

# Escaping Traditional Learning: The Role of Educational Digital Escape Games on Achievement and Motivation in Primary Math Education

Hatice Kübra Işık <sup>a</sup> , Ayşegül Liman Kaban <sup>b\*</sup> 

<sup>a</sup> Bahçeşehir University, Türkiye.

<sup>b</sup> Marry Immaculate College, University of Limerick, Ireland.

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## Highlights

- This study examines the effects of Educational Digital Escape Games (EDEGs) on mathematics achievement and motivation among elementary students.
- The experimental group using EDEGs demonstrated significantly higher academic achievement compared to the control group.
- Intrinsic motivation was positively correlated with academic performance, reinforcing the importance of engaging learning experiences.
- The study highlights the need for further research on long-term effects, scalability, and teacher perspectives on EDEGs.

## Abstract

Educational digital escape games (EDEGs) are digital versions of escape rooms where players solve puzzles and complete challenges to achieve educational goals. This study investigates the effects of EDEGs on the academic achievement and motivation of elementary school students in mathematics. Using an explanatory sequential mixed-method design, 45 third-grade students from a private school in Istanbul were divided into experimental and control groups. The experimental group used an EDEG designed with the ADDIE model over four weeks, while the control group followed traditional teaching methods. Findings indicate that students in the experimental group demonstrated significantly higher academic achievement than their peers in the control group. Additionally, while intrinsic motivation was positively correlated with achievement, no significant difference was observed in overall motivation scores between groups. Qualitative data from student interviews revealed that the game-based learning approach enhanced engagement, teamwork, and problem-solving skills, making mathematics more interactive and enjoyable.

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**Keywords:** Educational digital escape games, Game-based learning, Mathematics education, Academic achievement, Motivation

## 1. Introduction

Games have long played a role in education, particularly in mathematics, where interactive techniques foster deeper understanding. Traditional instructional methods, like lecture-based teaching, often fail to engage students actively, making it critical to explore alternative methods that foster both motivation and retention (Aktepe et al., 2015; Liman-Kaban & Karadeniz, 2021). Game-based learning and gamification offer immersive environments where abstract concepts are made tangible, enhancing comprehension (Çankaya & Karamete, 2009). Educational digital escape games (EDEGs) represent an evolution in this domain, merging the excitement of gaming with structured learning outcomes. EDEGs use puzzles and challenges to engage students in problem-solving while meeting curriculum objectives (Borrás-Gené et al., 2022). Despite growing interest, research on EDEGs remains fragmented, particularly regarding their role

\* Corresponding author. Marry Immaculate College, University of Limerick, Ireland.

e-mail addresses: [hatice.isik@bahcesehir.edu.tr](mailto:hatice.isik@bahcesehir.edu.tr), [aysegul.liman@bau.edu.tr](mailto:aysegul.liman@bau.edu.tr)

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in mathematics education. Addressing this gap, the present study investigates the effects of EDEGs on elementary students' achievement and motivation in mathematics, answering the question: "How can EDEGs improve learning outcomes and engagement in primary-level mathematics?"

## 2. The Effect of Educational Escape Games on Motivation and Achievement

Players in an educational escape room are expected to achieve educational goals. Escape room games are used in different fields. They are used to improve knowledge and skills in pharmacology, medicine, pharmacy, physiotherapy, interdisciplinary health education and mainly in nursing education. Liu, Patel, Ogunjinmi, Briffa, Chapman, Chapman, Coffey, Kallam, Leung, Lim, Shamsad, El-Sharnouby, Tsang, Whitehead, Bretherton, Ramsay and Shelmerdine (2020) in a collaborative study in the field of medicine, participants after a certain period. Improved memory and learning were said to be observed. In the study of Gomez Urquiza et al., (2019), second-year nursing students actively used both theoretical skills and practical skills by solving puzzles and finding the desired objects in the time allocated to them. At the end of this study conducted with nursing students, it was stated that many more escape games should be included in the curriculum as they enable them to learn the subject better. It was stated that they believed that escape games can attract students' attention and interest. Huang, Kuo, Chen (2020); Jiménez, Arís, Magreñán Ruiz, Orcos (2020); Vidergor (2021) also reported that escape games and game-based approaches facilitate learning and increase student motivation (Liman-Kaban,2021). The results of Akyol and Ural's (2023) study also show that mathematics escape games attract the attention and interest of 6th grade students.

- The information obtained from the research results shows that an escape game helps students improve their knowledge by filling learning gaps and encouraging them to learn.
- It positively affects children's interest and attention to the lesson.
- It makes the lesson more interesting and informative.
- Increased students' desire to learn.

The use of escape room games in education can provide many benefits that can help students improve their knowledge and skills.

Research shows that escape room games have positive effects on students' learning process. These games encourage students' active participation, improve problem solving skills and increase interest in the lesson. Furthermore, games increase students' motivation by making learning more fun and interactive. Therefore, the inclusion of escape room games in the educational curriculum and their use in different courses may have significant potential.

A quasi-experimental research method was applied for this study. While the experimental group was given digital escape games, the control group was given standard learning methods and the achievement and motivation levels of both groups in Mathematics were measured. Thus, the researchers examined the effect of digital escape games in the mathematics course.

The aim of this study is to investigate the effects of digital escape games in terms of academic achievement and motivation in mathematics courses.

In the quantitative dimension of the research:

- Is there a statistically significant difference between the Mathematics Achievement Posttest scores of the Experimental Groups and the Control Group?
- Is there a statistically significant difference between the Mathematics Motivation Scale scores of the Experimental Groups and the Control Group?

Qualitative dimension of the research:

What are the opinions of the experimental group participants who learned with the digital educational escape game design about mathematics teaching?

## 2.1 EDEGs

EDEGs can be used to improve student learning by providing engaging and interactive learning environments (Borrás-Gené, Díez, & Macías-Guillén, 2022). These games can help overcome limitations in traditional teaching methodologies and enhance student motivation and persistence in learning and these games also utilize game-based learning activities and gamification techniques to keep students interested and persistent in their learning (Videnovik et al., 2022). By incorporating educational content into the game design, students can self-assess their knowledge and actively participate in the learning process (Bisanti et al., 2022). Digital educational escape room games are valuable as they enhance students' cognitive, affective, skill, and personal development, providing a holistic learning experience (Sahin, 2023). According to Yoleri and Yilmaz (2021), training in digital game design and escape rooms significantly improved teachers' technology acceptance and digital game development self-efficacy, suggesting that such games can be effectively integrated into classrooms. The use of digital escape games has been shown to increase student engagement and motivation, leading to improved learning outcomes (Troussas et al., 2022). Additionally, the design thinking methodology can be applied to create these games, ensuring that they provide educational value and meet the needs of students (Horat & Przybylla, 2021). By combining different learning styles and optimizing the types of learning activities delivered to students, EDEGs can cater to individual student preferences and enhance their learning experience. Overall, these games offer a promising approach to enhance student learning in various educational domains.

Digital educational escape games have some notable weaknesses and drawbacks. One limitation is the logistical complexity and grandeur required to set up physical escape rooms, making them unsustainable for average classroom teachers or smaller tertiary courses (Bisanti et al., 2022). Another drawback is the need for adaptability in teaching methodologies to ensure quality education in different scenarios, which can be challenging (Clune, 2019). Additionally, the spread of fake news in online platforms poses a threat to society, and while games like "Escape Fake" can address this issue, further research is needed to explain the effects and increase effectiveness (Borrás-Gené, Díez, & Macías-Guillén, 2022). Despite these limitations, escape games offer potential benefits such as increased engagement and the promotion of subject knowledge and key competencies (Buchner, 2023; Menon & Romero, 2020).

## 2.2 Digital Educational Escape Games in Math Courses

The main aim is to ensure learning by teaching and to support students' learning of mathematics. The study also aims to support the process of teaching by using game-based learning to motivate. According to the studies of Samur (2020), among the reasons for deviations from game-based learning methods for mathematics are the development of targeted problem solving, gaining analytical thinking and using the right methods to help students learn mathematics. This method aims to facilitate students' mathematics learning, motivating them and maintaining their interest in mathematics. Jiménez, Arís, Magreñán Ruiz, Orcos (2020); Vidergor (2021); Huang, Kuo, Chen (2020) also found that escape game is reported to facilitate learning.

Most of the recent studies on escape rooms are related to design or logistics (Clare, 2015; Clarke et al, 2017; Duggins, 2019; Karageorgiou, Mavrommati, & Fotaris, 2019; Veldkamp, Merx & van Winden, 2020); and focus on higher education in general (Fotaris & Mstoras, 2019) or different fields: Computer education (Borrego, Fernandez, Blanes, & Robles, 2017), engineering (Queiruga-Dios, Santos Sanchez, Queiruga Dios, Gayoso Martínez, & Hernandez Encinas, 2020) and medicine (Jambhekar, Pahls, & Deloney, 2020). Veldkamp et al., (2020) conducted a systematic review of escape rooms in education and found that only three articles were published on science or Science Technology Engineering and Mathematics focused secondary education. The type of game used in the study was a digital escape game. These games are described as a new type of game that has recently entered the literature. EDEGs were designed to engage math learning students and provide them with a fun learning experience. These games require players to code puzzles and complete the game using clues to interpret math-related challenges. The digital escape game was designed considering all stages. This designed game is specially prepared to help teach the math learning process.

### 3. Methodology

Bond (2020) argues that relying solely on quantitative studies restricts the comprehensiveness of findings due to a rigid interpretation of their results. Consistent with this perspective, the present research integrates both quantitative and qualitative research approaches, embracing methodological diversity. Specifically, this study employs an explanatory sequential mixed-methods research design. In such designs, qualitative data collection follows quantitative data collection, to elucidate or further interpret the outcomes obtained from the initial analysis (Creswell & Plano-Clark, 2017). In this study, quantitative data collected from students, followed by qualitative data initially gathered from 3<sup>rd</sup> grade students, thereby characterizing it as an explanatory study (Fraenkel et al., 2018). This approach was chosen to ensure a comprehensive exploration of the data, leveraging faculty perspectives to interpret student data. The experimental group was exposed to a digital escape game from the Genially application for four weeks. During this time, the control group completed worksheets. After the intervention, both groups completed an achievement test and a motivation questionnaire. The experimental group also asked two separate questions on the motivation questionnaire: whether they enjoyed playing the digital escape game in math class and whether they would like to use it in other classes. Additionally, the experimental group participated in a structured interview after playing the digital escape game. The findings of the structured interview questions are presented in the section on the opinions of the students in the experimental group about the teaching of the math lesson with the digital escape game.

#### 3.1. Participants

This study employed a convenient sampling method, a type of non-random sampling. The population of the study consisted of all students in a private school in Istanbul, Turkey, during the spring semester of the 2022-2023 academic year. The sample of the study consisted of 45 students from grades 3-B and 3-C. The experimental group, class 3-C, consisted of 23 students (11 boys and 12 girls), with 7 students aged 8, 15 students aged 9, and 1 student aged 10. The control group, class 3-B, consisted of 22 students (10 boys and 12 girls), with 6 students aged 8, 14 students aged 9, and 2 students aged 10.

#### 3.2. Designing EDEGs with the ADDIE Model

The ADDIE model is a systematic approach to designing and developing instructional materials and experiences. It was developed by Michael W. Allen and his research team at the University of Florida in the late 1970s. The ADDIE model consists of five phases: Analysis, Design, Development, Implementation, and Evaluation.

The ADDIE model can be used to design and develop digital escape games for a variety of educational settings. Digital escape games are interactive learning experiences that require learners to solve puzzles and complete challenges in order to progress. They can be used to teach a variety of subjects and skills, and they can be adapted to meet the needs of different learners. To design a digital escape game using the ADDIE model, the instructional designer would first identify the learning objectives for the game. Once the learning objectives have been identified, the instructional designer would develop a plan for the game. This plan would include the content of the game, the puzzles and challenges that the learners will face, and the feedback that the learners will receive. The instructional designer would then develop the digital escape game. This may involve using a game development platform or creating the game from scratch. Once the game has been developed, the instructional designer would test it to ensure that it is accurate and effective. The digital escape game would then be implemented in the classroom or other learning environment. The instructional designer would provide support to the learners during the implementation phase. Finally, the instructional designer would evaluate the effectiveness of the digital escape game. This may involve collecting feedback from the learners or assessing learning outcomes. The instructional designer may also use the evaluation results to revise the digital escape game. The ADDIE model provides a systematic approach to designing and developing digital escape games. By following the ADDIE model, instructional designers can create effective and engaging learning experiences for their students.

The learning objectives table was created with Turkish Ministry of Education Mathematics Curriculum. Table 1 shows the distribution of questions in the Mathematics Achievement Test based on the learning outcomes.

**Table 1**

Distribution of Learning Objectives in the Mathematics Course Achievement Test by Number of Questions

| Learning Objectives                                                                                             | Question Number (Pcs) |
|-----------------------------------------------------------------------------------------------------------------|-----------------------|
| M.3.3.5.1. Tells the time in minutes and hours, reads and writes.                                               | 3                     |
| M.3.3.5.2. Explains the relationship between units of measuring time.                                           | 2                     |
| M.3.3.5.3. Compares the time that events occur.                                                                 | 1                     |
| M.3.3.5.4. Solves problems for which units of measuring time are used.                                          | 3                     |
| M.3.3.4.1. Shows the relationship between lira and kuruş.                                                       | 3                     |
| M.3.3.4.2. It solves problems with our money.                                                                   | 3                     |
| M.3.3.6.1. It measures objects in grams and kilograms.                                                          | 1                     |
| M.3.3.6.2. It estimates the mass of an object and checks the accuracy of its estimate by 1 making measurements. |                       |
| M.3.3.6.3. Solves problems with kilograms and grams.                                                            | 3                     |
| Total                                                                                                           | 20                    |

The experimental group had an additional learning tool in the form of the digital escape game, while the control group only had traditional learning materials (See Table 2). The purpose of comparing these activities is to determine the effects of using digital escape games in mathematics lessons on the academic performance and motivation of elementary school students.

**Table 2**

Comparison of Experiment and Control Group

| Experimental Group            | Control Group |
|-------------------------------|---------------|
| Course Book                   | Course Book   |
| Handouts                      | Handouts      |
| Digital Escape Game (4 Weeks) | -             |

### 3.3. Pilot Testing and Implementation of the EDEG

Once the EDEGs were designed, a pilot test was conducted. The pilot test was successful, and the EDEGs were then implemented with the experimental group students. To prepare for the implementation, a suitable environment was created in the classroom. The game was applied for four weeks to ensure continuity. For this purpose, the game was first designed as a whole story. The class was then divided into four groups of six students each. The game was implemented with the same groups until it was completed.

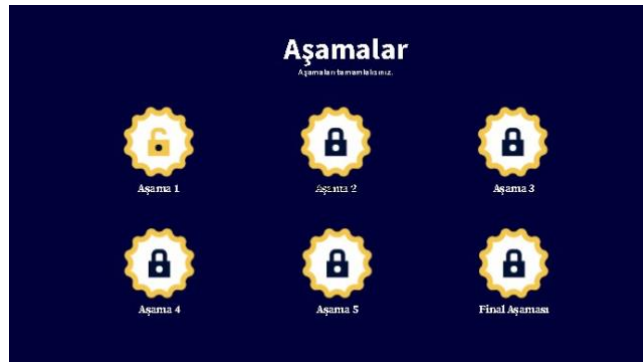


Each week, the questions in the digital escape game were changed and adapted to the story. The questions were based on the mathematics curriculum for the 2022-2023 academic year. Various studies on the Moon were also conducted to ensure that the game was consistent with the story.

Figure 1 is the welcoming screen of the digital escape game. In the digital escape game, students needed to answer all the questions correctly to complete the digital escape game. For this reason, a redirect button was placed when students made mistakes (See Figure 4). When students returned to the questions, they got wrong, they were able to learn why they got them wrong from their friends and find the correct answer by searching again. The duration of each digital escape game was one lesson hour. Figure 2 illustrates the different levels that players encounter as they progress through the game. Figure 3 shows the students while completing the digital escape game that was played during the third week of the study.



**Fig. 1.** Sample Input Screen



**Fig. 2.** Stages of the digital escape game screen



**Fig. 3.** Photograph of the 3<sup>rd</sup> weeks digital escape game



**Fig. 4.** Final screen of the digital escape game

### 3.4. Data Collection Instruments

**Math achievement test.** The mathematics achievement test was prepared to cover the topics of Measuring Time, Money, and Weighing in the Mathematics curriculum of the 3rd grade level of primary school. There are 9 sub-achievements under 3 main objectives. The objectives were tabulated and included in the study. The 20 multiple-choice questions, which are thought to measure these outcomes, were obtained from 2 printed sources published in 2022 and 2023 and actively used. The book published in 2022 contains new generation questions. To measure the suitability of the test consisting of 20 questions, it was applied to 45 students.

**Motivation scale.** In this study, a scale was used to determine the level of student motivation to learn Mathematics in the 3rd grade of primary school. The scale was developed by Balantekin and Oksal (2014). It was adapted to this study. It was prepared in a five-point Likert style and consists of 41 items. The scale was tested by applying to 308 students. Factor analysis to determine the construct value of the scale the results of the analysis showed that 14 items and 14 items had factor loading values between 0.52 and 0.80. Three factors explaining P.07 of the total variation were obtained. Accordingly, when the items were considered in terms of content, the first factor was named extrinsic motivation ( $\alpha=0.78$ ); the second factor was named motivation ( $\alpha=0.71$ ) and the third factor was named intrinsic motivation ( $\alpha=0.61$ ). In addition, the reliability of the scale was calculated by test-retest method with the data collected four weeks after the actual application. After the analysis, the correlation value was calculated as 0.71 for the two aspirations extrinsic motivation; 0.73 for a motivating factor; and 0.74 for the intrinsic motivation factor. This result shows the validity and reliability of the scale. The reason for using it in this study is that it will be used in the mathematics course. The scale was adapted and 14 items for the mathematics course were used. Within the scope of this study, it was applied to 45 students.

**Structured Interview.** The study employs structured interview questions that align with the research objectives, focusing on students' perceptions of the digital escape games and their impact on motivation and learning. The questions were designed to elicit detailed responses regarding the game's design, classroom atmosphere, and its role in learning mathematical concepts, ensuring the relevance and depth of the data collected. The study employs a content analysis approach to examine students' perceptions of Educational Digital Escape Games (EDEGs) and their impact on learning and motivation in mathematics. Responses from students were systematically categorized and analyzed to identify recurring themes, such as enjoyment, teamwork, motivation, and the perceived impact on learning outcomes. The inclusion of direct quotations from participants strengthens the credibility of the findings, providing evidence that interpretations are grounded in the raw data.

### 3.5. Findings and Discussions

#### Quantitative Findings

The results of the statistical analysis of the post-test mean scores of the mathematics course Achievement Test applied to the experimental group and the control group are given below. Intrinsic motivation scores had a mean of 21.42, a standard deviation of 6.49, and a reliability coefficient of 0.792, indicating consistent and moderately high reliability. The achievement scores also demonstrated good reliability at 0.817. Table 3 confirms that the instruments used in the study are both reliable and appropriately distributed, with skewness and kurtosis falling within acceptable ranges for normality.

**Table 3**

Frequency, normality and reliability table for mathematics course motivation scale and achievement test levels

|                      | Mean  | Min.  | Max   | SD   | Skewness | Kurtosis | Reliability |
|----------------------|-------|-------|-------|------|----------|----------|-------------|
| Extrinsic Motivation | 9,33  | 5,00  | 20,00 | 4,10 | 0,946    | 0,272    | 0,734       |
| Lack of Motivation   | 9,58  | 5,00  | 25,00 | 4,84 | 1,290    | 1,392    | 0,862       |
| Intrinsic Motivation | 21,42 | 4,00  | 30,00 | 6,49 | -0,586   | 0,014    | 0,792       |
| Motivation Scores    | 40,33 | 28,00 | 55,00 | 7,16 | 0,103    | -0,763   | 0,801       |
| Achievement Scores   | 15,38 | 6,00  | 20,00 | 4,31 | -0,637   | -0,835   | 0,817       |

**Table 4**

Comparison of mathematics lesson motivation scale and achievement test levels with groups

|                      | Groups     | Mean  | SD   | t test |         |
|----------------------|------------|-------|------|--------|---------|
|                      |            |       |      | T      | p       |
| Extrinsic Motivation | Experiment | 9,13  | 4,36 | -0,336 | 0,738   |
|                      | Control    | 9,55  | 3,89 |        |         |
| Lack of motivation   | Experiment | 9,35  | 3,92 | -0,323 | 0,748   |
|                      | Control    | 9,82  | 5,73 |        |         |
| Intrinsic Motivation | Experiment | 26,61 | 2,87 | 9,608  | <0,001* |
|                      | Control    | 16,00 | 4,41 |        |         |
| Motivation Total     | Experiment | 45,09 | 5,13 | 6,19   | <0,001* |
|                      | Control    | 35,36 | 5,40 |        |         |
| Achievement Scores   | Experiment | 17,35 | 3,43 | 3,519  | <0,001* |
|                      | Control    | 13,32 | 4,22 |        |         |

\*p<0,05

Table 4 presents the results of a group t-test comparing the motivation and achievement levels of the experimental group (who played the digital escape game) and the control group (who learned with traditional methods). The results show that the experimental group had significantly higher levels of internal



motivation and total motivation, and significantly higher achievement test scores, compared to the control group. The p-values for all significant differences were less than 0.05, indicating that the results are statistically significant.

**Table 5**

Mathematics course motivation scale and comparison of achievement test levels with gender

|                           | Gender | Mean  | SD   | t test |        |
|---------------------------|--------|-------|------|--------|--------|
|                           |        |       |      | T      | p      |
| Extrinsic Motivation      | Male   | 8,57  | 3,54 | -1,172 | 0,248  |
|                           | Female | 10,00 | 4,49 |        |        |
| Lack of Motivation        | Male   | 7,90  | 3,24 | -2,349 | 0,024* |
|                           | Female | 11,04 | 5,55 |        |        |
| Intrinsic Motivation      | Male   | 22,81 | 5,19 | 1,353  | 0,183  |
|                           | Female | 20,21 | 7,34 |        |        |
| General Motivation Scores | Male   | 39,29 | 6,81 | -0,916 | 0,365  |
|                           | Female | 41,25 | 7,47 |        |        |
| Achievement Scores        | Male   | 16,24 | 3,95 | 1,262  | 0,214  |
|                           | Female | 14,63 | 4,55 |        |        |

\*p<0,05

According to Table 5, female students had significantly higher levels of lack of motivation in math class than male students, but there were no significant differences in external motivation, internal motivation, total motivation, or academic achievement test scores between male and female students.

**Table 6**

Mathematics lesson motivation scale and comparison of achievement test levels with age groups

|                           | Age    | Mean  | SD   | F     | ANOVA    |       |
|---------------------------|--------|-------|------|-------|----------|-------|
|                           |        |       |      |       | P values | Dif** |
| Extrinsic Motivation      | 8 (1)  | 8,46  | 3,80 | 0,113 | 0,738    | -     |
|                           | 9 (2)  | 9,83  | 4,27 |       |          |       |
|                           | 10 (3) | 8,33  | 4,16 |       |          |       |
| Lack of Motivation        | 8 (1)  | 10,08 | 6,12 | 0,104 | 0,748    | -     |
|                           | 9 (2)  | 9,45  | 4,35 |       |          |       |
|                           | 10 (3) | 8,67  | 4,73 |       |          |       |
| Intrinsic Motivation      | 8 (1)  | 21,08 | 8,49 | 92,31 | <0,001*  | 2>1   |
|                           | 9 (2)  | 21,59 | 5,83 |       |          |       |
|                           | 10 (3) | 21,33 | 4,16 |       |          |       |
| Overall Motivation Scores | 8 (1)  | 39,62 | 5,58 | 38,32 | <0,001*  | 2>1   |
|                           | 9 (2)  | 40,86 | 7,82 |       |          |       |
|                           | 10 (3) | 38,33 | 8,50 |       |          |       |
| Achievement Scores        | 8 (1)  | 15,62 | 4,33 | 12,38 | <0,001*  | 1>3   |
|                           | 9 (2)  | 15,45 | 4,15 |       |          |       |
|                           | 10 (3) | 13,67 | 7,09 |       |          |       |

\*p<0,05;\*\*Tukey test

ANOVA (analysis of variance) results in Table 6 show that 10-year-old students had significantly higher intrinsic motivation and significantly lower academic achievement test scores in mathematics lessons compared to 8-year-old and 9-year-old students.

**Table 7**

The relationship between mathematics lesson motivation scale and achievement test levels

|             |   | <b>Extrinsic<br/>Motivation</b> | <b>Lack of Motivation</b> | <b>Intrinsic<br/>Motivation</b> | <b>Overall Motivation</b> |
|-------------|---|---------------------------------|---------------------------|---------------------------------|---------------------------|
| Achievement | r | -,608**                         | -,485**                   | ,660**                          | -0,077                    |
| test scores | p | <0,001*                         | <0,001*                   | <0,001*                         | 0,615                     |

\*p<0,05;\*\*Correlation test

Table 7 shows that intrinsic motivation has a strong and positive correlation with academic achievement in mathematics, while extrinsic motivation and lack of motivation have weak and negative correlations with academic achievement.

### Qualitative Findings

Feelings and Thoughts about the Design of the Educational Escape Game.

Participants were asked for their opinions about the design of the digital escape game. In general, positive feedback was received that the game was very liked, enjoyed, and that the game should be included in other acquisitions.

[...] I thought it was good. The fact that it was digital was more interesting (S2)

[...] I think the design and story of the game was very nice. (S15)

The participants' opinions about the design of the digital escape game were that the design made them feel happy and motivated.

The participants were asked what kind of design they would make if they were to design an educational escape game themselves or what they would add if they wanted to make an addition to the existing design, and the answers were that the questions in the game should be more difficult and the game duration should be longer.

[...] The game was good, the questions could have been more (S1)

[...] I think the game was actually good. The duration could have been a little more (S5)

Classroom Atmosphere during Educational Escape. During the implementation of the educational escape game, the participants were asked about the general atmosphere of the classroom, whether the instructions of the game were easy to understand, and whether the educational escape game was sufficient in the techniques of the common language game.

[...] that the game was generally very enjoyable, but that they would have liked the questions to be a bit more challenging. (S7)

[...] It was easy to understand, and the story was fun. (S14)

[...] We were very excited to reach the goal. We panicked while answering some questions. (S9)

[...] The story was gripping. We were all eager to reach the goal. As I solved the questions, I wished there were more. We did our best to reach the goal correctly and before the other groups. (S12)

In the general flow of the game, the participants felt happy and joyful, and it was observed that they had fun. At the same time, a good progress was made in terms of cooperation as they worked as a team. All children kept up with the flow of the game and made their best effort.

Their thoughts on the understanding of the subject covered with the educational digital escape game.

With the digital escape game, the topics of measuring time, money, and weighing were covered in the mathematics lesson with Grade 3 for 4 weeks. The participants were asked how they felt while learning

these topics with the digital escape game, whether they liked them and whether they could learn the related topics with the educational escape game. The participants responded that they felt motivated towards the related topics, that they learned the topics completely, and that they were able to solve the questions more easily by remembering the rules of the game while solving the questions related to the related topics. Table 8 shows that the majority of students enjoyed playing the digital escape game in mathematics class and found it to be a fun and engaging learning experience.

**Table 8**

Students' Answers to Interview Questions

| Answers                                                             | Frequency |
|---------------------------------------------------------------------|-----------|
| It was fun.                                                         | 19        |
| I would love to play individually.                                  | 1         |
| I loved the teamwork.                                               | 12        |
| It was delightful.                                                  | 10        |
| I would like to have digital escape games in Life 1 Sciences Class. | 1         |
| I would also like to use in science class.                          | 1         |
| There are no features that I don't like.                            | 14        |

Their opinions about teaching mathematics lessons with EDEG.

In addition to questions about the way they handled the subject, the participants were also asked about their opinions about the math lesson with the digital escape room. The comments received were that when they deal with problems in this way, it stays in their minds a lot and it is a lot of fun. Participants reported that they felt happier and more enjoyable. They expressed that they thought that other lessons would be more enjoyable if they were taught in this way. Participants were asked about their motivation after the digital escape game for the math lesson and their feelings about the idea of playing educational escape games in other lessons.

[...] It makes me feel very happy and excited (S1)

[...] When we play games, I both enjoy it more and how I solve the questions with my friends in the game becomes permanent in my mind (S2)

[...] While playing the game, we tried to solve it before the other groups and correctly. We were very excited during this time. Seeing that we could do it increased the motivation of my groupmates and me (S5)

[...] I loved the story because I always wanted to ride a rocket in my life (S9).

[...] When I played a digital escape game in math class, I was excited because I was curious about the end (S9).

It was observed that a digital escape game motivated students to engage in the mathematics lesson. When the participants encountered a digital escape game, they were scared and worried at first. However, as they progressed step by step, they became motivated as they saw what they could do. It was observed that the participants approached the teaching of the lessons positively in this way. It was observed that the participants' self-confidence increased when they saw themselves as a part of the game.

#### 4. Conclusion and Suggestions

A critical aspect of this study was the use of the ADDIE model to design the digital escape game, ensuring a structured and systematic instructional design process. The ADDIE model—comprising Analysis, Design, Development, Implementation, and Evaluation—provided a robust framework to align the learning objectives with engaging game-based elements. The pilot testing phase, which assessed the clarity of the

game mechanics and its alignment with learning objectives, is an example of formative evaluation. Additionally, students' feedback on motivation, enjoyment, and learning outcomes provided insights into how the game influenced their engagement and comprehension.

The findings of this study reveal significant insights into the effects of Educational Digital Escape Games (EDEGs) on mathematics achievement and motivation among elementary school students. The results demonstrate that EDEGs positively impact students' academic performance, underscoring their potential as an effective and engaging learning tool. However, while EDEGs increased students' intrinsic motivation, there was no statistically significant difference in overall motivation scores between the experimental and control groups. This finding is consistent with Huizenga et al. (2009), who similarly found no positive motivational response between experimental and control groups when using game-based learning approaches. It suggests that the motivational effects of EDEGs may vary across individuals, emphasizing the need for careful implementation and consideration of diverse learning styles. Teachers frequently utilize these games to establish dynamic and interactive learning environments, aligning with the results of the EDEG study, where students expressed heightened focus and enthusiasm during gameplay. This reinforces the idea that game-based learning not only enhances enjoyment but also nurtures intrinsic motivation (Emre, Gullep, Senel & Liman Kaban, 2022; Veldkamp, Knippels, & van Joolingen, 2020).

The experimental group, which engaged with EDEGs, demonstrated significantly higher academic achievement compared to the control group. This aligns with prior studies, such as those by Gómez-Urquiza et al. (2019) and Deeb and Hickey (2019), which showed that escape games enhance cognitive skills, knowledge retention, and academic performance. EDEGs provide opportunities for students to apply their mathematical knowledge in meaningful, real-world contexts, such as solving problems related to time, money, and weighing. These activities engage students in teamwork and collaborative problem-solving, helping them develop 21st-century skills like communication and critical thinking (Karampa & Paraskeva, 2024). Students in this study reported feeling excited and motivated by the competitive and interactive nature of the games, which encouraged their participation and sustained engagement. Bakar et al. (2023) similarly emphasize that well-designed escape games help develop essential skills like teamwork and problem-solving, which are crucial for future success.

Interestingly, the study found a strong positive correlation ( $r = 0.660$ ,  $p < 0.001$ ) between intrinsic motivation and academic achievement. This reinforces the importance of fostering intrinsic motivators, such as curiosity and personal interest, as key drivers of student success in mathematics. However, extrinsic motivation and lack of motivation showed negative correlations with achievement, highlighting the need to prioritize engaging and meaningful instructional approaches. While the benefits of EDEGs are clear, challenges remain, as noted by Bakar et al. (2023), who stress the importance of clear instructions, adequate time for activities, and thoughtful design to maximize effectiveness. Additionally, Huizenga et al. (2009) emphasize that digital escape games may not motivate every student in the same way and that alternative approaches may be necessary for some learners.

Qualitative findings further illustrate the impact of EDEGs on students' learning experiences. Students reported that the games made learning enjoyable and memorable, with many recalling mathematical concepts by associating them with the game. This aligns with observations by Deep and Hickey (2019), who found that escape games significantly increased participation and academic achievement. Students highlighted the collaborative nature of EDEGs, noting that teamwork and sharing perspectives helped them better understand the material. This cooperative learning approach also strengthened their communication, problem-solving, and collaboration skills. Moreover, the competitive and immersive aspects of the games increased students' focus and enthusiasm, further reinforcing their motivation to learn mathematics. According to the systematic review, which was conducted by Veldkamp, Knippels, and van Joolingen (2020) highlights that students in escape room activities exhibit high levels of engagement and motivation. Educators often implement these games to create active learning environments, which resonate with findings from the EDEG study, where students reported increased focus and excitement during gameplay. This supports the notion that game-based learning can make learning enjoyable while fostering intrinsic motivation. Escape rooms are shown to foster teamwork and communication skills, with structured tasks

requiring collaboration among participants. The EDEG study echoes this by demonstrating that collaborative problem-solving in games helps students engage more deeply with mathematical concepts. This aligns with the idea that teamwork enhances not only social skills but also cognitive understanding.

Despite the promising outcomes, this study has limitations. The small sample size and single-institution setting may restrict the generalizability of the results. Additionally, the study's short intervention period may not fully capture the long-term effects of EDEGs on motivation and achievement. Future research should address these limitations by involving larger and more diverse samples and extending the duration of interventions to assess sustained impacts. Furthermore, as highlighted by Jiménez et al. (2020) and Voloshynov et al. (2019), game-based learning approaches can have varying effects across different educational contexts, suggesting the need for further research into how EDEGs can be adapted to meet diverse student needs.

In conclusion, this study highlights the potential of EDEGs as an innovative tool for improving mathematics achievement and fostering intrinsic motivation in elementary school students. By providing engaging, interactive, and collaborative learning experiences, EDEGs can make mathematics learning more accessible and enjoyable. However, as suggested by Lagmay et al. (2024), the effectiveness of EDEGs may be enhanced by tailoring them to diverse learning preferences and integrating them into broader instructional strategies. Future research should explore the scalability of EDEGs, their applicability across varied educational contexts, and their impact on different learner profiles. Ultimately, the use of EDEGs represents a promising step toward transforming traditional mathematics instruction into a dynamic and inclusive learning experience.

### Limitations and Future Directions

This study has several limitations that should be considered when interpreting the results. First, the sample size was relatively small, and the study was conducted within a single institution, limiting the generalizability of the findings. Future studies should include a larger and more diverse sample to increase the applicability of the results across different educational settings. Second, the intervention period was short, which may not have allowed for a comprehensive understanding of the long-term effects of EDEGs on motivation and academic achievement. Longitudinal studies should be conducted to assess the sustained impact of digital escape games on student learning. Additionally, while this study examined achievement and motivation, other potential benefits of EDEGs, such as improvements in problem-solving skills, collaboration, and cognitive development, should be explored in future research. Comparative studies with other interactive learning methods, including augmented reality and serious games, could help determine the relative effectiveness of different approaches. Finally, future research should investigate teachers' perceptions and challenges in implementing EDEGs to provide insights into best practices for successful integration into the curriculum. Addressing these limitations will contribute to a deeper understanding of the educational value of digital escape games and support their broader implementation in mathematics education.

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