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Optimising Students' Enjoyment and Engagement in Learning via Scaffolding-fused Digital Game-based Learning

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Abstract

Objective: To determine how a scaffolding-fused digital game impacted primary school students' enjoyment and engagement in Mathematics. **Method:** This experimental study was carried out with two groups of primary students. The experimental group was taught using the scaffolding fused digital game-based learning, whereas the control group was taught with the conventional method. The instruments used in this study were pre and post-interviews, and, pre and post-observations. The data were analysed using independent t-tests, matched pair t-tests and a One-way Analysis of Covariance. **Findings:** The results revealed statistically significant differences concerning enjoyment ($F = 34.373$, $P < .05$) and engagement ($F = 6.498$, $P < .05$) in mathematics learning at 0.01. The enjoyment and engagement of students in the experimental group were much higher than that of the control group. **Novelty:** As a result of technological advancement, games play an essential role in mathematics education today. Affective factors, precisely emotions, have been widely recognised as influential elements contributing to enjoyment engagement and achievement in the learning process. Engaged learners are motivated, inspired, and eager to put effort into their learning.

Keywords: Scaffolding; Enjoyment; Engagemen; Digital game based learning

1 Introduction

The advent of technology has significantly expanded the possibilities for creative expressions and innovative practices while facilitating personalised learning experiences and equipping students with the necessary skills to succeed. Many students face challenges while learning mathematics. Teachers use various strategies to enhance the enjoyment and entertainment of students while learning mathematics [(1)]. Traditionally, mathematics is taught with a teaching style where students are introduced to a particular topic using the chalk-and-talk method. Traditional teaching methods may only sometimes effectively engage and motivate learners, and students may need help understanding the concept. Since mathematics imparts practical knowledge that applies to various aspects of daily life, cultivating interest in mathematics during primary school is paramount. Still, many students perceive mathematics as complex, and there needs to be more confidence in learning mathematics among students, which may cause them to give up on their efforts to increase their competence in mathematics. Mathematical learning anxiety is a significant factor that might hinder students' motivation to engage in mathematics learning and can hinder their overall proficiency in the subject[(2)]. So, it is essential to learn mathematics pleasantly to assist learners in enjoying it more, prevent mathematics anxiety, and improve their mathematical ability. In the context of this study, enjoyment is 'the pleasure of an individual'. Teaching through games can be a great way to get students interested in maths. Digital game-based learning (DGL) involves linking subject content to gameplay, enabling students to apply their knowledge in real-world scenarios, and making learning more engaging and enjoyable[(3)]. It is an educational approach incorporating enjoyable elements to engage students in challenging activities. It involves the utilisation of computer-based games as a means to enhance learning and facilitate teaching, Kucher[(4)]. It allows the learner to interact unrestricted with the game using a predefined set of actions, viz., facilitating active and self-directed learning, allowing students to engage with real-world scenarios and receive prompt feedback[(5,6)]. Engagement in teaching and learning is crucial to learning well-being. In this study, 'engagement' is operated as 'the attention, curiosity, and interest of an individual'.

Digital games facilitate active and self-directed learning, allowing students to acquire knowledge from real-life scenarios and receive prompt feedback. DGL is perceived as more appealing to students than text-based content due to its incorporation of challenges, goals, feedback, entertainment, and interaction. This comprehensive approach fosters a positive attitude and sustained motivation among learners, ultimately leading to enhanced learning outcomes[(7)]. Students learn by solving problems and completing game tasks, which help them reach their learning goals[(8)].

Vygotsky introduced the Zone of Proximal Development (ZPD), where students cannot perform a task independently yet can do so with guidance and support[(9)]. Then, Wood, Bruner, and Ross coined the term scaffolding to describe the assistance that "enables a child or novice to solve a problem, carry out a task, or accomplish a goal that would be beyond his unassisted efforts"[(10)]. When teachers effectively scaffold learning, they help students bridge the gap between what they already know and what they need to know. Thus, the ZPD indicates the abilities that a learner is just beginning to master, and scaffolding provides the support necessary for the student to progress to succeeding stages of understanding[(11)].

Additionally, the majority of games utilised in previous research[(12–15)] possess the characteristic of providing opportunities for play and recreation. Due to the limited research[(16)], incorporate the acquisition of subject matter knowledge. Moreover, existing online games (Demolition Division, Division Derby, Croc Doc, Speed math) for learning division primarily involve students participating in practice-and-drill exercises or engaging in competitive environments. The games consist of quizzes where students must answer a series of questions. If students are unfamiliar with the concept being taught in the game, playing the game merely for recreational purposes will not facilitate their learning. A comprehensive understanding of the game's concept is crucial. The current study focuses on conceptual understanding in the learning process. The learner can access the game's content in the tutorial mode at any stage of progression. The developed digital game offers basic knowledge of mathematical operations. The game facilitates the acquisition of knowledge in addition, which subsequently serves as a foundation for understanding multiplication and division.

This study provided scaffolding through several instructional strategies such as demonstration, questioning, explanation, and activation of past knowledge. Improvement in students' performance gradually reduces the instructor's support level. The teacher's scaffolding provides suitable support to students, facilitating their familiarity with the digital game and their ability to solve arithmetic problems while engaging in games. It is operationally defined as a method using a digital game designed for learning division in which the teacher assists students by using scaffolds such as demonstration, questions, offering explanations, and prior knowledge to move students progressively towards more vital understanding and, ultimately, greater independence in the learning process. The study's uniqueness involves the development of a division game that integrates scaffolding elements.

Additionally, this digital game promotes high levels of active participation and involvement throughout the class. This game is appropriate for learners of all backgrounds, including those who may be marginalised or from disadvantaged communities. Additionally, the necessary infrastructure for distributing this game is minimal.

1.1 Significance of the study

Students' frustration and opposition come from the need for more engaging educational activities that capture their interest. Positive emotions extend our attention capacity and stimulate flexible and efficient thinking; they also make everyone more inclusive towards information and more accepting of it[(17)]. Furthermore, an enjoyable learning experience motivates students to study and helps them retain information. The main goal of an educational game is to help the player reach learning goals while having fun. Games provide a natural framework for engaging pupils and pulling their inner drive to learn. Gaming activities are a good source of engagement and bring enjoyment into learning by offering immediate rewards to players when tasks are accomplished, allowing them to progress to higher stages within the gameplay. Learning engagement is determined by how the learner feels about what they know and interacts with the learning environment [18]. Students with high behavioural, emotional, and cognitive engagement levels are likelier to achieve academically, connect better with their school, and have a more positive sense of social-emotional well-being [19]. When learning is enjoyable, students are more engaged, which reduces distractions [3]. Understanding student engagement in the teaching-learning process is a must, to have students' achievement in learning.

1.2 Review of related studies

Several studies have examined the educational objectives and effectiveness of utilising digital games for learning purposes. Digital games can promote students' learning achievement and retention of mathematics, Yang & Chen [19]. Some studies have found that students have a positive attitude towards using computer games for learning [20–25]. DGL has been found to promote enjoyment [26,27], reduce anxiety and boredom [26], increase motivation for learning and academic achievement [12,16,22,25,28–35], and increase student engagement and interest in learning [36–41].

Several studies have demonstrated the positive impact of instructional scaffolding on students' learning outcomes [16,19,28,42,43]. Additionally, scaffolding has been effective in facilitating students' problem-solving skills [44]. There is a significant interactive effect of scaffolding DGL and cognitive styles on learning emotion, cognitive load, and learning performance. Additionally, it identifies more effective combinations of scaffolding and cognitive styles for learning [19]. A studyby Sun, Ruokamo, Siklander, Li, & Devlin [12] found that incorporating teacher scaffolding strategies at different stages of DGL enhances students' engagement in learning activities and their perception of mathematics education. However, some studies indicate that DGL needs to promote problem-solving skills effectively.

1.3 Research gap

The literature review indicates a substantial body of research concerning the impact of educational digital games on academic performance. Many researchers have noticed that DGL has excellent potential to enhance learning performance and positively affect learning achievement. Furthermore, using scaffolding has demonstrated the potential to facilitate the learning process. However, a limited body of research has yet to explore the implementation and examination of scaffolding within the context of DGL. Sun, Ruokamo, Siklander, Li, & Devlin [12] found that students require the support of scaffolding from teachers to effectively address challenges and establish links between their existing subject knowledge and the knowledge acquired from digital games.

Furthermore, the scarcity of research on using scaffolding fused DGL on enjoyment and engagement of primary school students in learning mathematics has drawn attention. To bridge the research gaps and establish empirical evidence regarding DGL's benefits for learning, the authors have developed and investigated scaffolding fused digital games for enjoyment and engagement of primary school students in learning mathematics. The present study aimed to investigate the effects of scaffolding fused DGL on primary school students' enjoyment and engagement in mathematics and provides insights into the integration of scaffolding in DGL, specifically emphasizing the role of teacher scaffolding in DGL.

1.4 Objective of the study

The objective of the study was to know whether scaffolding fused digital game-based learning impacts enjoyment and engagement in learning mathematics among primary school students.

1.5 Hypotheses of the study

1. There will be a significant difference in the mean scores of the control and experimental groups concerning the enjoyment of learning mathematics among primary school students.
2. There will be a significant difference in the mean scores of the control and experimental groups concerning engagement in learning mathematics of primary school students.

2 Methodology

Based on a pre-test-post-test-equivalent group design, the study had an independent variable, 'scaffolding fused digital game-based learning', and two dependent variables, namely mathematics enjoyment and mathematics engagement.

2.1 Participants

The study included 48 second-grade students selected from a senior secondary school in Tenkasi, Tamil Nadu. The Raven's Coloured Progressive Matrices (CPM) intelligence test and the attitude towards mathematics test were initial steps in student grouping. A total of 24 students were assigned to the control and experimental groups based on their intelligence and attitude scores.

2.2 Measuring tools

2.2.1 ***Enjoyment***

The students' enjoyment of learning mathematics was measured through an interview using 'SaWi's Interview Schedule on Enjoyment' (SISE) before and after the treatment for both the control and experimental groups. The SISE was prepared as a structured interview schedule. For the content validation of the tool, it was given to ten experts, and their suggestions made the tool to be valid. The researcher kept the interview's direction, avoided irrelevant conversation, and tried to keep the respondent on the way. Also, the researcher kept pause, pace, and intonation at par with the respondents' abilities. The schedule is attached in Appendix A.

2.2.2 ***Engagement***

The student's engagement in learning was measured through observation using 'SaWi's Observation Schedule on Engagement' (SOSE) before and after the treatment for both the control and experimental groups. It was developed as a structured observation schedule. Initially, it was given to ten experts for validity, and their suggestions made the tool to be valid. In this study, along with the researcher, one more trained observer was engaged in the observation process to measure primary school students' engagement in learning mathematics. The schedule is given in Annexure B.

2.2.3 ***Digital Game-based approach***

A digital game for the learning division was developed for this study. It is a 2D game developed with Phaser, a fun, free, fast 2D game framework for making HTML5 games for desktop and mobile web browsers. Visual Studio 1.62.1 is used to edit, debug and build the code. In this game, TypeScript is the backend to store data regarding the application. This game consists of 11 levels, through which students learn division. The game's first three levels are about multiplication tables 1-10. Since tables are the basis for the division problems, they were included in the game. The other levels have different types of division topics — division using number strips, division as repeated subtraction, division using multiplication facts, properties of division, division of two-digit numbers, division of two-digit numbers with remainder, and long division method. Every level consists of 3 modes: tutorial, demo, and game. In tutorial mode, pre-recorded videos of appropriate topics are included. In demo mode, it demonstrates to the player how to play the game. There are 15 tasks at each level. If the students answered correctly, they moved to the next task. If wrong, the popup sound comes, and students can try again. The below figure shows the gameplay of various levels. After finishing the 15 tasks, the player will be innovatively awarded.

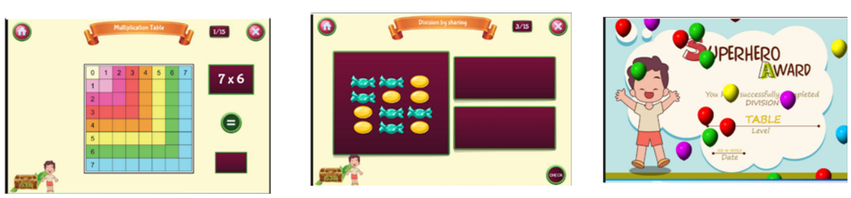

Fig 1. Game Interface

2.3 Experimental procedure

An experiment enhances the conditions under which something was observed, leading to more accurate results. In this process, two groups of subjects equivalent concerning their scores of intelligence and attitude were carefully chosen. Three weeks of intervention were given to both groups, and their responses were observed. The control group underwent the conventional method of lecture. The experimental group learned through the researcher-made digital game. The experimental group experiences the 11 levels of the game by playing one level of the game a day. If needed, the student can replay the same game level several times.

Scaffolding techniques, viz., demonstrations, activation of prior knowledge, posing questions, and provision of explanations within the context of digital game-based learning, were also provided to the students. The investigator initiated the lesson by showcasing the game, its interface, and its essential features. As students engage with the game, she has encouraged them to draw connections between what they already know and the new concepts introduced. If the students make mistakes or encounter challenges, the investigator provides explanations to guide students in understanding the correct approach and learning from their errors. Throughout the game, especially during critical moments, the investigator poses questions encouraging students to think critically or apply learned concepts within the game context. After completing every three levels, an embedded test was conducted to check the students' understanding. Based on their performance, they move to the next level. As students' proficiency increases, guidance is gradually reduced, enabling them to take responsibility for their learning. The investigator observed that the fused scaffolding techniques promoted an immersive learning environment.

3 Result of the Study

3.1 Enjoyment

A pre-interview was conducted to measure the students' enjoyment of learning before the experiment, and the students' enjoyment of the control group was more than that of the experimental group (Table 1).

Table 1. t-test Result of the Enjoyment Pre-interview Ratings of the Two Groups

Group	N	Mean	SD	t	p
Contl.	24	54.17	5.917	2.35	.023*
Exptl.	24	50.42	5.064		

*Significant at 5% level

Table 2 shows that the student enjoyment of the experimental group was two times more than the control group after the treatment. ANCOVA revealed significant differences between the two groups in the enjoyment of learning mathematics ($F = 34.373$, $P < 0.05$; Table 3). It indicates that the students in the experimental group had more enjoyment in learning mathematics than the control group.

Table 2. t-test Result of the Enjoyment Post-interview Ratings of the Two Groups

Group	N	Mean	SD	t	p
Contl.	24	68.29	7.393	52.91	.000**
Exptl.	24	185.46	7.940		

**Significant at 1% level

Table 3. ANCOVA Result of the Enjoyment Post-interview Scores of the Two Groups

Group	N	Mean	SD	Adjusted mean	$F_{(1,44)}$	p
Contl.	24	68.29	7.393	67.791	34.373	.000**
Exptl.	24	185.46	7.940	185.558		

**Significant at 1% level

3.2 Engagement

Engagement is an essential component of the learning process. In this study, a pre-observation was used to measure the students' engagement in learning before the experiment. As shown in Table 4, the t-test result showed that the control group engaged more in learning mathematics.

Table 4. t-test Result of the Engagement Pre-observation Ratings of the Two Groups

Group	N	Mean	SD	t	p
Contl.	24	44.13	4.256	3.05	.004*
Exptl.	24	40.79	3.243		

**Significant at 1% level

Table 5 shows that the student engagement of the experimental group is two times more than the control group after treatment. ANCOVA revealed significant differences between the two groups in engagement in learning mathematics (F = 6.498, P < 0.05; Table 6). It indicates that the students in the experimental group show a higher level of engagement in learning mathematics than the control group.

Table 5. t-test Result of the Engagement Post-observation Ratings of the Two Groups

Group	N	Mean	SD	t	p
Contl.	24	45.54	5.978	45.93	.000**
Exptl.	24	121.46	5.461		

**Significant at 1% level

Table 6. ANCOVA Result of the Engagement Post-observation Ratings of the Two Groups

Group	N	Mean	SD	Adjusted mean	$F_{(1,44)}$	p
Contl.	24	45.54	5.978	45.624	6.498	.000**
Exptl.	24	121.46	5.461	122.452		

**Significant at 1% level

4 Discussion

The study examined the enjoyment and engagement of students who played digital games compared with those who did not participate in digital game-based learning. The reward system and the provision of feedback attracted students' attention as the most exciting parts of the game. One of the important results of this study is that the use of digital games impacted learner enjoyment (Table 3). The current study proved that the experimental group enjoyed more than the control group (Mean = 185. 56, 67.71). The finding that the use of digital games positively impacted learner enjoyment in learning confirms earlier research findings [22,26,27]. It is inferred that, in an interactive digital game-based learning environment, students are generally more willing to accept challenges and try their best to complete the learning tasks, resulting in better performance. It is probably because the digital game makes the lesson more exciting and provides instant feedback, significantly affecting their enjoyment. While playing the game, they can see their score on the screen. Moreover, applying technology in the classroom motivates them to learn more with fun compared to the traditional way of learning.

Concerning engagement in learning, based on the findings, a significant difference was found in post-test scores between the two groups of students in learning mathematics (Table 5). It revealed that the experimental group engaged themselves in learning mathematics better than the control group (Mean = 121.46, 45.54). The students learning with the digital game outperformed conventional learning in terms of engagement in learning. These results resonate with other studies [37–39]. The fun and exciting classroom atmosphere they experienced in DGL might be a valid reason for this. Also, the students in the experimental group had an opportunity to learn the content in a challenging way. This problematic learning path enhances their curiosity and involvement in learning.

To sum up, this study confirmed that the digital game improved students' enjoyment and engagement in learning. Integrating scaffolding with digital games was found helpful for enhancing students' mathematics learning experience. Based on the findings of this study, it is concluded that the scaffolding fused digital game approach appears to be an effective and engaging way of learning mathematics.

Table 7. Significance of Difference in Intelligence Scores

Group	Mean Intelligent Scores	SD	t	p
Contl.	21.96	6.23	0.062	0. 951^{NS}
Exptl.	22.00	6.95		

Table 8. Significance of Difference in Attitude Scores

Group	Mean Attitude Scores	SD	t	p
Contl.	27.84	6.98	.493	0. 627^{NS}
Exptl.	27.92	6.83		

5 Conclusion

This study preliminarily explored enhancing enjoyment and engagement via digital game-based learning. Naturally, games can improve students' enjoyment of the learning process. Numerous features are available within the game—students will likely appreciate animation, graphics, and sounds. Games foster enthusiasm, involvement, and a sense of accomplishment. Every game presents a challenge to stimulate the student, making it more interesting. During each level of gameplay, users encounter various challenges and are rewarded with points and awards. The experience of deriving pleasure from the learning process fosters a sense of self-confidence in students.

Moreover, the game's context is often more engaging since there is a task to complete at each step, which keeps the learner motivated. Since the game's nature revolves around victory and defeat, educators must enlighten students about the true underlying objective of game-based learning. In the conventional educational paradigm, students can occasionally have feelings of boredom. However, in the context of DGL, it is observed that a sense of joy and enthusiasm accompanies the process of learning. The results of the study support that the developed digital game promotes students' enjoyment and engagement in learning mathematics if developed following psycho-technological procedures. Providing games that embedded appropriate content and activities may make the introduction of mathematical operations into school classrooms more feasible and impactful.

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