandinavia.com). Notably, its "smart mode" feature allows the robot to recognize its position on game cards and provide children with various tasks, making the learning process more interactive. In this context, Doc Robot, like Bee-Bot, is a programmable educational tool suitable for preschool use and offers an alternative depending on the goals and conditions of implementation. However, in this study, Bee-Bot was deemed a more appropriate choice considering the targeted learning outcomes and the practical conditions of the application.

Related Research

A game was designed by (Zhao, 2017), that includes the basic elements of computational thinking, such as problem solving, abstraction, algorithmic thinking, conditional logic, iterative thinking, and debugging. The results of the study revealed that students showed a significant increase in their computational thinking skills after playing the game for less than two hours. As a result of the study conducted by (Ciftci et al., 2018), it was revealed that digital games have positive effects on programming self-efficacy, computational thinking, reflective thinking about problem solving and the ability to follow developments in the field of computers. Investigated the effects of educational games on students' basic knowledge of object-oriented programming and computational thinking skills. According to the findings of the study, the developed educational digital game contributed to the students' learning the basic concepts of object-oriented programming and developing their computational thinking skills, were presented by Akkaya (2018).

In their research to determine at which education levels digital games can be used, Aksoy (2021) stated that digital games can be used at all levels of education, but they are more suitable, especially for younger age groups. In other research, the effects of science teaching with educational digital games and in-class educational games on the cognitive development levels of pre-school students were examined (Yıldız and Zengin, 2021). At the end of the research, it was revealed that the relevant methods were effective in increasing the cognitive development of pre-school students. In this study (Aksoy, 2021), the views of pre-school teachers on the use of technology in education were examined. According to teachers, technological educational tools contribute to language and cognitive development, while also increasing students' interest in learning and supporting the permanence of information. This shows that technology is more than just a tool; it can play an active role in pedagogical processes. Especially in early childhood, the use of such tools can help make learning more fun and engaging. examined the effects of science courses conducted through educational digital games on students' knowledge retention, academic achievement, and attitudes. As a result of the research, it was concluded that science courses conducted through educational digital games positively increased the cognitive development levels of students (Agırgol et al., 2022).

Examined the effects of a digital game-based education program on the phonological awareness skills of 60-72-month-old children. The research results revealed that the children in the study group showed a significant improvement in their phonological awareness skills in the pre-test and post-test comparisons. Additionally, according to the post-test results, it was found that the experimental group scored higher than the control group. These findings show that digital game-based educational programs contribute to children's language development and improve phonemic awareness skills (Gole and Temel, 2023).

Emphasized that the use of digital game-based learning in early childhood has increased in recent years. They analyzed 37 articles to determine the effects of the relevant method in childhood. According to the results of the study, it was seen that digital game-based learning can have an active impact on developing children's thinking skills and strengthening their learning processes. These findings demonstrate that digital game-based learning is a potentially powerful tool in early childhood education, supporting cognitive development (Behnamnia et al., 2023).

In their study (Unal and Erbil, Kaya, 2024), they investigated the use of digital games in mathematics education in early childhood. According to the findings of the study, it has been revealed that the integration of digital games and applications into mathematics education contributes to the development of children's mathematical skills. However, in order for these technologies to be implemented effectively, pre-school teachers need to include digital games appropriately in the learning process, take into account children's individual needs and interests, and establish a strong collaboration with parents. Examined studies on the use of digital games in mathematics classes can be found in Turkey by Aydın and Ata (2024). When the instructional features of the studies were evaluated, it was observed that digital game-based learning generally had positive effects on mathematical achievement and cognitive and affective skills related to mathematics. In addition, the studies examined showed that digital games were mostly used for reinforcement purposes in classes.

According to the results of another study, which investigated the effects of educational mobile games on the critical thinking skills of pre-school children. The results of the study show that integrating educational mobile games into the existing pre-school curriculum improves children's critical thinking skills (Calhan and Goksu, 2024). Digitalization could potentially benefit children's creative and cognitive development, and aimed to examine the effect on a sample of pre-school children. The digital intervention used in the study is a specially designed digitally supported learning program called "Pre-schoolers: Digital Adventures"(Chen and Ding, 2024). The current findings of the study reveal that digital enrichment of the learning process in pre-school education can help improve certain aspects of children's creative-cognitive development. This case shows that digital tools can play a supporting role in education in early childhood.

The Purpose of the Study:

This study proposes to analyze the contributions of digital games to computational thinking and to develop educational materials and digital game-based learning experiences that are appropriate for children's developmental needs. The purposes of this study are as follows:

- To determine how computational development can be supported with digital games in early childhood.
- To examine the effect of providing computational thinking skills in early childhood on children's problem solving, reasoning, and algorithmic thinking abilities.
- To discuss the usability of information technologies and digital games as an educational tool in developing children's computational thinking skills.

The sub-objectives determined in line with these general objectives are presented below:

- Is there a significant difference between the pre-test and post-test achievement test scores of the experimental group?
- Is there a significant difference between the pre-test and post-test achievement test scores of the control group?
- Is there a significant difference between the pre-test achievement test scores of the experimental and control groups?
- Is there a significant difference between the post-test achievement test scores of the experimental and control groups?
- What are the learning outcomes at the end of the 4-week training process?

The Importance of the Study:

This study aims to examine the concurrence of these two topics by addressing the impact of digital games on computational thinking in early childhood. This study draws attention to the need to investigate the role of digital games and computational thinking that can contribute to the cognitive, social, and emotional development processes of children aged 0-6 and to create educational materials suitable for this age group.

It can be said that children's perception of play has changed in parallel with technological developments today. While children used to play with their peers on the streets in the past, today technological devices have become play tools for the children we call Generation Z. Therefore, digital games have become indispensable in children's lives (Bird, 2012; Korkusuz and Karamete, 2013). It is known that digital games have positive and negative effects on children, especially in a critical period such as early childhood. It is seen that digital games are effective in developing hand-eye coordination, focusing attention, and problem-solving skills in children (Kim and Smith, 2017; Lin and Hou, 2016). In addition, it is known that if creative games suitable for children's ages are selected, it can contribute to the development of children's creativity through these games (Arslan and Gorgulu, Arı, 2023).

In this context, it is foreseen that the relevant research will offer an innovative perspective in developing educational materials by drawing attention to the importance of digital game-based learning experiences that develop computational thinking skills of children in early childhood, how they can be integrated into the educational process, and revealing the learning opportunities offered by digital games.

Materials and Methods

This section includes the research model, study group, process steps, structure of groups, data collection tools and data analysis sections.

Research Model

In this study, the fully experimental method, one of the experimental research designs, was used. Experimental studies are studies aimed at testing the effect of the differences created by the researcher on the dependent variable (Buyukozturk et al., 2019). The reason for using experimental research, one of the quantitative research methods, in this study is that it is the most appropriate method for applying digital game applications to a group with defined limits and properties. For this reason, experimental and control groups were randomly created, and a comparison was made after the implementation.

Table 1. *Study groups*

Groups	Girl	Boy
Experimental group	13	12
Control group	12	13

Research Model

This study was conducted with kindergarten students studying in a pre-school institution in Turkey in the 2024 – 2025 academic year. The experimental and control groups in the study consisted of 25 students each. The 50 students (25 girls, 25 boys) included in the study were aged 5.

Sample Method

In this study, the convenience sampling method was selected from the sampling methods. Convenience sampling method is the collection of data from a sample that the researcher can easily reach. For example, the selection of schools that are easy for the researcher to access and permit. The relevant sampling method is a method that accelerates the research. Because in this method, the researcher selects a situation that is close and easy to access (Kılıc, 2017).

Process Steps

Table 2 shows the path followed during the study. The study was carried out in 3 steps: pre-implementation, implementation, and post-implementation.

Table 2. *Process steps*

Process Steps	Preparation Process
Before Implementation	Preparing activity Obtaining permissions to use Rubric Creating an achievement test
Implementation	Conducting pre-tests 4-week implementation process Conducting post-tests
After Implementation	Analyzing data Presenting the findings Determination of learning outcomes

For this study, firstly, the activities and games to be used in the lessons were prepared. Rubric permissions were obtained, and the achievement test was created. Then, the validity and reliability study of the achievement test was carried out. After the preparations of the achievement test were completed, experimental and control groups were created and pre-tests were applied to the groups. Then the teaching plan was applied to the students who participated in the study. After the application was completed, the post-tests were applied to the students and the data were analyzed and the findings were presented.

In this study, a 4-week training activity was conducted on experimental and control groups to develop the computational thinking skills of 5-year-old pre-school children. The aim of the study was to children understand the commands of going forward-backward, turning right and turning left through activities using Bee Bot, paper activities and digital games. With Bee Bot (https://www.robokids.com.tr/bee-bot-okul-oncesi-programlama-robotu), paper activities and digital games were designed by researchers in accordance with the applications themed around shapes and colors. The designed activities and games were restructured after being submitted to expert opinion, and necessary revisions were made. The students participating in the study had not been taught algorithms or coding before. Students from two different classes were randomly selected as one class control group and the other class experimental group. During the 4-week study, the educational activities applied to both groups were differentiated, and in this context, student development was measured with rubric evaluations made by two different computer teachers. The cognitive development of the 5-year-old students who made up the study group was tested through observation by the course teachers. Observation is mostly used as a way to easily reveal behavioral changes in children and to understand and detail this behavior. It is also a way to predict behavior in advance.

Structure of Groups

Experimental Group: The group consisting of 5-year-old children who have not taken a coding course and who received Bee Bot training supported by digital games.

Control Group: A group of 5-year-old children who had not taken a coding course and received Bee Bot training through paper activities.

The planned activities for the groups are shown in Table 3-Table 3.1. below.

Table 3. *Experimental group study plan*

Weeks	Activities
Week 1	Getting to know Bee Bot
Week 2	Basic forward-backward, turn right-turn left command exercises with Bee Bot. Activity practices, achievement test (pre), and rubric pre-test.
Week 3	Digital Game-1 Digital Game 2 Applications.
Week 4	Achievement test (post), rubric post-test, determination of teaching outcomes

Table 3.1. *Control group study plan*

Weeks	**Activities**
Week 1	Getting to know Bee Bot
Week 2	Basic forward-backward, turn right-turn left command exercises with Bee Bot. Activity practices, achievement test (pre) and rubric pre-test.
Week 3	Paper activity 1-2, Paper activity 3-4.
Week 4	Achievement test (post), rubric post-test, determination of teaching outcomes

Experimental group activities: Includes digital game activities in addition to Bee Bot.

Control group activities: Includes Bee Bot apps and paper activities. Bee Bot applications were used to teach the same commands to both groups. The inclusion of digital games in addition to the experimental group was done to observe the effect of digital games on computational thinking skills.

Data CollectionTools

The achievement test prepared for the cognitive domain consists of 15 multiple-choice questions prepared for target achievements to be used as a pre-test and post-test. In the preparation of the achievement test, expert opinions were taken from 3 faculty members, who teach in the Pre-School Education Department of the Basic Education Department. Following the expert opinion received, expert faculty members confirmed that the achievement test was suitable for the relevant teaching level. It has been recommended by expert faculty members that the questions be read to pre-school students by assistant teachers and their answers be obtained.

With the Ladybug U bot coding tool supported by digital games and paper activities used throughout the 4-week teaching period, children were taught game-supported and paper activity topics and commands such as algorithm creation, sequencing, function creation, loops, and debugging. The questions developed for the achievement test were prepared to measure the learning of these topics and commands. While developing the achievement test, the process applied by Seker and Gencdogan (2014) for the achievement test was taken into consideration. The procedures carried out in this direction are presented below:

a) Determining the scope: The purpose of the test is to determine the readiness level of the students in the experimental and control groups.
b) Determination of targets/learning outcomes: The learning outcomes are within the scope specified in the pre-school curriculum. In this direction, there are 5 basic achievements expected to be achieved in the unit.
c) Creation of evaluation rubrics: A rubric sample developed by the researchers was used to evaluate student performances with various criteria.
d) Preparation of test questions: Expert opinion was obtained on the item pool created based on the achievements, and it was decided to prepare multiple-choice questions. A question pool of 23 items was created.
e) Test implementation/scoring: In line with the opinions received from a program developer, a measurement & evaluation and a field expert, 3 questions in the item pool were removed, and it was decided to apply 20 questions as is.
f) Implementation of the test, validity and reliability study: The achievement test, consisting of 5 achievements and 15 items, was applied to the experimental and control groups of 50 people, and KR-20 was calculated for reliability.

Performing item analysis: The highest score that can be obtained from the test was determined as 20, the lowest score as 0. Each question was determined as 5 points. As a result of the analysis of the answers given to the test, the item difficulty index (p) and the item discrimination index (D) were calculated. Accordingly, at least one question remained that measured each gain.

Kuder Richardson-20 was used in reliability analysis because of the coding of right and wrong answers as 1 and 0 while developing the achievement test. In the item difficulty index calculated using the formulas shown in Table 4, .20 to .00: very difficult; .21 to .40: difficult; .41 to .60: medium difficulty; .61 to .80: easy; .81 to 1.00: very easy. In item discrimination values, items with values below .20 were removed from the test.

Table 4. *Scores regarding the analysis of the test*

Question	Item Difficulty Index (p)	Item Discrimination Index (D)
Q1	.62	.30
Q2	.70	.21
Q3	.65	.30
Q4	.66	.34
Q5	.69	.30
Q6	.66	.30
Q7	.60	.31
Q8	.67	.33
Q9	.63	.36
Q10	.59	.31
Q11	.59	.30
Q12	.56	.34
Q13	.59	.30
Q14	.62	.31
Q15	.58	.30
Q16	.46	.28
Q17	.73	.31
Q18	.65	.36
Q19	.73	.31
Q20	.83	.21

According to Table 4.1; an achievement test consisting of 20 items was developed by the researchers in order for students to comprehend the relevant structures. The KR-20 reliability of the test was found to be 0.84. Getting a high score from the test shows that the level of achievement of the gains is high. KR-20 value of 0.80 or greater is desirable. However, 0.70 and above is also acceptable. Scales with KR-20 value of less than 0.70 are not good enough (Shepard, 2005).

Creation of Evaluation Rubrics

Rubrics are usually in the form of tables based on horizontal and vertical axes. The vertical axis usually contains performance criteria, and the horizontal axis contains increasing performance levels from the lowest level to the highest level. At the intersection of the horizontal and vertical axes, there are performance definitions related to the performance level of the performance criterion. Performance criteria allow the components of performance to be seen.

Table 5. *Evaluation rubric*

	Excellent(6)	Very good(5)	Good(4)	Average(3)	Limited(2)	Very limited(1)
Analysis	Separate a problem into smaller parts accurately, precisely and confidently. Explains the problem systematically	Properly separate the problem into smaller pieces	Separates the problem into smaller pieces with minor mistakes	Separates the problem into smaller pieces with significant mistakes	Separates the problem into smaller pieces with the teacher's guidance	Shows no evidence of analysis.
Pattern recognition	Recognizes patterns accurately and reliably, making accurate predictions based on pattern variations	Recognizes patterns accurately	Recognizes patterns with minor mistakes	Recognizes patterns with major mistakes	Recognizes patterns under the guidance of the teacher	Shows no evidence of pattern recognition.
Abstraction	Simplifies a problem, identifies main ideas accurately and confidently, and explains the most important details of the problem	Simplifies a problem and identifies main ideas accurately	Simplifies a problem and identifies main ideas with minor mistakes	Simplifies a problem and identifies main ideas with significant mistakes	Simplifies a problem and identifies main ideas with teacher guidance	Does not show any evidence of abstraction.
Algorithm design	Creates a logical sequence of steps, solves a problem accurately, effectively, and safely, and can explain procedures in detail	Creates a logical sequence of steps to correctly solve a problem	Creates a logical sequence of steps to solve a problem with minor mistakes	Creates a logical sequence of steps to solve a problem with major mistakes	Creates a logical sequence of steps to solve a problem with teacher guidance	Shows no evidence of the algorithm.
Logical reasoning	Correctly predicts the logical facts of a problem	Accurately determines the logical facts of a problem	Guessing the logical truths of a question with small mistakes	Guessing the logical truths of a problem with major mistakes	Guess the logical truths of a problem under the guidance of the teacher	Provides no evidence of logical truths.
Evaluation	Evaluates solutions, identifies any mistakes, successfully fixes them and suggests improvements	Evaluates solutions, identifies and corrects any mistakes	Evaluates solutions, identifies most mistakes and successfully fixes them	Evaluates solutions, identifies and corrects some of the mistakes	Evaluates solutions under teacher guidance	Shows no evidence of evaluation.

Rubrics are scoring scales developed by teachers or other assessment professionals to guide students in their learning process or to help them understand how to analyze learning products and thus support their learning (Mertler, 2001; Truemper, 2004; Moskal, 2000; Shepard, 2005). According to the table above a rubric sample developed by the researchers was used to evaluate student performances with various criteria. The success criteria in the relevant rubric were observed and scored by two computer teachers throughout the teaching-learning process. Rubric criteria are structured according to the computational thinking approach developed by the (Panadero and Jönsson, 2013).

Analysis of Data

In cases where there are fewer than 30 participants in the experimental and control groups, it is difficult to assume that the scores are normally distributed. In such cases, it is appropriate to use non-parametric tests for analysis (Buyukozturk et al., 2011). Wilcoxon Signed Rank Test and Mann-Whitney U-Test were used in the analysis of the data because the number of groups was small and the distribution did not show normality.

Results

Comparison of the experimental groups and the control group separately according to their scores before and after the training was made using Kruskal-Wallis and Mann-Whitney U non-parametric tests, as the data did not show a normal distribution. Since p<0.5 was obtained within the scope of the Kolmogorov-Smirnov test, it was accepted that the data did not show a normal distribution. The general average was taken into account in explaining the differences in the data. The findings obtained in the study are presented below through the relevant tables.

Comparison of Achievement Tests of Experimental and Control Groups:

Comparison of achievement tests of experimental and control groups was made using the Mann-Whitney U test. The Mann-Whitney U-test can be used when the aim is to show the difference in the value of an ordinal, interval, or proportional variable between two groups.

Table 6. *Comparison of Pre-Test Success Scores of Experimental and Control Groups: Mann-Whitney U Test Result*

Groups	N	Average Rank	Total Rank	U	p	Significant Difference
Experimental Groups	25	57.10	3426	1596	.281	There is no significant difference between the groups
Control Groups	25	63.90	3834			

According to the table, since the p value is .281> .05, there is no significant difference between the pre-test success scores of the experimental group and the control group.

Table 6.1. *Comparison of Post-Test Success Scores of Experimental and Control Groups: Mann-Whitney U Test Result*

Groups	N	Average Rank	Total Rank	U	p	Significant Difference
Experimental Groups	25	67.68	4061	1369	.004	There is a significant difference between the groups
Control Groups	25	53.32	3199			

According to the table, since the p-value is .004 < .05, there is a significant difference between the post-test success scores of the experimental group and the control group, and this difference is in favor of the experimental group.

Experimental Group Pre-Test & Post-Test Achievement Test:

Table 6.2. *Wilcoxon signed rank test results of achievement test scores before and after the experimental group*

Groups	Pretest-Post test	N	Average Rank	Total Rank	Z	P	Significant Difference
Experimental Group	Negative Orders	1	.00	.00	-6.736	.000	There is a significant difference between the groups
	Positive Orders	24	30.25	1830.0			
	Equal	0					

Pre-test and post-test achievement test scores of the experimental group students were tested with the Wilcoxon signed-rank test. According to Table 6.2, the learning outcomes of the experimental group students participating in the study were examined. In this context, the Wilcoxon Signed Rank Test was used to determine the significant difference between the pre-test and post-test academic achievement scores. When the academic achievement scores of the experimental group students were compared to the relevant test, a significant difference was found in favor of the post-test (z=-6.736; p<.05).

Table 6.3. *Wilcoxon signed rank test results of achievement test scores before and after the control group*

Groups	Pretest-Post test	N	Average Rank	Total Rank	Z	P	Significant Difference
Experimental Group	Negative Orders	1	4.88	19.5	-6.593	.000	There is a significant difference between the groups
	Positive Orders	24	32.33	1810.5			
	Equal	0					

According to Table 6.3, the learning outcomes of the control group students participating in the study were examined. In this context, the Wilcoxon Signed Rank Test was used to determine the significant difference between the pre-test and post-test academic achievement scores. Accordingly, when the academic achievement scores of the control group students were compared with the relevant test, a significant difference was found in favor of the post-test (z=-6.593; p<.05).

Evaluation Rubric Analysis:

The responses from 50 students to the relevant rubric developed by Panadero and Jönsson (2013) were analyzed and delivered to 2 computer teachers. In addition, teachers were given a graded scoring key and a scoring table with student names. Teachers first graded the problems without using a scoring rubric. Each question is worth 15 points in the evaluation. Since there are 6 problems, a student who answers all of them correctly will receive a total of 90 points, and the student with the lowest score will receive a total score of 0. The scores made by the teachers without using the rubric were collected. The same teachers scored the same papers with the rubric, and they did these scores 2 weeks later to reduce the memory effect. The consistency between the scores given by the teachers to the student answers using the graded scoring key was examined separately for the 1st-6th problems.

Table 7. *Correspondence between the scores given by teachers to student responses using a rubric*

	N	Kendall w	Sd	p
1. Problem	50	.85	26	.000
2. Problem	50	.83	26	.000
3. Problem	50	.82	26	.000
4. Problem	50	.83	26	.000
5. Problem	50	.81	26	.000
6. Problem	50	.82	26	.000

When Table 4-1 is examined, the Kendall w result between the scores given by 50 raters to the student answers using the rubric was found to be .85 for problem 1, .83 for problem 2, .82 for problem 3, .83 for problem 4, .81 for problem 5, and .82 for problem 6. These values show that there is a high consistency between the scores given by the teachers using the rubric for each problem. Since the Kendall W test is a test used to evaluate the compatibility of raters, it can be said that the consistency between the separate scores of the teachers for each question is at a high level. Although the Kendall w coefficients of all 6 problems are close to each other, it is seen that the highest consistency is in problem (Buyukozturk et al., 2011).

Discussion

In their research, Pan et al. (2024) studied improving the computational thinking competence of secondary school students through game-based learning. The findings of the study confirmed that game experience positively affected students' computational thinking self-efficacy, but did not affect their game-based engagement. When comparing the demographic factors of age (grade) and previous gaming experience, it was found that the gender factor tended to play a more important role in students' self-efficacy regarding computational thinking competence and in the extent to which it moderated game-based participation. At the end of the study, implications and possible directions for future research on using game-based learning to improve computational thinking competence are discussed.

According to the results of another study, researchers studied middle school students on the subject of computational thinking through game design and contributed a case study to the literature in the relevant field. This study used Code.org's block-based programming curriculum and evaluated its impact on middle school students' Computer Technology (CT) skills and attitudes toward CT and CS (Computational Science). The findings of the study proved that the participants showed a significant increase in algorithmic thinking, debugging, and pattern recognition skills, but not in abstraction skills (Cafarella and Vasconcelos, 2024).

In their study, Cheng et al. (2023) examined the development of computational thinking skills throughout program question strategies in a game-based learning platform. The study group consisted of 53 primary school students, and the data were collected during four lesson hours consisting of experimental Computational Thinking (CT) activities. This study shows that the experimental group using the student-generated questions (SGQ) strategy with the game-based learning (GBL) platform exhibited significantly higher information technology (IT) skills than the control group.

Conclustion and Recommendation

This study proposes to analyze the contributions of digital games to computational thinking and to develop educational materials and digital game-based learning experiences that are appropriate for children's developmental needs. This study was conducted with kindergarten students studying in a pre-school institution in Turkey in the 2024 – 2025 academic year. The experimental and control groups in the study consisted of 25 students each. The 50 students (25 girls, 25 boys) included in the study were aged 5. Within the scope of relevant purposes, a 4-week training activity was conducted on experimental and control groups to develop the computational thinking skills of 5-year-old pre-school children. The study aimed to help children understand the commands of going forward-backward, turning right and turning left through activities using Bee Bot, paper activities, and digital games. With Bee Bot, paper activities and digital games were designed by researchers in accordance with the applications themed around shapes and colors. The designed activities and games were restructured after being submitted to expert opinion, and necessary revisions were made. The students participating in the study had not been taught algorithms or coding before. Students from two different classes were randomly selected as one class control group and the other class experimental group. During the 4-week study, the educational activities applied to both groups were differentiated, and in this context, student development was measured with rubric evaluations made by two different computer teachers.

In this study, the fully experimental method, one of the experimental research designs, was used. In cases where there are fewer than 30 participants in the experimental and control groups, it is difficult to assume that the scores are normally distributed. Non-parametric tests were preferred in the analysis of data because the number of groups was small and the distribution did not show normality. The test results for the sub-objectives determined in the research are presented below:

There is a significant difference between the pre-test and post-test academic achievement scores of the experimental group participating in the program regarding the course outcomes. A significant difference was found in favor of the post-test in terms of achievement scores. There is a significant difference between the pre-test and post-test academic achievement scores of the experimental group participating in the program regarding the course outcomes, and no significant difference was found in favor of the post-test in terms of academic achievement scores. According to the results of the Mann-Whitney Test conducted to compare the pre-test and post-test achievement tests of the experimental and control groups, there is no significant difference between the pre-test success scores of the experimental group and the control group. There is a significant difference between the post-test success scores of the experimental group and the control group, and this difference is in favor of the experimental group.

The responses from 50 students to the relevant rubric developed by the researchers were analyzed and delivered to 2 computer teachers. In addition, teachers were given a graded scoring key and a scoring table with student names. Each question is worth 15 points in the evaluation. Since there are 6 problems, a student who answers all of them correctly will receive a total of 90 points, and the student with the lowest score will receive a total score of 0. The consistency between the scores given by the teachers to the student answers using the graded scoring key was examined separately for the 1st-6th problems. the Kendall W result between the scores given by 50 raters to the student answers using the rubric was found to be .85 for problem 1, .83 for problem 2, .82 for problem 3, .83 for problem 4, .81 for problem 5, and .82 for problem 6. These values show that there is a high consistency between the scores given by the teachers using the rubric for each problem.

Within the scope of the study, the following suggestions are presented for future research and researchers:

- This study was conducted with kindergarten students studying in a pre-school institution in Turkey in the 2024 – 2025 academic year. In order to obtain different and/or similar results within the scope of the situation, the same research can be repeated by different researchers, in different educational environments and with different study groups.
- Studies can be conducted in educational institutions to determine to what extent students are informed about the theory, application, and evaluation methods of the computational thinking approach or to what extent the relevant approach is adopted by students.
- It is recommended that similar research be conducted by updating the learning content and materials in line with the developments in the field.

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Conflict of interests

The authors declare no conflict of interest.

Author Contributions

Conceptualization, Ayse ALKAN; methodology, Ezgi Pelin YILDIZ; software, Murat TEZER; validation, Ezgi Pelin YILDIZ, Ayse ALKAN & Murat TEZER; formal analysis, Ezgi Pelin YILDIZ; research, Ayse ALKAN; resources, Murat TEZER; data curation, Ezgi Pelin YILDIZ; writing - review & editing, Ezgi Pelin YILDIZ; visualization, Murat TEZER; supervision, Ezgi Pelin YILDIZ, Ayse ALKAN & Murat TEZER; project administration, Ezgi Pelin YILDIZ. The authors read the final version of the article together and decided to publish together.

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