Interactive Tarsia Puzzle for Enhancing Mathematics Engagement in Secondary Education

Mohd Shukor Bin Abd Rahman*, Alias Bin Deraman, Nurul Amira Fitriyah Binti Mohd Fauzi

University Technology MARA, Malaysia

***Corresponding author**

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ABSTRACT

This study examines the design and development of an interactive Tarsia puzzle game, aiming to increase interest in mathematics among secondary school students. The game aimed to minimize math anxiety, increase motivation, and encourage positive learning by incorporating problem-solving exercises into the gamification mechanics of a puzzle. As many as 30 Form 4 students participated in classroom trials, measuring engagement using the User Engagement Scale–Short Form (UES-SF). The findings showed high scores in the topics of aesthetic appeal, reward factor and perceived usability, suggesting the effectiveness of using gaming features like feedback, scoring, and visualization in a learning environment. This research contributes to the adaptation of the digital Tarsia puzzle game, demonstrating its scalability and replicability within learning environments, thereby bridging the gap between traditional learning and interactive learning. Furthermore, the results indicate that digital puzzle-based learning can be an addition to current teaching methods while fostering inclusivity, accessibility, and student engagement in mathematics. The study employed a four-phase process (design, development, implementation, and evaluation) and was conducted with 30 Form 4 students in a classroom setting. Engagement was assessed using the UES-SF and showed high perceived usability (4.1), concentration (4.2), and aesthetic appeal (4.3), with reward mechanics reinforcing persistence. Compared with traditional approaches, the digital Tarsia puzzle reduced anxiety, encouraged collaboration, and supported on-task behavior. These results suggest that embedding timers, scoring, and immediate feedback can sustain attention and improve learning experiences. Future work will explore adaptive difficulty to support diverse learners and examine longer-term academic outcomes across additional mathematics topics.

Keywords: Game-Based Learning, Tarsia Puzzle, Mathematics Education, Engagement, Digital Learning

INTRODUCTION

For many students, mathematics is considered the most difficult subject, often associated with high anxiety and low motivation. Although traditional teaching methods have succeeded in helping students with diverse learning needs, they may not capture the attention of students who respond better to more interactive and engaging methods. The use of game-based learning (GBL) has appeared as a potential means to respond to such complications as gameplay merges both enjoyment and quality pedagogy.

It is possible to say that Tarsia puzzle as a traditional paper-based tool gives an opportunity to collaborate, think critically, and solve problems. Its online version offers more engaging learning, scalable and accessible in a classroom and online environment. This study examines how digital Tarsia puzzles can be used to enhance mathematics learning, that is, at the secondary level, quadratic functions and number bases. This paper outlines the design, development, operational deployment and assessment of an interactive Tarsia puzzle in Construct 3 and Canva. It looks at the use of the puzzle and how it impacted the participation of students and analyzes its implications for pedagogy in mathematics learning.

LITERATURE REVIEW

Research has highlighted that student engagement is critical for achievement in mathematics. [2] observed that

mathematics anxiety may result in behaviors [3][10]such as avoiding mathematics learning that impairs learning outcomes. Similarly, [1] found that lecture-based teaching tends to cement a negative attitude to mathematics. Interactivity, feedback, and motivation conceptualize game-based learning [4][11]as a way of promoting engagement. Game-based learning increased active learning and collaboration [5][7], where more than 89 percent of students who actively enjoy gaming, suggesting a strong link between gaming and education [8].

Mathematics education is an area where game-based learning can be successful, as illustrated in Fig. 1, which summarizes common approaches identified in prior studies. The figure highlighted how puzzle-based learning, simulations, and interactive games contribute to enhancing problem-solving skills, motivations and collaboration in mathematics education.

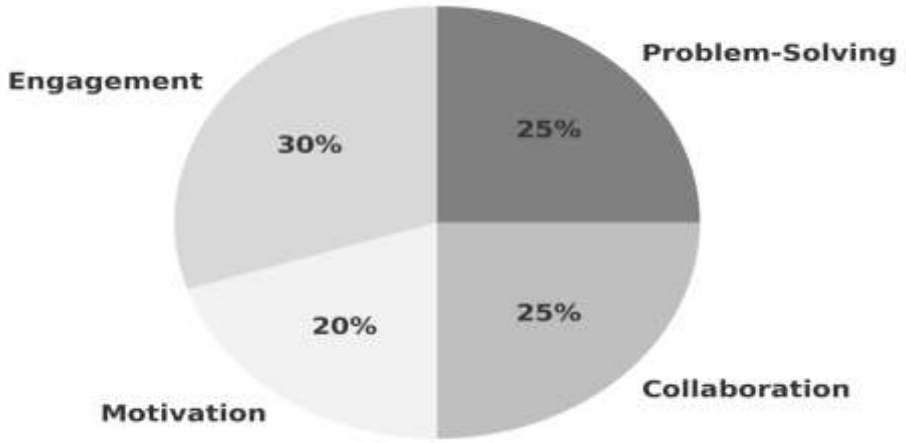

Fig. 1. Distribution of Game-Based Learning Approaches

The puzzle-based media demonstrated that it was effective with more than 80 percent learners successfully mastering their tasks [12]. The study concluded that puzzles in mathematics significantly enhanced conceptual knowledge [9]. Moreover, another study focused on the importance of learning by working on puzzles in secondary schools which found that working on puzzles helps students develop the ability to solve problems and collaborate with others [13]. Likewise, the systematic review of digital gamification in mathematics noted the effectiveness of gamification features on student motivation and engagement when different learning contexts are considered i.e., points, rewards, and feedback [14]. In addition, game-based learning approaches also produced remarkable outcomes on student motivation during STEM learning, which prospects the idea that a more attractive and productive learning process in mathematics can be introduced to students, through the involvement of puzzles and gamification in the educational process [15].

Group tasks, e.g. Tarsia-type puzzles, not only encourage problem-solving, but foster peer learning and communication which allow solving tasks through teamwork and critical thinking [6]. This paper extends the research on the previous idea of implementing Tarsia puzzles to digitally adapt them to a mathematics classroom.

METHODOLOGY

The study follows a four-phase research framework, designed as such: Design, Development, Implementation and Evaluation. Flowcharts and storyboards were used to design gameplay around the puzzle to ensure that learning activities are embedded into engaging game mechanics. Timers, scoring and real time feedback opportunities were also included as gamification add-ons, to increase motivation.

The puzzles were constructed in Construct 3 and visual assets were offered in Canva. The interactive Tarsia puzzle was administered to 30 Form 4 students in a classroom setting. Data was obtained to provide quantitative measures about the engagement on the User Engagement Scale-Short Form (UES-SF). The research was developed in a conceptual framework that connects digital puzzle-based learning, gamification features, and the outcome of student engagement, shown in Fig. 2. This framework guided both the design and evaluation phases of the study.

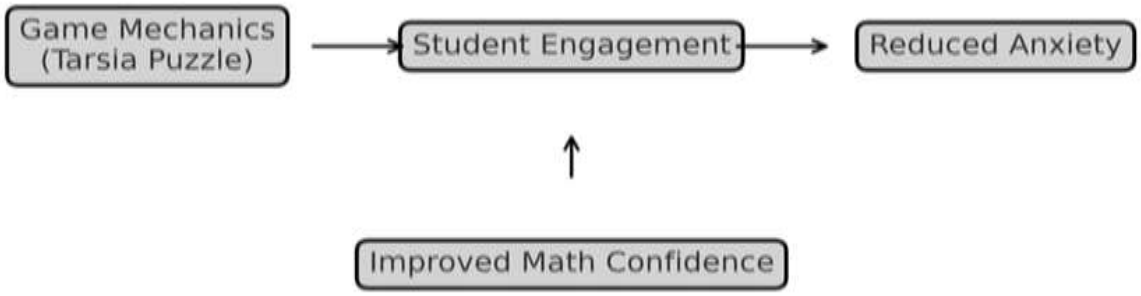

Fig. 2. Conceptual Framework of the Study

RESULTS AND DISCUSSION

Students' engagement was assessed across four dimensions using UES-SF as shown in Fig. 3. Two-level factor analysis of UES-SF scores showed good levels of engagement in all dimensions. Perceived usability scored 4.1, indicating that students found the game easy to use. The highest score was 4.3 in aesthetic appeal indicating that design aspects had a positive influence on learning.

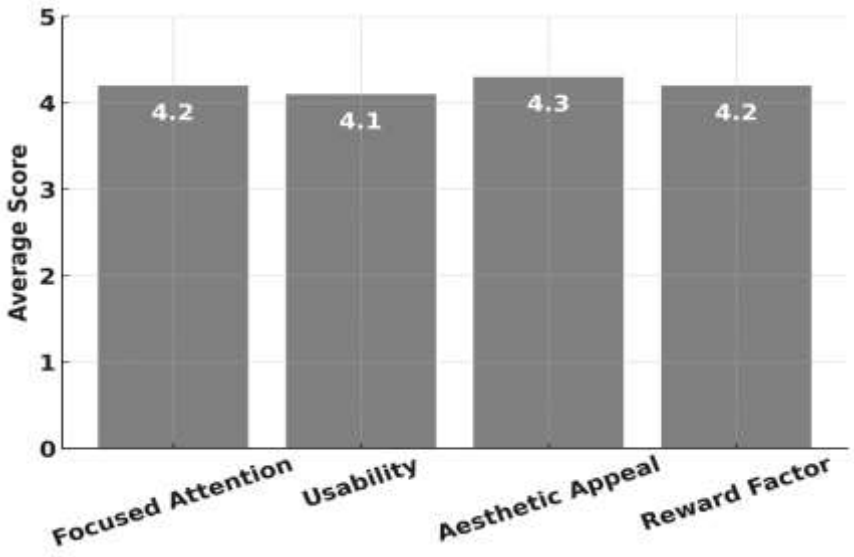

Fig. 3. Student Engagement Scores

The reward factor scored 4.2, meaning that the elements of gamification did encourage students to continue solving problems. Concentration was equally high with a score of 4.2, which shows that they were very involved during the game.

The results follow similarities with the conceptual framework (see Fig. 2) where the emphasis was placed on the expert subject of gamification and interactivity in fostering engagement. These results correspond with previous studies on the positive effects of GBL based on puzzle. The interactive Tarsia puzzle was compared to the traditional methods, and they revealed that the former reduced anxiety levels, enhanced attendance, and collaboration between students.

The value of the puzzle and the ability to keep students motivated were mentioned in responses to the feedback form. Other students had the idea to make variable difficulties more inclusive. Subsequent versions can also have adaptive functionality to support a wide range of learners

CONCLUSION

The present study has evidence that digital Tarsia puzzles can increase engagement, motivation, and confidence with mathematics. There is evidence that puzzle-based GBL should be incorporated into mathematics learning

to give teachers an alternative approach. Future studies ought to examine the long-term impact on academic performance and examine whether it can be extended to other fields of mathematics.

Ethical Approval

The study involving secondary school students was conducted in accordance with institutional ethical standards. Ethical approval was obtained from the authors' institutional research ethics committee; approval number and date will be provided upon request. Informed consent was obtained from participants.

Conflict Of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

Data Availability

The datasets generated and/or analyzed during the current study are not publicly available due to student privacy considerations.

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