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تأثیر ارزیابی مبتنی بر بازی بر کاهش اضطراب امتحان دانش‌آموزان پایه سوم ریاضی

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چکیده

این مطالعه اثربخشی ارزیابی مبتنی بر بازی را در کاهش اضطراب امتحان در بین دانش‌آموزان کلاس سوم در درس ریاضی بررسی کرد. این تحقیق با استفاده از یک طرح شبه‌آزمایشی پیش‌آزمون-پس‌آزمون، شامل ۶۰ دانش‌آموز پسر ۸ تا ۹ ساله بود که به طور تصادفی به گروه‌های آزمایش و کنترل تقسیم شدند. گروه آزمایش در سه جلسه ارزیابی ۱۰ دقیقه‌ای مبتنی بر بازی در یک دوره سه هفته‌ای با استفاده از ابزار «حقایق سرگرم‌کننده ریاضی: بازی برای کودکان» شرکت کردند، در حالی که گروه کنترل تحت ارزیابی‌های سنتی مبتنی بر کاغذ قرار گرفتند. سطح اضطراب امتحان با استفاده از پرسشنامه اضطراب امتحان (TAI) که قبل و بعد از مداخله اجرا شد، اندازه‌گیری شد. نتایج نشان‌دهنده کاهش قابل توجه اضطراب امتحان و افزایش قابل توجه مشارکت در بین دانش‌آموزان گروه آزمایش در مقایسه با همسالانشان در گروه کنترل بود. این یافته‌ها پتانسیل ارزیابی مبتنی بر بازی را به عنوان یک استراتژی نوآورانه برای کاهش اضطراب مرتبط با امتحان و ایجاد یک محیط یادگیری جذاب و حمایتی برجسته می‌کند و از این طریق از ادغام آن در شیوه‌های آموزشی برای افزایش نتایج دانش‌آموزان پشتیبانی می‌کند.

واژه‌های کلیدی

ارزیابی آموزشی، یادگیری مبتنی بر بازی دیجیتال، اضطراب امتحان، ارزیابی مبتنی بر بازی.

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ORIGINAL ARTICLE

The Impact of Game-Based Assessment on Reducing Test Anxiety in Third-Grade Mathematics Students

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ABSTRACT

This study examined the effectiveness of game-based assessment in reducing test anxiety among third-grade students in mathematics. Employing a quasi-experimental pretest–posttest design, the research involved ٦۰ male students aged ۸ to ۹, who were randomly assigned to experimental and control groups. The experimental group participated in three ۱۰-minute game-based assessment sessions over a three-week period using the "Fun Math Facts: Games for Kids" tool, whereas the control group underwent traditional paper-based assessments. Test anxiety levels were measured using the Test Anxiety Inventory (TAI), administered before and after the intervention.The results indicated a significant reduction in test anxiety and a notable increase in engagement among students in the experimental group compared to their peers in the control group. These findings highlight the potential of game-based assessment as an innovative strategy for alleviating test-related anxiety and fostering an engaging and supportive learning environment, thereby supporting its integration into educational practices to enhance student outcomes.

KEYWORDS

Educational Assessment, Digital Game-Based Learning, Test Anxiety, Game-Based Assessment.

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Introduction

Research on educational games has gained increasing importance in the context of learning, and in light of ongoing advancements in science and technology (Usman et al., ۲۰۲٤). By stimulating the motivational and affective impacts that game elements can produce, numerous researchers have explored the influence of gamification in educational settings, aiming to achieve desirable outcomes such as enhanced engagement, user retention, knowledge acquisition, and collaboration through the design and scaffolding of game-based learning experiences (Barzilai & Blau, ۲۰۱٤). This approach can also influence various academic dimensions, including the reduction of test anxiety (Öden et al., ۲۰۲۱). In this regard, it is necessary to define the concept of test anxiety.

Test anxiety has long been recognized as a major concern within educational systems, as it can undermine learners' self-esteem and academic performance, thereby creating obstacles to effective learning (Pitoyo, ۲۰۱۹). This issue is pervasive across all educational levels—from elementary schools to universities—and even affects extracurricular programs, thereby altering the expectations, missions, and functions of educational systems (Frank et al., ۲۰۱۷).

According to studies conducted by Mavridis and Tsiatsos (۲۰۱٦, ۲۰۱۷), game-based assessment has been shown to reduce students' test anxiety. Their research, which investigated the impact of a three-dimensional computer-based educational game on students' test anxiety and performance compared to traditional assessment methods, demonstrated that game-based evaluation could be potentially beneficial for learners by reducing exam-related stress. Similarly, Turan and Meral (۲۰۱۸) examined the effects of game-based and non-game-based online response systems on students' achievement, engagement, and test anxiety levels. Their findings indicated that game-based response systems, compared to non-gamified ones, led to higher academic success and participation, as well as lower levels of test anxiety.

Although test anxiety is recognized as one of the most common issues among students at both school and university levels, relatively few studies—particularly those focusing on game-based assessment—have been conducted in this area. Mathematics, as one of the most fundamental and influential subjects in educational systems, poses significant learning and comprehension challenges for many students (Nazari Dust & Bagheri, ۲۰۲۳). Game-based assessment, however, has been identified as one of the most effective strategies for alleviating students' anxiety and stress during evaluation.

Frank et al. (۲۰۱۷) examined the role of assessment in influencing students' test anxiety, while Mavridis and Tsiatsos (۲۰۱۷) investigated the impact of game-based assessment on test anxiety and exam performance among higher education students. Similarly, Stowell and Bennett (۲۰۱۰) explored the effects of online testing on performance and test anxiety among U.S. college students. Building upon these studies, the present research focuses on the impact of game-based assessment on test anxiety among elementary school students—a critical age group in which managing anxiety is especially important for healthy emotional and academic development.

Test anxiety, as a psychological–emotional phenomenon, was initially conceptualized in the works of Sarason and Mandler (۱۹۵۲). These researchers suggested that test situations

elicit two types of drives: task-oriented drives, which facilitate performance, and pre-existing anxiety-related drives, which manifest as behaviors irrelevant to the task. Frank et al. (٢٠١٧) further described test anxiety as encompassing affective (physiological and emotional arousal), cognitive (worry), and behavioral (procrastination and avoidance) components, all of which hinder academic progress (Hembree, ١٩٨٨; Zeidner, ١٩٩٨; Effrey, ٢٠١٠).

Based on recent research, such as that conducted by Jingili et al. (٢٠٢٣), technology and gamification appear to serve as promising tools for promoting students' psychological well-being and reducing anxiety levels during learning and assessment processes

According to a preliminary study conducted in a high school setting using a test anxiety questionnaire, the results revealed that in regular schools, ١١,٥٪ of students reported no test anxiety, while ٨٨,٥٪ experienced some level of anxiety. In contrast, in key or selective high schools (for gifted students), ١٦,٦٪ of students were not anxious, whereas ٨٣,٤٪ reported experiencing test anxiety. Although students in selective schools demonstrated slightly lower anxiety rates compared to those in regular schools, the data suggest that a significant majority (٨٣,٤٪) of these students still experience anxiety related to various types of examinations, particularly university entrance exams (Zhang, ٢٠٢٣).

Digital Game-Based Learning (DGBL) represents an instructional approach through which educational objectives can be effectively pursued using digital games (Mavridis & Tsiatsos, ٢٠١٧). According to Gee (٢٠٠٥), computer and digital games can be regarded as rich and potentially powerful learning environments. These games often incorporate elements such as feedback, assessment, interaction, and gamified user interfaces, along with multiple levels aligned with learners' progress. Such features foster active, experiential learning and enable the transfer of acquired knowledge to new and authentic contexts. Moreover, digital games promote collaborative learning, making it easier, more enjoyable, and more engaging for students to grasp complex or abstract subjects (Mavridis & Tsiatsos, ٢٠١٧; Kafai, ٢٠٠٦).

Most mathematics teachers and instructors are aware of the prevalence of math anxiety and are familiar with its debilitating effects. Although they often propose strategies to alleviate it, their understanding of the phenomenon is not always comprehensive. Consequently, instead of striving to comprehend mathematical concepts, many students focus on avoiding failure (Klee et al., ٢٠٢٢). Students who experience math anxiety tend to perform poorly not only in tests and practice sessions but also throughout the entire learning process. This diminished performance is often attributed to momentary cognitive disruptions caused by anxiety (Daker et al., ٢٠٢٣).

In this regard, the integration of digital technologies and digital games (DGs) can serve as effective tools for enhancing learning, motivation, and performance optimization across various stages of education (Papadakis, ٢٠١٨). Thus, games can be employed throughout the teaching–learning process to help reduce students' stress and anxiety levels. Supporting this notion, Ahmed et al. (٢٠٢٢) investigated the effects of game-based learning on anxiety and motivation among ٥٨ Iranian EFL learners. Their findings indicated that the use of games led to reduced anxiety, improved learning outcomes, and increased motivation

among participants. Conversely, in a study involving ٣٤ students learning science, Anggraini and Arif (٢٠٢٤) reported inconsistent results, suggesting that the STEM-oriented game-based learning model had no significant impact on students' learning motivation or anxiety levels.

As noted above, assessment and examination constitute integral components of the teaching–learning process; however, they are often accompanied by stress and tension among students—particularly in mathematics. To mitigate this issue, the use of games and game elements can be advantageous, as these elements not only help achieve instructional objectives but also foster intrinsic motivation, which in turn contributes to anxiety reduction. For instance, Bonefont et al. (٢٠٢٢) found that digital games could serve as viable alternatives to traditional examinations, promoting students' psychological well-being and reducing exam-related anxiety. Nonetheless, some studies have reported inconclusive or biased outcomes concerning gamification interventions (Christy & Fox, ٢٠١٤).

Several studies have explored game-based assessment and its influence on various educational and psychological variables. For example, Udeozor et al. (٢٠٢٤) proposed a conceptual framework for implementing game-based assessment, while Nazari Dust and Bagheri (٢٠٢٣) investigated the effects of gamified, game-based testing using the Kahoot platform on test anxiety, interest, and mathematics learning among sixth-grade students. Their findings demonstrated a positive impact of this assessment method. Similarly, studies conducted by Yang et al. (٢٠١٨), Mavridis and Tsiatsos (٢٠١٧), and Frank et al. (٢٠١٧) reported that game-based assessment effectively reduced students' test anxiety. However, Anggraini and Arif (٢٠٢٤), using a quantitative descriptive approach, reported contrary results, indicating no significant effect of game-based assessment on reducing test anxiety.

In most of these studies, games or assessments were administered through computer-based platforms or electronic quiz generators. The present research differs from previous studies in that it employs a pre-developed game application rather than a custom-designed one created specifically for research purposes. The selected game offers adjustable question levels and formats aligned with students' learning progress, along with an age-appropriate interface and game elements suitable for third-grade learners.

The primary objective of this study is to determine the effect of game-based assessment on test anxiety among elementary students in mathematics. The study hypothesizes that participation in game-based assessment will lead to a significant reduction in students' mathematics test anxiety.

Method

This study employed a quasi-experimental design following a pretest–posttest structure with experimental and control groups. This approach allowed for the assessment of the intervention's effectiveness over time and for the accurate examination of changes resulting from the treatment. Participants were randomly assigned to two groups: a control group, which did not receive the intervention, and an experimental group, which was exposed to the educational game intervention.

The intervention was based on a digital educational game. Members of the experimental group engaged with the game, while those in the control group did not

participate in any gaming activity during the study period. Test anxiety was measured using a standardized questionnaire administered before the intervention (pretest) and immediately after the intervention (posttest) for both groups. After data collection, differences between the control and experimental groups were analyzed to determine the effects of the intervention on students' participation, motivation, and learning outcomes. Data analysis was conducted using appropriate statistical tests, including ANOVA, to identify significant relationships between the intervention and observed changes.

The study population consisted of all third-grade students (N = ٦١٠) in the city of Soltanieh during the ٢٠٢٣–٢٠٢٤ academic year. The sample was selected from among three elementary schools, each having two third-grade classes. One school was randomly chosen for participation. The sample included ٦٠ students who were randomly assigned to the experimental group (n = ٣٠) and the control group (n = ٣٠). The participants were all male third-grade students aged ٨–٩ years, enrolled in two classes (Class A and Class B) at Shahid Shahriyari Public School, a prominent boys' elementary school in Soltanieh, Zanjan Province.

Students' average academic performance was described as "very good," and their mathematics grades were generally rated as "good" based on the school's descriptive evaluation system. Parents of students in both classes actively and consistently participated in school activities and assignments. The students' families represented a range of socioeconomic backgrounds, but no participants were children of divorced parents; all lived with their families.

Table ١. Independent Variable Intervention Across Groups

Group	Pretest Measure	Independent Variable	Posttest Measure
Experimental	Test Anxiety Inventory (TAI)	Game-Based Assessment (*Fun Math Facts: Games for Kids*)	Test Anxiety Inventory (TAI)
Control	Test Anxiety Inventory (TAI)	No Intervention	Test Anxiety Inventory (TAI)

Sampling Procedure:

To select the study sample, a non-random, convenience sampling method was initially used to choose one school from among the elementary schools in the city. The selected school had two third-grade classes. Subsequently, Classes ٣A and ٣B were chosen using a combination of convenience and random sampling. Necessary arrangements were made to ensure the availability of devices (smartphones) for the intervention.

The two classes were selected because the teaching methods of the mathematics teachers, according to prior observations and school records, were identical, and both classes used the same mathematics textbook. Furthermore, through coordination between the researcher and the teachers, the teaching of mathematics in both classes was aligned to ensure consistency and comparability of instruction throughout the study period.

Educational Interventions:

Initially, both groups were assessed by their teachers to determine baseline learning levels. After reviewing key concepts and providing general instructions, both groups received in-person lessons. In the experimental group, the game was implemented as the assessment

method, whereas the control group underwent traditional assessment procedures.

Control Group: The pretest was administered first. Mathematics lessons were then delivered by the teacher based on the standard textbook, covering topics such as single-digit multiplication, review of addition and subtraction, textbook exercises, and related activities. After completing all instructional sessions, students in the control group were assessed using traditional paper-and-pencil methods, while formative assessment was conducted orally with the teacher's assistance. The posttest was then administered.

Experimental Group: The pretest was administered first. Mathematics lessons, identical to those delivered to the control group, were provided by the teacher, including single-digit multiplication, review of addition and subtraction, textbook exercises, and activities. Upon completion of the instructional sessions, assessment was conducted using a pre-developed educational game. Formative assessment was also carried out through the game, with supervision by both the teacher and the researcher. The posttest was then administered.

It is essential to emphasize that *Fun Math Facts: Games for Kids* is not merely a digital testing tool, but a fully-fledged game incorporating core game elements such as goals, rules, challenges, fantasy, immediate feedback, and reward systems (stars, levels, character customization). These features are designed to create an engaging, playful experience that students perceive as entertainment rather than a formal examination.

The intervention deliberately used a game, not a gamified quiz, to assess students' mathematics performance. Students engaged with the game as they would with any commercial mobile game—focusing on defeating the oncoming character by answering questions correctly, which shifted their attention from 'being tested' to 'playing and progressing.

In this group, the game-based assessment was implemented across three educational sessions over three weeks. Each gaming session lasted approximately ١٠ minutes, during which students completed one stage of the game and received points based on their performance (Table ٢).

Table ٢: Summary of the Intervention Protocol for the Experimental Group (Game-Based Assessment)

Session	Week	Duration	Activity in the Experimental Group	Mathematical Content	Data Recorded
١	١st	١٠ minutes	Introduction to the game *"Fun Math Facts: Games for Kids"* and completion of Level ١	Single-digit multiplication	Observing engagement, recording in-game score
٢	٢nd	١٠ minutes	Completing Levels ٢ and ٣ of the game	Single-digit multiplication, review of addition and subtraction	Recording intermediate scores, monitoring progress
٣	٣rd	١٠ minutes	Completing Levels ٤ and ٥, final review, and posttest preparation	Mixed operations (multiplication, addition, subtraction)	Recording final game score, administering the posttest

To ensure transparency and replicability of the intervention, Table ٢ provides a session-by-session breakdown of the game-based

assessment implemented for the experimental group over three weeks.

Procedure:

Initially, all participants completed a pretest using the Test Anxiety Inventory (TAI) developed by Abolghasemi et al. (١٩٩٦) to assess their baseline levels of test anxiety. Subsequently, the educational game was selected by the researcher based on the study's objectives and the content to be assessed. The game application was then shared in the classroom, and participants were guided by their teachers to install it on their smartphones.

Over a period of three weeks in the ٢٠٢٤ academic year, both groups participated in three sessions related to the educational game. Following teacher-led instruction, the game was employed as a formative and summative assessment tool in the classroom, focusing specifically on mathematics instruction. The posttest was conducted after three weeks to evaluate learning outcomes in third-grade mathematics. The educational content was centered on single-digit multiplication, as outlined in the third-grade mathematics curriculum, and the game questions were aligned with this content.

The procedure began with a coordination session between the researcher and the teachers of both experimental and control classes to ensure consistency in teaching methods, content delivery, and instructional materials. The purpose of the study and the research instruments were explained to the teachers. In the first week, students' mathematics test anxiety was measured using the TAI questionnaire for both groups. During the same session, teachers provided a synchronized review of the mathematics lessons using identical teaching methods.

In the second session, students in the experimental group were instructed to bring their smartphones and install *Fun Math Facts: Games for Kids*, a game designed for mathematics learning and assessment. The single-digit multiplication module was selected and made available to the students. Completing ten levels of the game was sufficient for the study. The game effectively increased students' motivation, as the immersive environment and engaging game elements encouraged them to continue playing. In contrast, the control group completed the mathematics test using a traditional paper-and-pencil format within a ٢٠-minute session.

In the third week, the posttest was administered to both the experimental and control groups. The posttest included the same TAI questionnaire used in the pretest; however, minor modifications were made to some items to reduce bias and maintain validity while preserving the importance of each question. The researcher also provided clarifications for items that students found difficult to interpret. The results demonstrated the appropriateness of the TAI questionnaire for measuring reductions in test anxiety through game-based assessment.

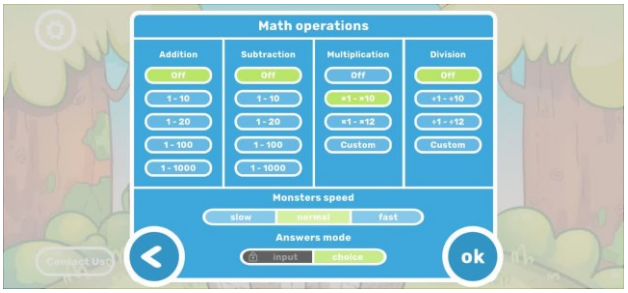
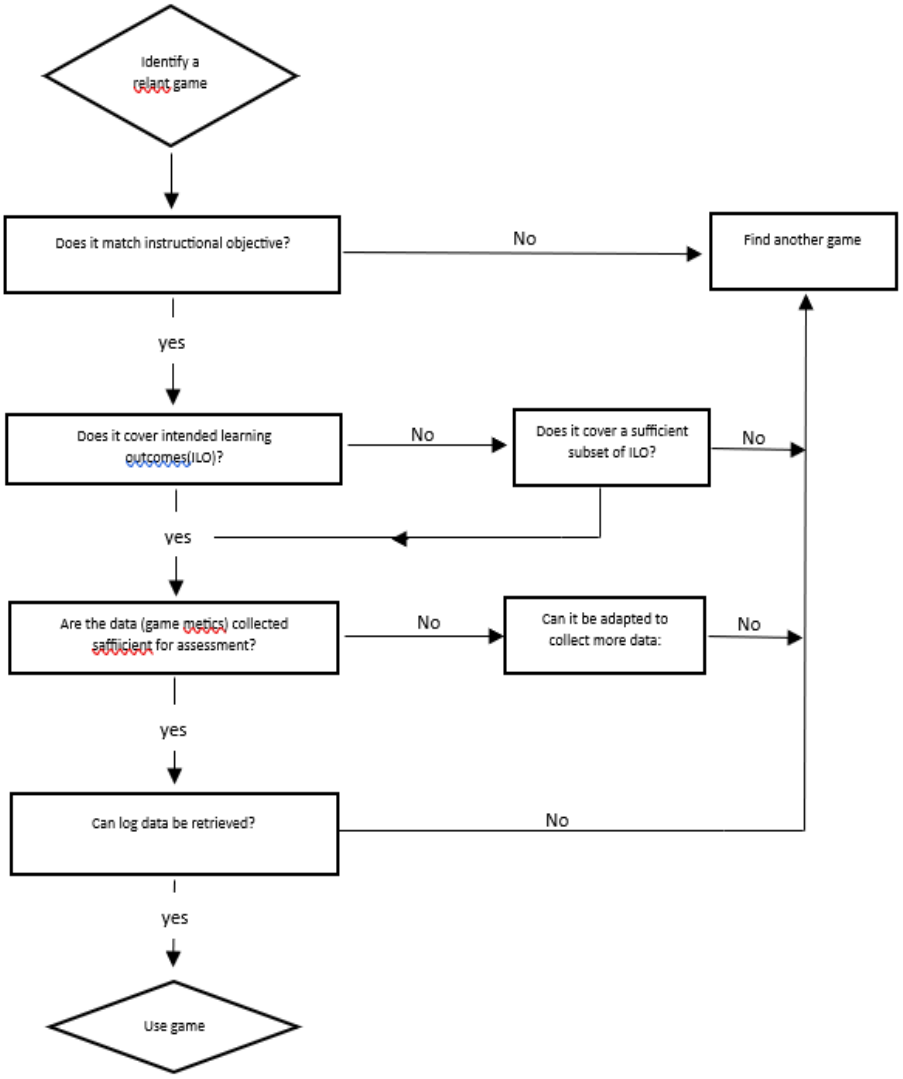


Figure ۴: Selection of Question Types

Instruments and Materials:

Game:

The game *Fun Math Facts: Games for Kids* was selected from among multiple available games, following the template of Game ١ as proposed by Udeozor et al. (٢٠٢٤), and was subsequently implemented in the experimental group. As shown in Table ٢, the game presents the instructional content of various lessons, providing an interactive platform through which students can engage with and learn the curriculum.



Template ١: Selection Method for *Fun Math Facts: Games for Kids*

Game Description

In this study, we utilized the latest version (٨,١,٠) of *Fun Math Facts: Games for Kids* for Android. The game features a fully age-appropriate graphical environment for the participants and provides an engaging, exciting atmosphere. During gameplay, students must answer questions correctly to prevent an approaching entity from eliminating the player. This mechanic creates excitement and immersion, allowing students to focus on learning and gameplay rather than the stress of testing (Figure ٢).

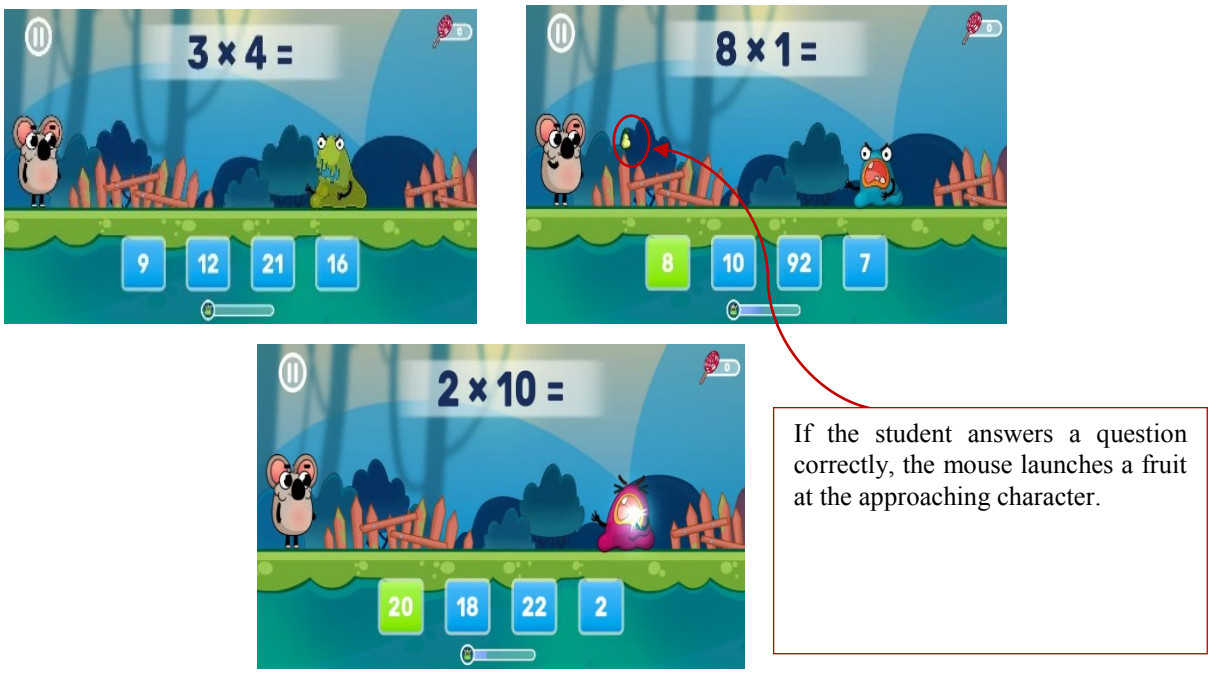


Figure ٢: Game Environment and Its Questions

The game also enhances students' motivation, as they actively participate based on prior gaming experiences, engaging in a more sophisticated manner and transforming test anxiety into excitement (De Freitas & Neumann, ٢٠٠٩). The immersive environment fosters deep engagement, keeping students absorbed in the learning process.

Students progress through the game by correctly answering questions at each stage. The scoring system varies depending on performance: answering all questions correctly earns three stars, while fewer correct responses yield fewer stars (Figure ١). This reward mechanism further encourages participation and effort, reinforcing both learning and engagement.

Figure ١: Game results from answering questions (wins and losses)

As students advance to higher levels in the game, the number of questions increases, and the criteria for earning points and stars are adjusted accordingly. At the beginning of the game, students can customize the game according to their own level and needs across four domains: multiplication, division, addition, and subtraction. Within each domain, learners can select whether numbers are single-digit or double-digit, based on their prior knowledge

and learning requirements. The game also allows practice with addition and subtraction involving up to three digits (Table ٢).

Table ٢: Playable by Students from Grades ١ to ٦

Grade Level	Application of *Fun Math Facts: Games for Kids*	Relevant Math Standards (CCSS)
Kindergarten	Addition and subtraction within ١٠	–
Grade ١	Addition and subtraction within ٢٠	CCSS.MATH.CONTENT.١.OA.C.٥
Grade ٢	Two-digit addition and subtraction, multiplication tables	CCSS.MATH.CONTENT.٢.OA.B.٢
Grade ٣	Multiplication and division, addition and subtraction within ١٠٠, times tables	CCSS.MATH.CONTENT.٣.OA.C.٧; CCSS.MATH.CONTENT.٣.NBT.A.٢
Grade ٤ and above	Three-digit addition and subtraction	–

Additionally, the game includes practice modes that allow players to select specific math facts and operations, as well as configure the number of tasks and their speed. The variety of levels, weapons, additional stages, and character costumes prevents learners from becoming bored. Instead, these elements motivate them to progress through the learning process. The game was designed with the idea that battling slime monsters would be a more engaging and enjoyable way to practice daily math skills than using flashcards or quiz applications for learning mathematics.

Measurement Instruments:

Data were collected using the standardized Test Anxiety Inventory (TAI) developed by Abolghasemi et al. (١٩٩٦), which consists of ٢٥ items rated on a ٥-point Likert scale (Never, Rarely, Sometimes, Often, Always). The validity and reliability of this questionnaire were confirmed in a previous study (Ghasemi, ٢٠١٤). Table ٣ presents a sample of the questionnaire items, and Table ٤ shows the scoring system for the inventory.

The TAI addresses topics related to students' test anxiety, including concerns about performance, physiological and emotional arousal, and behavioral tendencies such as avoidance and procrastination. [Note: The original Persian text mentions topics like earthquakes, seismic waves, crustal movements, volcanoes, and their effects—these seem unrelated to math anxiety. You may need to clarify whether this is from a different questionnaire or context; otherwise, it can be generalized to "test anxiety content" for clarity.]

Table ٣: Sample Items from the Test Anxiety Inventory (TAI) by Abolghasemi et al. (١٩٩٦)

Question	Always	Often	Sometimes	Rarely	Never
I think a lot about failing exams.					
I feel nervous during exams.					
I become very restless before an exam begins.					
I get flustered during exams.					

Table ٤: Scoring Method of the Questionnaire

Minimum Score	Average Score	Maximum Score
٢٥	٧٥	١٢٥

- If the questionnaire scores range from ١ to ٢٥, the level of the variable in this population is considered low.
- If the questionnaire scores range from ٢٦ to ٧٥, the level of the variable is considered moderate.
- If the questionnaire scores are above ٧٥, the level of the variable is considered high.

Data Collection

Data were collected in person. The questionnaires for both the pretest and posttest were administered face-to-face by the teachers to the students. Prior to the study, a meeting was held with the teachers to discuss the procedures for conducting the project, including the distribution and collection of the questionnaires. Throughout this process, the researcher supervised the implementation to ensure proper administration and adherence to the study protocol.

To answer the research questions, analysis of covariance (ANCOVA) was employed. Pretest scores were used as a covariate to control for any pre-existing differences between the groups. The analyses were conducted using SPSS version ٢٢. Descriptive statistics were also used to summarize quantitative findings.

Ethical Considerations

All participants were initially informed about the study objectives, and informed consent was obtained for their participation. Participants were free to withdraw from the study at any time without any consequences. After the completion of the study, participants were provided access to the educational methods used by the other group. Specifically, the control group, which did not receive the game intervention, was introduced to the game both through the class messenger platform and with guidance from their teacher. All data collected during the study were kept confidential to ensure participants' privacy.

Demographic Characteristics Table ٥ presents the demographic characteristics of the participants, including age and gender. The sample consisted of third-grade male students with similar socio-economic and academic backgrounds. The mean age and standard deviation of the experimental group were ١١,١٢ ± ٠,٣٤ years, and for the control group, ١١,١٤ ± ٠,٣٥ years. Analysis of variance (ANOVA) revealed no significant age differences between the two groups.

Table ٥: Demographic Characteristics of Participants

Variable	Grouping	Control (Mean ± SD / N)	Experimental (Game-Based Assessment) (Mean ± SD / N)
Age	١٠–١١	١١,١٤ ± ٠,٣٥ / ٣٠	١١,١٢ ± ٠,٣٤ / ٣٠
Gender	Male	٣٠	٣٠
	Female	٠	٠

Descriptive statistics were used to analyze the research data (see Table ٦).

Table ٦: Mean and Standard Deviation of Pretest and Posttest Scores in Experimental and Control Groups

Dimension / Assessment	Experimental Group (Mean ± SD)	Control Group (Mean ± SD)
Posttest	٤,٤٠٦ ± ٠,٢٤٥٢٥	١,٧٤٢٧ ± ٠,١٧٧٥٥
Pretest	٢,٨٥٧٣ ± ٠,٨٨٤٠٥	١,٨٣٦٠ ± ٠,٢٥٥٦٦

To test the research hypothesis regarding the effect of the game on students' test anxiety, paired-sample t-tests were conducted. The results indicated that the use of the game significantly reduced test anxiety in mathematics among the students, showing a substantial effect in the experimental group.

In the paired-sample t-test for the experimental group, the standard deviation of the mean difference was ٠,٨٢٩١٢, the standard error of the mean was ٠,١٥١٣٨, the mean difference was -١,٥٤٩٣٣, and the significance level was **p = .٠٠٠**. In contrast, the control group showed a standard deviation of ٠,٣٢٠٥٧, a standard error of ٠,٠٥٨٥٣, a mean difference of ٠,٠٩٣٣, and **p = .١٢٢**. These results indicate that the experimental group experienced lower test anxiety compared to the control group. For further analysis, analysis of covariance (ANCOVA) was also employed to control for pre-existing differences and assess the impact of the game-based assessment more precisely.

Table ٧: Analysis of Covariance (ANCOVA) Table

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	١٠٦,٦٤٢a	٢	٥٣,٣٢١	١٢٣٠,٤٧٢	.٠٠٠
Intercept	٣٤,١٧٣	١	٣٤,١٧٣	٧٨٨,٦٠٦	.٠٠٠
Pretest (PISH)	٠,١٨٨	١	٠,١٨٨	٤,٣٤٨	.٠٤٢
Group	٦٠,٧٣٢	١	٦٠,٧٣٢	١٤٠١,٥٠٢	.٠٠٠
Error	٢,٤٧٠	٥٧	٠,٠٤٣	–	–
Total	٦٧٦,٣٢٦	٦٠	–	–	–
Corrected Total	١٠٩,١١٢	٥٩	–	–	–

To analyze the data using analysis of covariance (ANCOVA), several assumptions must be met. One of the key assumptions is normality, which can be assessed using the Kolmogorov–Smirnov test. If the data are normally distributed, parametric tests can be applied; otherwise, non-parametric tests should be used. The results of the Kolmogorov–Smirnov test indicated that the data were normally distributed (see Table ٧), allowing the use of parametric tests for further analysis.

The ANCOVA results, examining the effect of the game intervention on test anxiety in the experimental group, revealed a significant difference between groups (F=٤,٣٤٨F = ٤,٣٤٨F=٤,٣٤٨, p=.٠٠٠p = .٠٠٠p=.٠٠٠) after controlling for pretest scores (see Table ٥). This significant difference indicates that the game-

based assessment implemented in the experimental group had a considerable effect on reducing mathematics test anxiety among third-grade students at a ۹۵٪ confidence level.

Furthermore, follow-up analyses using paired comparisons and the Least Significant Difference (LSD) test showed significant differences in learning assessment scores between the experimental and control groups ($p<.۰۵$ $p < .۰۵$ $p<.۰۵$), providing additional evidence for the effectiveness of game-based assessment in reducing test anxiety.

Conclusion

The findings of this study indicate that game-based assessment significantly reduces test anxiety among third-grade students in mathematics. These results are consistent with previous research conducted by Pitoyo (۲۰۱۹), Mavridis & Tsiatsos (۲۰۱۷), and Yang et al. (۲۰۱۸).

This study confirms that when a game (not merely a digital test) is used for assessment, students experience lower anxiety because they interpret the situation as play. The game's immersive and fun-oriented design transforms the evaluative context into a safe, low-stakes activity.

Specifically, studies by Mavridis & Tsiatsos (۲۰۱۷) and Nazari Dust & Bagheri (۲۰۲۳) investigated the effect of game-based assessment on test anxiety and academic performance using a three-dimensional computer-based game compared to traditional assessment methods in secondary education. The quantitative data analysis and interview findings demonstrated that test anxiety decreased while student performance improved during game-based assessments, suggesting that this approach can be potentially beneficial for students.

Similarly, Pitoyo (۲۰۱۹) examined the effects of game-based assessment on reducing test anxiety through game elements on the Quizizz platform. This case study, conducted with ۱٤ English language learners in Solo, revealed that gamified assessment effectively reduced test anxiety.

In another related study, Yang et al. (۲۰۱۸) investigated the effects of anxiety levels on learning outcomes and performance in digital game-based learning. Their findings indicated that learners with higher anxiety levels were still able to perform well in assessments, further supporting the potential of game-based learning and assessment in mitigating test anxiety while maintaining academic performance.

As explained in the previous sections, the game *Fun Math Facts: Games for Kids* was selected due to its age-appropriate environment for third-grade mathematics students and its alignment with the educational objective of learning single-digit multiplication. This game is capable of assessing the learning objectives of the lesson in a playful manner, allowing students to evaluate their learning without feeling as though they are being formally tested. Students demonstrated desirable performance in this environment from three perspectives:

First, since students engage in the assessment outside the traditional exam setting and do not use paper-and-pencil tests, their test anxiety is significantly reduced.

Second, students receive immediate feedback on their performance, learning quickly whether they have succeeded or failed, and can retry to achieve better results. Research on biofeedback and virtual reality-based games indicates that feedback can help regulate anxiety (Weerdmeester et al., ۲۰۲۱).

Third, because students are accustomed to using smartphones for leisure and gaming, this game was engaging for them, allowing them to pursue learning objectives in an informal environment. They could play at school or at home, independent of time and location. Supporting this, a study by Machmud & Abdulah (٢٠١٨) on the use of mobile phones in English language learning found that students who learned via mobile applications achieved higher learning gains compared to those who received traditional instruction. This suggests that mobile applications can enhance students' abilities, particularly benefiting learners with higher anxiety levels.

Gamified and game-based assessments incorporate elements that reduce test anxiety, improve student performance, and foster competition either individually or among peers to motivate learners toward success (Sepehr & Head, ٢٠١٣). When a game is properly selected or designed in accordance with students' needs and interests, game-based assessment can reduce test anxiety, enhance motivation for continued learning, and provide a stimulating, low-anxiety learning environment suitable for students' age and preferences.

Educational games create a learning environment in which students can engage in learning without anxiety, feel comfortable, and focus easily on their learning objectives. The educational use of digital games can serve as a learning tool, a stimulus, and a generator of curiosity, thereby acting as an effective means to optimize students' learning and performance during daily practice. The positive relationship between learning and student engagement in digital games has been confirmed by various independent studies over the years (Papadakis, ٢٠١٨).

The components evaluated in the game specifically target single-digit multiplication in mathematics, which allows for the assessment of students' test anxiety in this subject. The "educational elements" of the game include game mechanics, questions, participation, Q&A, and simulations. Findings indicate that players immerse themselves in the learning environment, transforming anxiety into excitement. Learners are internally motivated by factors such as curiosity and the desire to learn. Consequently, active teaching methods—such as inquiry-based learning, serious games, project-based activities, hypothesis testing, Q&A, role-playing, and simulations—are preferred as effective instructional approaches.

In a study integrating educational objectives, game elements, scoring tables, and stages with varied questions, the researcher observed that students in the experimental group demonstrated higher motivation to engage with the game and were eager to continue playing. This increased motivation, along with reduced anxiety, enabled students to approach educational content with greater focus and enthusiasm, resulting in more active engagement. Moreover, a significant difference was observed between the experimental group and the control group, which received traditional assessments—a finding that contrasts with the study by Mohamed Ahamed Elshazly et al. (٢٠٢٣).

Bilgin (٢٠٢١) demonstrated that most students experience mathematics-related anxiety and that mobile educational games can positively influence students' attitudes toward mathematics and reduce their anxiety. Consequently, it is recommended that teachers, students, and parents utilize educational games to reduce test anxiety and improve learning outcomes.

Another study examining game-based assessments in online courses found that these tools positively impacted learning motivation, reduced cognitive load, and enhanced learners' focus. Additionally, all participants were able to enjoy both components of the game-based assessment tool regardless of their individual learning abilities. Overall, this study highlighted the high potential of game-based assessment tools in educational settings (Jo et al., ٢٠٢٣), emphasizing their benefits.

Gamification is an educational approach that employs game elements to engage learners in instructional environments (Kapp, ٢٠١٢). Game-based learning can enhance active participation and plays a key role in the development of cognitive and affective knowledge. In learning-focused games, players must adhere to a set of rules to achieve specific learning objectives. Such games provide opportunities for simulation and active learning, offering an engaging and enjoyable learning experience (Hung, ٢٠١٨).

Game-based assessment offers a novel way to understand the processes students use to solve problems and introduces new challenges in identifying which player actions provide evidence of knowledge, skills, and learner characteristics, thereby assisting evaluators in the assessment process (DiCerbo, ٢٠١٧).

Future research should investigate other elements such as scoring, rewards, types of feedback, and their effects on learning, motivation, and reasoning skills. Based on the findings of this study, future studies should aim to enhance academic performance, student motivation, creativity, and reasoning in game-based assessment. Additionally, researchers should explore other potential applications of this independent variable.

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