Evaluating the Effect of a Mobile Interactive Damath Game on Grade 8 Students’ Performance in Integer Operations: A Quasi-Experimental Study

.

ABSTRACT

|  |
| --- |
| This study determined the effect of mobile Damath game on Grade 8 students’ academic performance on integer operations and their level of engagement with the game. Conducted at Badas National High School, Mati City Division, Mati City, Davao Oriental, Philippines, the study employed a quasi-experimental design with 60 respondents equally distributed to experimental and control groups. The experimental group was given the mobile Damath learning intervention while the control was taught with traditional instruction for three (3) weeks. Data were gathered through validated researcher-made test and AI-assisted survey questionnaire. Statistical tools including mean, standard deviation, independent sample t-test, and Pearson correlation were utilized to assess math performance and engagement levels. Data on pre-test conducted to experimental group (male-16, female-14), showed an average score of 64.29%. Meanwhile, the control group (male-20, female-10) resulted with a mean of 64.04%, both under the Beginning proficiency level. The t-test revealed a statistically significant difference (P=0.004) in the post-test results between the experimental group (M=77.35, SD=4.23) and control group (M=73.61%, SD=5.44). Findings further explained that although both groups initially performed at the Beginning level, they improved, with the experimental group progressed to Developing level, indicating the effectiveness of the mobile Damath intervention. However, while the experimental group revealed a significant improvement, their engagement with the game did not exhibit a strong correlation with learning outcomes (*r= -0.088, P= .645*). This indicated that while game-based learning enhances students’ attitude and engagement with the game, it did not directly translate to their academic achievement. Based from these findings, the following recommendations to use mobile Damath game are encouraged: (1) Integrate the mobile Damath game into classroom instruction, (2) Implement the mobile Damath game across schools and grade levels to enhance generalizability, and (3) Conduct future research to explore deeply on the relationship between math performance and engagement. |

*Keywords: game-based learning, mobile Damath game, integers, academic performance, intervention, level of engagement*

INTRODUCTION

Mathematics plays a significant role in improving students’ critical thinking, problem-solving skills, and logical reasoning abilities, all of which are essential for academic and future success. Despite its importance in supporting scientific and technological progress, many developing countries face constant challenges in delivering high-quality mathematics instruction (Hussein, 2023). Enhancing math education aims to equip learners with the skills necessary to enrich their mathematical abilities and cognitive processes, and to improve their decision-making skills and academic performance (Cipriano, 2023).

Results from international assessments such as the Programme for International Student Assessment (PISA) and the Trends in International Mathematics and Science Study (TIMSS) expose significant performance gaps, with the Philippines scoring far below the international average due to challenges in curriculum delivery, teacher training, and resource allocation (Mullis et al., 2020). The PISA 2022 results revealed that only 16% of Filipino students reached Level 2 competency in math, compared to the OECD average of 69%, while TIMSS 2019 recorded a low average score of 297, well below the scale centerpoint of 500 (OECD, 2023; Mullis et al., 2020). With high school students age 15, took the test in PISA and Grade 8 students on TIMSS focusing on content domains for eighth grade Math: number (30%), algebra (30%), geometry (20%), and data and probability (20%) (Mullis et al., 2020). These results point out on the low academic performance and achievement of students in mathematics in the Philippines.

Integers represent a core concept in Mathematics, serving as the basis for understanding more complex topics such as inequalities, linear and quadratic equations. Mastery of integer operations is essential, yet many students encounter difficulties, particularly with the rules related to positive and negative signs (Chong et al., 2022). A study involving year 8 students at St. George’s School in Brunei Darussalam demonstrated most of them had limited comprehension of integer-related content as evident by the low performance in pre-test scores on integer test (Chong et al., 2022). In the Philippine context, most students found it difficult to comprehend and retain concepts on integer operations, which hinders their progress in learning more advanced mathematical ideas (Tanghal, 2020). While Chong et al. (2022) identified misconceptions on sign-related functions (the use of negative sign as operation or as an integer sign), as a significant factor, Tanghal (2020) emphasized lesson retention as a major factor. Despite these differing focal points, both studies underscore the abstract nature of integer operations and suggest a need for teaching strategies that engage students more concretely. Game-based learning emerges as a promising approach to address this gap by making abstract concepts more accessible and engaging.

In the Philippines, integrating mathematical games, like Damath, into teaching and learning, effectively reinforced classroom learning since it has been shown to improve mental arithmetic and performance in mathematical operations (Baog, 2024; Martus et al., 2024). Moreover, Godoy (2020) discussed game-based learning enhances student engagement, motivation, and learning outcomes. However, research gaps remain, including limited evidence on the game’s impact on higher-order thinking, problem-solving skills, and long-term retention of concepts (Magsombol, 2021). Studies on Damath showed an increase in students’ engagement and positive attitude towards Mathematics, fostering a deeper understanding of mathematical concepts as evident in the improved results in formative and summative tests. Moreover, integrating Damath helps enhance students’ critical and analytical skills (Larita et al., 2024).

This study sought to explore the use of the mobile Damath game as a learning intervention for Grade 8 struggling learners at Badas National High School. Specifically, it aims to evaluate its effect on students’ performance in integers and the level of engagement with the game.

**RELATED LITERATURE REVIEW**

**Factors Affecting Math Performance and Game Engagement**

**Age and Gender**

The study of Ocampo et al. (2023), highlights age as a significant determinant of mathematics performance. Similarly, Wang et al. (2023), identified a positive correlation between student age, math self-efficacy, and math achievement.Likewise, Corcoran and O'Flaherty (2022), found that age was a significant predictor of math performance among Filipino students. These findings align with prior researches demonstrating the influence of age on math performance. For instance, Xi and Hamari (2019), observed that older students outperformed their younger peers on mathematics assessments. Further, these findings imply that in designing math curricula, educators should consider the age of their students. Age-appropriate teaching strategies and resources can help sustain students' interest and motivation in mathematics, while younger students may be provided with support system and supervision along knowledge acquisition to address diverse needs.

Previous research has shown that disparities in mathematical performance often depend on the type of task students are required to complete. For example, studies have indicated that females tend to excel in arithmetic and calculus, while males perform better in mathematical problem-solving tasks (Pina et al., 2021). According to Wang et al. (2023), research studies found out that correlation between gender and arithmetic proficiency indicated a positive impact, favoring male students. Likewise, in the study of Awofala et al. (2020), data showed that male students outperformed female students in mathematics subject. In addition, empirical research conducted in the US and Europe, shows men are more certain while studying arithmetic (Xie & Liu, 2023; Mozahem et al., 2021). One of the societal gender norms that has the strongest impact to women's learning in math is the gender stereotyping (Xie & Liu, 2023), which causes them to feel more anxious about the topic and consider themselves as less competent (Mozahem et al., 2021). However, Ocampo et al. (2023), found no significant correlation between gender and arithmetic proficiency. These performance differences are not consistent among all groups and can vary significantly depending on ethnic origins, social and cultural settings, and other factors (Xie & Liu, 2023; Wang et al., 2023).Therefore, it may be argued that variables other than gender, such as motivation, individual variations, and cultural and social factors, probably influence gender-based differences in mathematical achievement.

**Attitude and Motivation**

Several research on students' attitudes toward mathematics have been published. These studies are always interpreted as whether or not students like the subject (Davadas & Lay, 2020). Some students in secondary level view mathematics as an abstract, difficult to understand, uninteresting, and has a little significance in everyday life. Consequently, they tend to feel insecure and unmotivated to learn and engage in math activities. Indeed, for some, mathematics is a way nightmare (Wakhata et al., 2022).

Motivation may be defined as the intense desire to participate in an activity or the enthusiasm one has for something. It may be naturally inherited or altered by external factors. The main factor that determines whether a person succeeds or fails academically while learning is motivation. It focuses on the learning process and determines the student's level of engagement readiness (Asanre et al., 2024).

Students' commitment to mathematics is essential for developing their mathematical skills and understanding. Students must be confident in their mathematical learning and problem-solving skills to perform at their best. For this reason, self-esteem in problem-solving is considered to be important in mathematical achievement and may be one of the factors influencing students' mathematical success. Additionally, it was shown that students with positive attitudes about mathematics do better than those with negative views. In fact, children who do well in math are more likely to excel in the subject and to succeed in life (Shah, 2023; Hwang & Son, 2021). According to Asanre et al. (2024), students' interest in learning, which are characterized by pleasure, affirmation, and concentration, is essential and crucial. When people are interested, they tend to work actively, focus on a specific skill, and understand more concepts and ideas. In the study of Oluwadamilare et al. (2024), pupils' academic performance in mathematics is significantly impacted by their motivation. Motivated students are more likely to establish goals, use their time wisely, and do better in arithmetic.

On the other hand, Okigbo & Onoshakpokaiye (2023), found no connection between the academic achievement of secondary school students in Mathematics and their motivation. Therefore, these findings imply that other factors like environmental factors such as classrooms, adequate teaching and learning resources, highly qualified teachers, and teaching methodology may contribute to students’ academic performance in mathematics (Mbarute & Ntivuguruzwa, 2022).

**Integration of Game-Based Approach to Math Instruction**

In the study of Campilla & Castañaga (2021), 21st century teachings stress on the integration of technology, such as the internet, multimedia tools, and other digital resources, to improve the educational process. In a modern classroom setting, Math teachers utilize a variety of instructional techniques and resources to encourage student active engagement. In contrast to traditional methods, 21st century techniques promote collaboration and experiential learning enabling students to construct their understanding through hands-on activities and real-world applications. Further, in the study conducted, teaching strategies utilized by Mathematics teacher in the 21st century include Multimedia-based strategy, Game-based strategy, Manipulative-based strategy, Contextual learning Strategy.

Game-based learning uses a combination of games and instruction which aim to achieve educational goals. It is, further, the use of games, both traditional and digital, to support and enhance learning, teaching, and evaluation. Moreover, it encourages student’s participation and engagement, improves critical thinking, motivation and self-confidence while they involve themselves in hands-on, experiential learning. These games are viewed as an effective, imaginative, and interactive alternative to support the conventional teaching methodologies and practices through reinforcement of previously acquired information and skills, thus, fosters the development of 21st-century skills (Bayeck, 2020; Chong et al., 2022; Torkuglo, 2019).

Game-based learning programs should provide students the opportunity to participate in their education and to apply what they have learned to real-world situations (Adipat et al., 2021). In addition, mathematics game-based learning has been found to achieve higher-level learning outcomes in the teaching process compared to traditional instructional methods (Jarrah et al., 2022). Technology-based learning interventions, such as gamification and interactive software, have been shown to enhance students' mathematics performance (Hillmayr et al., 2020). Digital game-based learning, when combined with integrated educational content, enhances students' interest and engagement. Thus, it is possible to significantly improve students' learning experiences and learning results by incorporating teachers' educational activities into digital game-based learning (Sun et al., 2021).

Game-based learning approaches align closely with constructivist principles, which emphasize that learners actively construct their own understanding through experience, rather than passively receiving information. According to Triantafyllou (2022), through game-based learning, students actively engage in the learning process rather than merely receiving information. This pedagogical shift is foundational in constructivism, where students develop knowledge by exploring, interacting, and reflecting on their experiences.

**The Damath Game**

In Philippines, Damath is a board game created by a Filipino teacher Jesus Huenda in the late 1970. This game was designed to facilitate his teaching with his students who had difficulty in learning the basics of mathematics, making it more enjoyable and educational at the same time (Ramos et al., 2018). The use of instructional games, such as Damath, in math classes has been studied by a number of writers. For instance, Ramirez and Mercado (2023), discovered that integrating mathematical games into classroom activities may increase accomplishment levels in mathematics, improve learning outcomes, help students grasp basic operations on integers and rational numbers, and raise their academic performance in the subject. Additionally, in the study of Magsombol (2021), data revealed that the use of Damath game is effective as shown in the result of the post-test of Damath group which is 26.73 of mean compared to the result of the post-test of the group without Damath which is 18.73 of mean.

The study of mobile Damath game holds significant relevance as it integrates traditional educational games with technology to enhance mathematics learning. The mobile adaptation of Damath addresses the portability and mobility of the game as well as the growing need for technology-based instructional strategies in 21st-century classrooms, where digital tools are increasingly utilized to support learning (Ramos et al., 2018). Implementing the Damath strategy has revealed significant improvements in students' cognitive and mathematical abilities. Participants noted enhanced mental stimulation, increased focus, improved strategic thinking, and stronger problem-solving skills as a result of regular gameplay. The strategy effectively boosted mental arithmetic and mastery of mathematical operations, proving to be a valuable tool for reinforcing classroom lessons. These findings underscore Damath's potential to foster cognitive development, critical thinking, and mathematical proficiency, ultimately enriching students' overall educational experience (Baog, 2024).

However, existing studies on Damath have relied on small sample sizes and short-term interventions, which may not fully capture its effectiveness or applicability across grade levels and broader educational systems (Martus et al., 2024). Further, few studies have specifically examined its effectiveness in teaching integer-related contents on Grade 8 students. The relationship between engagement with the game and actual performance in Math also remains underexplored while most studies have focused on traditional Damath board game rather than mobile applications. These limitations underscore the need for more localized, large-scale studies to assess the mobile Damath game’s impact on students’ mathematical proficiency, attitudes toward learning, and long-term academic achievement.

methodology

This study employed a quasi-experimental design with pre-test and post-test assessments of both experimental and control groups. The experimental group engaged with the mobile Damath game as an intervention for learning integer operations, while the control group received traditional instruction on the same content. Both quantitative data on performance and engagement were collected and analyzed to determine the effectiveness of the mobile Damath game and its relationship to students’ mathematical achievement

**Design**

In this study, the quasi-experimental method determined the effectiveness of the interactive mobile Damath game as an intervention to those low performing students of Grade 8 students in Mathematics of Badas National High School.

A Quasi-Experimental Design was selected as the most appropriate approach for this study because it allows for the examination of cause-effect relationships between variables (mobile Damath game intervention and mathematics performance) without random assignment. This design aligned with the constructivist theoretical framework by enabling the comparison of two different learning environments – one facilitating active knowledge construction through gameplay and another using traditional instruction. The inclusion of a descriptive component allowed for detailed characterization of students’ engagement levels and demographic variables. The implementation phase of three weeks was considered to allow the participants engage with the game consistently throughout the duration. Further, this timeframe aligns with the school calendar to ensure no disruption of classes. However, while positive impact is observed at the beginning, it is still recommended to conduct future research to examine long-term effects of using the mobile Damath game to students’ math achievement.

**Sampling**

This study employed purposive sampling to select participants who met specific criteria aligned with the objectives of the research. From the total population of 106 Grade 8 students enrolled at Badas national High School for SY 2024-2025, all students were first administered with a pre-test focused on integer operations. Based on the results, the 60 lowest-performing students were identified and chosen as the participants for the study.

The decision to focus on low performing students was intentional and strategic. The primary goal of this research was to evaluate the effectiveness of the mobile Damath game in improving mathematical performance and engagement, particularly in students who are struggling with foundational skills in integers. Selecting students with the greatest need for intervention allowed the study to more accurately assess whether the game-based approach could produce meaningful improvements in learning outcomes. By focusing on this group, the study aimed to address learning gaps and help create teaching strategies that better support the struggling learners.

After identifying the 60 participants, a systematic assignment process was used to divide them equally into two groups: the experimental group and the control group. This method ensured a fair and balanced distribution of academic performance across both groups, minimizing potential biases and improving the comparability of results. The experimental group was exposed to mobile Damath game as an instructional intervention for learning integers while the control group received traditional instruction.

**Collection**

Data for this study were collected using three primary instruments: a demographic questionnaire, a pre-test and post-test in Mathematics, and an AI-assisted survey questionnaire. The demographic questionnaire was used to gather information on the respondents’ profiles in terms of age and gender, the pre-test and post-test were employed to assess their academic performance in integer operations, while the survey questionnaire focused on assessing students’ level of engagement with the mobile Damath game.

**Research Instrument**

***Survey Questionnaire***

An AI-supported survey questionnaire was used to gather data on students’ engagement and perceptions toward playing the mobile Damath game. Initial items were drafted using ChatGPT AI tool to ensure clarity, consistency, and alignment with the study’s objectives. The test of reliability revealed that the initial Cronbach’s Alpha for the Attitude scale, composed of 10 items, was 0.312, indicating poor internal consistency (Taber, 2018). After removing four poorly performing items, the adjusted Cronbach’s Alpha improved significantly to 0.719, suggesting acceptable reliability. Similarly, the Motivation scale initially recorded a Cronbach’s alpha of 0.695 for 10 items. By eliminating one item, the reliability slightly improved to 0.725. These adjustments contributed to an overall Cronbach’s Alpha of 0.828 for the entire questionnaire, demonstrating good internal consistency across the instrument (Tavakol & Dennick, 2011). These items were then reviewed by experts in the field to ensure its content validity and appropriateness for the target participants. These reviewers included a faculty member of Davao Oriental State University (DORSU) with expertise in educational research, an Education Program Supervisor who assessed the clarity and language of the items, and a Master Teacher specializing in Mathematics who evaluated the questionnaire’s relevance to the subject matter. Their collective feedback was used to refine and improve the instrument prior to its pilot testing and implementation.

Following expert validation, the questionnaire was subjected to a pilot test involving a small group of Grade 8 students from the same school, not included in the actual study, with similar characteristics. Feedback from the pilot test was used to revise unclear or ambiguous items, ensure age-appropriate language, and improve the overall structure of the survey. The final version of the questionnaire was then administered after the intervention.

***Pre-Post Test Questionnaire***

A 40-item researcher-made Pre-Test was administered to Grade 8 learners at the start of the 4th Quarter. This determined the baseline knowledge of students in solving integer-related problems prior to the intervention. The instrument has undergone pilot testing to Grade 8 students (not included in the actual study) from the same school. Reliability test result showed that the instrument has a Cronbach’s alpha of 0.735, indicating an acceptable with good internal consistency instrument. Moreover, content validity was also ensured by conducting expert validation from the same panel Participants took the test simultaneously for 2 hours. After the intervention has made, a post-test, with the same number of items, was administered to evaluate the improvement in students' ability to solve integer-related problems. This process helped identify whether the use of mobile Damath game had a positive impact on their learning of concepts of the four basic operations in integers that is, increasing the post test result compared to the pre-test result.

***Interactive Mobile Damath Interface***

The mobile application utilized in this study was sourced from DAMATH.PH. It is an online version of the board game Damath. The player had the option to compete against another player or an AI opponent. As a form of intervention, this mobile Damath application was presented to the respondents for this study. The researcher explained thoroughly how to use the said mobile application, the extent of engagement, and the time schedules. For Grade 8 students, they dealt with the four fundamental operations on integers.

The researcher declared that there are no financial, personal, or professional conflicts of interest that could influence the study’s outcomes. This study was conducted purely for academic purposes, and no external funding or affiliations with the developers of the mobile Damath game exist. The results were analyzed and reported objectively to ensure the integrity of the research findings.

**Data**

In this study, the data were collected from the responses of 60 student participants. The pre-test and post test scores were analyzed using mean, standard deviation and independent sample T-test. Performance metrics was also used as reference of students’ performance level in Mathematics. This is adapted from Department of Education (DepEd) Order No. 31, s. 2012: Policy Guidelines on the Implementation of Grades 1 to 10 of the K to 12 Basic Education Curriculum (BEC) Effective School Year 2012–2013as shown in Table1.

Likewise, the students’ level of engagement with the mobile Damath game was analyzed using mean and standard deviation and interpreted using 5-point scale to provide clear description interpretation as shown in Table 2.

Further, the correlational analysis between the engagement level and academic performance was analyzed using Pearson correlation.

**Table 1. Performance metrics on the Student’s Performance level in Math.**

|  |  |
| --- | --- |
| **Equivalent Numerical Value** | **Level of Proficiency** |
| 90% and above | Advanced level |
| 85% – 89% | Proficient level |
| 80% – 84% | Approaching Proficiency level |
| 75% – 79% | Developing level |
| 74% and below | Beginning level |

**Table 2. Qualitative Interpretations of the 5-point scale on the Level of Engagement with the mobile Damath game.**

|  |  |  |
| --- | --- | --- |
| **Range** | **Descriptive Interpretation** | **Indicators** |
| 4.21 – 5.0 | Very High | Participants are very highly engaged with the mobile damath game |
| 3.41 – 4.20 | High | Participants are highly engaged with the mobile damath game |
| 2.61 – 3.40 | Moderate | Participants are moderately engaged with the mobile damath game |
| 1.81 – 2.60 | Low | Participants are slightly engaged with the mobile damath game |
| 1.00 – 1.80 | Very Low | Participants are not engaged with the mobile damath game |

results and discussion

This section presents the findings of the study on the impact of the interactive mobile Damath game on the performance of Grade 8 students in solving integers. The study involved 60 Grade 8 students from Badas National High School, with 30 assigned to the Experimental Group and 30 to the Control Group. Statistical methods were used to analyze and interpret the results based on the research questions. An independent sample t-test was applied to examine whether there was a significant difference in academic performance between students who used the mobile Damath game and those who learned through traditional instruction. Additionally, a correlation analysis was conducted to explore the relationship between students’ performance and their engagement with the game, particularly in terms of attitude and motivation. The students’ age and gender were also taken into account, and both pre-test and post-test scores were evaluated.

**Demographic Profile of the Respondents**

The table presents the demographic profile of the respondents in terms of age and gender. Understanding these characteristics provides context for interpreting the results of the study, as individual differences may influence students’ academic performance and engagement with the mobile Damath game. The respondents consisted of Grade 8 students from Badas National High School, with data gathered from both the experimental and control groups.

**Table 3. Demographic Profile of the Respondents**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  | **Groups** | | **Frequency**  **(n=60)** | **Percentage**  **(100%)** |
| **Experimental**  **(n=30)** | **Control**  **(n=30)** |  |  |
| **Age** | 13 years old | 10 | 10 | 20 | 33.33% |
| 14 years old | 13 | 16 | 29 | 48.33% |
| 15 years old | 4 | 3 | 7 | 11.67% |
| 16 years old | 3 | 1 | 4 | 6.67% |
|  |  |  |  |  |  |
| **Gender** | Male | 16 | 20 | 36 | 60% |
| Female | 14 | 10 | 24 | 40% |

Table 3 presents the demographic profiles of the 60 student respondents, (30 experimental group, 30 control group), highlighting their age and gender distribution. The majority of the students in both groups were 14 years old with 13 participants and 16 participants for experimental and control group, respectively, comprising 48.33% of the total. Indicating that most respondents were in the early adolescent stage, typically associated with junior high school levels. In terms of gender, the experimental group consisted of 16 males and 14 females while the control group included 20 males and 10 females. With 60% male and 40% female, the data suggested a male-dominated sample. Overall both groups showed comparable distributions in age and gender, supporting the assumption of group equivalence prior to the intervention.

According to Ocampo et al. (2023), age emerges as a significant factor influencing students’ performance in mathematics. This finding is consistent with the earlier research that has established a correlation between age and mathematical achievement. For example, Xi & Hamari (2019), reported that older students tend to perform better on mathematics assessments compared to their younger counterparts. Similarly, Corcoran & O’ Flaherty (2022) found that age was a significant predictor of mathematics performance among Filipino students.

Awofala et al. (2020), identified gender as a significant factor influencing high school students’ performance in mathematics, with male students outperforming their female peers. This disparity may stem from societal gender stereotypes that portray males as naturally more competent in math. Such stereotypes can negatively affect females by increasing math-related anxiety and decreasing their confidence and interest in the subject (Xie & Liu, 2023; Mozahem et al., 2021). However, contrary to these findings, Ocampo et al. (2023), reported no significant correlation between gender and arithmetic proficiency. These variations in performance are not universal and may be influenced by factors such as ethnicity, cultural background, and social context (Xie & Liu, 2023; Wang et al., 2023).

When evaluating the effectiveness of an educational intervention like the mobile Damath game, considering learners’ characteristics - particularly age and gender - is crucial. These factors can significantly influence how students engage with and benefit from the game, as well as how they perform academically in mathematics.

However, the data shows a higher number of male respondents compared to female, indicating an uneven distribution due to the use of purposive sampling. Despite this, it is important to highlight that incorporating game-based strategies such as the mobile Damath game in teaching and learning can help bridge the gender gap in competitiveness. This is achieved by providing diverse engagement and motivational approaches that cater to both genders while promoting collaboration over competition, minimizing the effects of gender stereotypes, and fostering equal participation among students.

**Math Performance Level of Experimental and Control Groups in Terms of Pre-Test Results**

In this study, the pre-test was used to establish the baseline knowledge of students in integers for both the experimental and control groups prior to the conduct of intervention. The post-test then assessed the student performance after the intervention was implemented for the experimental group and traditional instruction was provided to the control group. A total of 106 Grade 8 students participated in the pre-test. The researcher used a purposive sampling technique in identifying the study participants, selecting 60 students who scored the lowest in a 40-item test, with raw scores ranging from 4 – 18. The pre-test result is interpreted using mean percentage score as shown in the table.

**Table 4. Pre-test Results of Experimental and Control Groups**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Groups** | **Average** | **Proficiency Level** | **SD** | **df** | **t-stat** | **P-value** | **Cohen’s D** |
| **Pre-Test** | Experimental | 64.29% | Beginning Level | 4.58 | 58 | 0.223 | 0.824 | 0.058 |
| Control | 64.04% | Beginning Level | 4.07 |

Table 4 illustrates the students’ performance in the pre-test of both experimental and control groups. The experimental group obtained a mean score of 64.29% with a standard deviation of 4.58, while the control group had a mean of 64.04% and a standard deviation of 4.07. An independent sample t-test revealed no statistically significant difference between the two groups, *t*(58) = .223, *P* = .824. The computed Cohen’s *d* of 0.058 indicates a negligible effect size, suggesting that both groups had comparable levels of performance prior to the intervention. This implies that any subsequent differences in post-test outcomes are less likely to be attributed to pre-existing disparities in student performance. The results indicated that the 60 respondents fall within the "Beginning" level, corresponding to scores of 74% and below. It further showed that no students reached the "Developing," "Approaching Proficiency," "Proficient," or "Advanced" levels, indicating a general need for targeted instructional intervention to improve foundational mathematical skills across the cohort.

This result aligns with the findings of Martus et al. (2024) whose study on integers showed high school students had a pre-test mean score of 73%, placing them at the Beginning level. Similarly, Magsombol (2021) reported a 73% proficiency level in a pre-test, with respondents likewise falling under the Beginning category. Likewise, students from Grades 7-12 achieved very low result in the pre-test of both experimental and control groups (Buhay & Tandog, 2025).

The finding that the majority of the respondents scored within the beginning level (74% and below) in the pre-test suggests a significant gap in foundational mathematical understanding among the students. This underperformance in math reflect either a lack of prior mastery, ineffective instructional strategies, or possible learning gaps from earlier grade levels. As such, there is clear need for targeted interventions, such as differentiated instruction, remedial programs, or the integration of more engaging and context-based learning strategies to help students build a stronger conceptual understanding of integers. Addressing these deficiencies early on is crucial, as integer operations serve as a fundamental skill essential for more advanced math topics.

**Participants’ Level of Engagement with the Mobile Damath Game**

This section provides the information on the students’ participation with the learning intervention. It includes descriptive interpretation on the indicators in terms of attitude and motivation and the level of engagement with the game as measured by the mean and standard deviation.

**Table 5. Level of Students’ Engagement with the Mobile Damath Game in terms of Attitude and Motivation.**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Mean** | **SD** | **Descriptive Interpretation** |
| ***Attitude*** |  |  |  |
| I regularly engage in the mobile Damath game as part of my daily routine | 4.47 | 0.57 | Very High |
| I actively participate in the gameplay with others on a regular basis. | 4.37 | 0.61 | Very High |
| I prefer to play the game alone with an AI opponent | 4.53 | 0.63 | Very High |
| I am highly focused and attentive while playing the mobile Damath game | 4.43 | 0.50 | Very High |
| I enjoy competing and strategizing while playing the mobile Damathgame. | 4.47 | 0.51 | Very High |
| I keep track of my previous scores/record to monitor my progress | 4.60 | 0.50 | Very High |
| **Overall** | **4.48** | **0.28** | **Very High** |
| ***Motivation*** |  |  |  |
| I play the mobile Damath game regularly to challenge myself and test my abilities. | 4.03 | 0.49 | High |
| I am motivated to play the mobile Damath game because it is enjoyable and fun. | 4.43 | 0.50 | Very High |
| I enjoy playing the mobile Damath game because it allows me to compete with others. | 4.23 | 0.57 | Very High |
| I am motivated to learn new strategies to improve my performance in the mobile Damath game. | 4.30 | 0.65 | Very High |
| I enjoy the challenge of solving difficult problems in the mobile Damath game. | 4.37 | 0.67 | Very High |
| I feel overwhelmed every time I get high score over my opponent | 4.53 | 0.51 | Very High |
| My progress in the mobile Damath game motivate me to play more | 4.40 | 0.50 | Very High |
| I feel a sense of accomplishment when I complete a level in the game | 4.47 | 0.51 | Very High |
| I am driven to understand the rules of the mobile Damath game deeply to improve my skills | 4.77 | 0.43 | Very High |
| **Overall** | **4.47** | **0.28** | **Very High** |

Table 5 presents the level of students’ engagement with the mobile Damath game in terms of attitude and motivation. Results show that students exhibited a very high level of engagement across both dimensions. In terms of attitude, all items received mean scores ranging from 4.37 to 4.60, with an overall mean of 4.48 (SD = 0.28), indicating that students were highly enthusiastic, attentive, and consistent in playing the game. Similarly, in the area of motivation, most indicators also registered very high ratings, with mean scores between 4.03 and 4.77 and an overall mean of 4.47 (SD = 0.28). Notably, the highest motivation was seen in the students' drive to understand the game deeply (M = 4.77, SD = 0.43), while the item on playing for self-challenge showed the lowest but still high rating (M = 4.03, SD = 0.49). These findings suggest that the mobile Damath game effectively fosters positive attitudes and strong intrinsic motivation among students, supporting its potential as an engaging educational tool.

**Math Performance Level of Experimental and Control Groups in Terms of Post-Test Results**

The study was conducted over a period of three (3) weeks. During the implementation phase, both the experimental and control groups were allotted one (1) hour per day. Both classes were handled by the researcher herself to maintain consistency. In the experimental group, students engaged in activities involving the Damath game, which included an introduction to the game, a discussion to integer operations (addition, subtraction, multiplication, division), strategy development, and sharing of gameplay experiences. Meanwhile, the control group followed a traditional teaching approach focused solely on lectures and discussions about integers. After this period, a post-test was administered to the participants to evaluate the impact of the intervention and the traditional teaching method on the math performance of the experimental and control groups, respectively. The outcome of the post-test is presented in the table below.

**Table 6. Post-test Results of Experimental and Control Groups**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Groups** | **Average** | **Proficiency Level** | **SD** | **df** | **t-stat** | **P-value** | **Decision on** Ho |
| **Post-Test** | Experimental | 77.35% | Developing Level | 4.23 | 58 | 2.972 | 0.004 | Reject |
| Control | 73.61% | Beginning Level | 5.44 |

Table 6 presents the students’ performance in the post-test, showing a statistically significant difference in mathematics performance between the experimental and control groups, as revealed by an independent samples t-test, t(58) = 2.972, *P = 0.004*. Further, the experimental group progressed from the Beginning level (64.29%) to Developing level (77.35%). Conversely, the control group still belongs to the Beginning level, indicating failed to meet the DepEd passing requirement of 75% yet still improved their performance from 64.04% to 73.61%. With the computed effect size, Cohen’s d = 0.77, indicates a moderate to large practical significance and the increase in the post-test scores of both experimental and control groups – from an average of 64. 17% (beginning level) to 75.80% (developing level) – indicates that both the mobile Damath game and traditional teaching methods contributed positively to students’ understanding of integers. This improvement implies that targeted instruction, whether through game-based approaches or conventional teaching, can be effective in enhancing mathematical performance.

This findings align with the result reported by Magsombol (2021), where the experimental group attained a mean of 26.73, higher than the average score of 20, while the control group attained a mean of 18.78, below the average score. This showed an increase in the proficiency level of the experimental group from 73% (Beginning) to 84% (Developing). Also, Martus et al. (2024) reported an increase in the post test result of Grade 7 students from 73% to 81%. Suggesting the Damath game was effective. Similar findings was also reported on the increase in the post-test scores of both experimental and control groups, showing the positive effect of Damath on the students’ performance on integer operations.

However, the movement from beginning to developing level also suggests that while progress was made, students still have not yet reached the “proficient” level of mastery. This underscores the need for continuous instructional support and possibly integrating both traditional and digital game-based learning methods to reinforce concepts and engage learners more deeply.

**Comparison of the Post-Test Results between the Experimental and Control Groups**

From the table above, the results show a statistically significant difference in mathematics performance between the experimental and control groups, as revealed by an independent samples t-test, *t(58) = 2.972*, *P = .004*. The experimental group (M = 77.35%, SD = 4.23) outperformed the control group (M = 73.61%, SD = 5.44), with a 95% confidence interval for the mean difference ranging from 1.23% to 6.25%. The computed effect size, Cohen’s d = 0.77, indicates a moderate to large practical significance, suggesting that the intervention had a meaningful and beneficial impact on students’ mathematics performance. As a result, the null hypothesis (Ho), which posits no significant difference in academic performance between the groups, is rejected. This suggests that the intervention or condition applied to the experimental group had a positive impact on their Mathematics performance.

Further, the post-test results reveal that while both the experimental group (mobile damath game) and the control group (traditional teaching) improved from the beginning level (average of 64.17%), the experimental group achieved a higher average score of 77.35% compared to 73.61% in the control group. This suggests that while traditional teaching methods were effective in helping students progress to the developing level, the use of the mobile Damath game provided a more impactful and engaging learning experience that led to greater improvement in understanding integers. This finding reinforces the idea that game-based learning contributes to enhancing students’ academic performance. As highlighted in the study by Jarrah et al. (2022), that game-based approaches implemented across various curricula has a more substantial impact on improving student achievement compared to conventional teaching methods. Nevertheless, a comparative study by Falasi (2024) highlighted that both traditional and modern teaching possess distinct advantages and limitations. Traditional methods provide structure and thorough content delivery, along with objective evaluation. On the other hand, modern approaches, like game-based learning, foster student engagement and cater diverse learning needs, but may not fully challenge students to develop higher order thinking skills.

The implication of this finding is that game-based learning tools like the mobile Damath game can be a valuable supplement to traditional instruction – enhancing, rather than replacing conventional instruction, especially for students who struggle with abstract mathematical concepts. From a constructivist perspective, the game’s interactive format aligns with the principle that learners construct knowledge more effectively through active engagement, social interaction, and hands-on experience. The strategic gameplay encouraged students to apply prior knowledge, test hypotheses, and receive immediate feedback, thereby deepening their conceptual understanding of integers, These experiences not only contributed to the greater gains observed in the experimental group but also hold potential for long-term retention and continued improvement, as students are more likely to internalize mathematical concepts through repeated, meaningful engagement. Over time, such game-based interventions may lead to more sustained academic progress, particularly in foundational topics like integers, which support higher-level mathematical learning.

**Relationship between Students’ Performance and Engagement in the Mobile Damath Game in Terms of Attitude and Motivation**

This section explored the relationship between students’ performance in mathematics and their engagement with the mobile Damath game, focusing specifically on two key dimensions of engagement: attitude and motivation.

**Table 7. Correlation Analysis on Students’ Performance and Students’ Engagement with the mobile Damath Game in terms of Attitude and Motivation.**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | | **Attitude** | **Motivation** | **Overall Student Engagement** | **Math Performance** |
| **Attitude** | r-value | 1 | .371 | .822 | -.101 |
| p-value |  | .044 | .001 | .594 |
| **Motivation** | r-value |  | 1 | .833 | -.045 |
| p-value |  |  | .000 | .814 |
| **Overall Student Engagement** | r-value |  |  | 1 | -.088 |
| p-value |  |  |  | .645 |
| **Math Performance** | r-value |  |  |  | 1 |
| p-value |  |  |  |  |

Table 7 displays the correlation analysis between students’ mathematics performance and their engagement in the Damath game, specifically in terms of attitude and motivation. A significant positive correlation is observed between attitude and motivation (r = .371, *P = .044*), and a stronger, highly significant correlation exists between both attitude and overall student engagement (r = .822, *P = .001*) and motivation and overall engagement (r = .833, *P = .000*). However, the correlation between math performance and attitude (r = -0.101, *P = .594*), motivation (r = -0.045, *P = .814*), and overall student engagement (r = -0.088, *P = .645*) is weak and not statistically significant. These findings suggest that while students' engagement components are closely interrelated, such engagement does not have a direct or significant correlation with their mathematics performance in this context. One possible reason for this is the short implementation period of only three weeks, which may not have been sufficient for engagement to significantly influence performance outcomes. Additionally, the Damath game may be more effective in influencing students’ attitude and motivation rather than immediately improving test scores. Students in this said grade level might have been more engaged with the gameplay itself rather than deeply mastering the mathematical concepts.

These results support the findings of Okigbo & Onoshakpokaiye (2023), who reported no significant correlation between students’ motivation and math performance, as indicated by a p-value of 0.726. In contrast, Oluwadamilare et al. (2024), found a significant positive relationship, with the calculated *r* (1.33) exceeding the critical value (0.02), leading to the rejection of null hypothesis of there is no significant relationship between motivation and students’ academic performance in Mathematics. The correlation between students’ attitude towards Mathematics achievement was positively significant (Hwang & Son, 2021). However, the study has limitations. First, it may be biased or exaggerated since information gathered are based on students’ self-reported data. Second, the sample was limited to Singaporean eighth-grade students, so the results may not apply to other countries or grade level. Lastly, attitude towards mathematics explained just 7.8% of the variance in math achievement, limiting the generalizability of the findings.

Henceforth, the strong correlation between students’ attitude, motivation and overall engagement in the Damath game suggests that the game is effective in capturing learners’ interest and promoting active participation. However, the lack of a significant relationship between these engagement factors and actual mathematics performance indicates that positive engagement alone may not directly lead to improved academic outcomes. This implies that while game-based learning tools like the mobile Damath game can enhance the learning environment and foster student enthusiasm, additional instructional support and strategic integration are necessary to ensure that engagement is translated into deeper understanding and measurable improvement in mathematics performance.

To build on the findings of this study, future research could explore the long-term impact of using Damath on students’ mathematics performance by extending the duration of the intervention beyond three weeks. Moreover, including qualitative data, such as student reflections and interviews, could provide deeper insights as to how engagement influences learning. Further, it may also be beneficial to examine the effect of Damath on different math concepts, or to involve students from different grade levels to determine if certain groups benefit more from game-based learning.

Conclusion

This study examined the effectiveness of the mobile Damath game in enhancing students’ performance in integers and explored the relationship between student engagement – measured through attitude and motivation – and mathematics achievement. Findings revealed that while both traditional teaching and the mobile Damath game led to improved post-test results, the experimental group showed significantly better performance, as confirmed by t-test results. This suggests that the mobile Damath game can be an effective tool for supporting math learning, particularly among low-performing learners.

Interestingly, although students in the experimental group exhibited high levels of engagement – with strong positive correlations between attitude, motivation, and overall engagement – these affective factors did not significantly correlate with actual math performance. This indicates that while game-based learning can enhance interest and involvement, engagement alone may not be a sufficient predictor of academic success. It highlights the importance of using educational games in a well-planned and teaching-focused way to make sure students stay mentally engaged and meet learning goals.

From a theoretical perspective, the findings were consistent with constructivist learning theory, which emphasizes the importance of active, student-centered learning experiences. The mobile Damath game reflected these principles by encouraging exploration, interaction, and problem solving.

The broader educational implications of the study indicate that mobile and game-based tools, when thoughtfully integrated, complement traditional instruction and support differentiated learning. For struggling learners, such tools can provide a more engaging and supportive learning environment that fosters both skill development and positive attitudes toward Mathematics. To maximize their impact, however, teachers need to be equipped with the appropriate training and resources to implement game-based strategies effectively.

In conclusion, the study provides empirical evidence that integrating mobile game-based tools such as Damath can enhance mathematics instruction for low-performing students. Rooted in constructivist theory, the intervention supports student-centered, interactive learning environments. The findings support further integration of educational games in the curriculum, teacher training for effective implementation, and further research to explore long-term impacts of engagement-driven digital tools on academic achievement.

**Consent:**

As per international standards, parental written consent has been collected and preserved by the author(s).

**Disclaimer (Artificial intelligence)**

Option 1:

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

Option 2:

Author(s) hereby declare that generative AI technologies such as Large Language Models, etc. have been used during the writing or editing of manuscripts. This explanation will include the name, version, model, and source of the generative AI technology and as well as all input prompts provided to the generative AI technology

Details of the AI usage are given below:

1.

2.

3.

References

Adipat, S., Laksana, K., Busayanon, K., Asawasowan, A., & Adipat, B. (2021). Engaging students in the learning process with game-based learning: The fundamental concepts. International Journal of Technology in Education (IJTE), 4(3), 542-552. <https://doi.org/10.46328/ijte.169>

Asanre, A., Aviwe, S., & Abiodun, T. (2024). Impact of interest and motivation on academic achievement of junior secondary school students in Mathematics. Journal of Mathematics Instruction, Social Research and Opinion (JMISRO), 3(3), 275 – 284. <https://doi.org/10.58421/misro.v3i3.269>

Awofala, A., Lawani, A., & Adeyemi, O. (2020). Motivation to learning mathematics and gender as correlates of senior secondary school students’ performance in mathematics. Journal of Educational Sciences, 4(2), 318-333. <https://jes.ejournal.unri.ac.id/index.php/JES>

Baog, I., Bartolome, J., Hayo, M., Agbon, A., & Roferos, G. (2024). Unlocking mathematical success: A qualitative case study on grade 10 learners' challenges and triumphs with the DAMATH strategy. International Journal of Research and Innovation in Social Science, 8(7), 1124-1133. <https://dx.doi.org/10.47772/IJRISS.2024.807092>

Bayeck, R. Y. (2020). Examining board gameplay and learning: A multidisciplinary review of recent research. Simulation & Gaming, 51(4), 411–431. [https://doi.org/10.1177/1046878119901286](https://psycnet.apa.org/doi/10.1177/1046878119901286)

Buhay, C. & Tandog, L. (2025). The application of enhanced Damath in learning operations on integers and developing strategic thinking. Journal of Effective Teaching Methods (JETM), 3(2), 90-102. https://doi.org/10.59652/jetm.v3i2.522

Campilla, J., & Castañaga, V. (2021). Teaching strategies utilized by mathematics teachers in the 21st-century.International Journal of Sciences: Basic and Applied Research (IJSBAR), 59(2),140-160.

Chong, W., Shahrill, M., Asamoah, D., & Latif, S. (2022). Non-digital card game and year 8 students’ performance in integers. Journal of Mathematics and Science Teacher, 2, 1. <https://doi.org/10.29333/mathsciteacher/11928>

Cipriano, N. (2023). Exploring mathematics education in the 21st century. Journal for Educators, Teachers and Trainers, 14(3), 749-758. DOI: 10.47750/jett.2023.14.03.086

Corcoran, R. P., & O'Flaherty, J. (2022). Social and emotional learning in teacher preparation: Pre-service teacher well-being. Teaching and Teacher Education, 110. <https://doi.org/10.1016/j.tate.2021.103563>

Davadas, S. D., & Lay, Y. F. (2020). Contributing factors of secondary students’ attitude towards Mathematics. *European Journal of Educational Research,* 9(2), 489-498. https://doi.org/10.12973/eu-jer.9.2.489

Falasi, M. (2024). Innovative pedagogies: A comparative analysis of traditional and modern teaching methods. Academy of Educational Leadership Journal, 28(1), 1-2.

Godoy Jr., C. (2020). A Review of game-based mobile e-learning applications. International Journal of Computing Sciences Research, 4(3), 340-350. DOI: 10.25147/ijcsr.2017.001.1.45

Hillmayr, D., Ziernwald, L., Reinhold, F., & Hofer, S., Reiss, K. (2020). The potential of digital tools to enhance mathematics and science learning in secondary schools: A context-specific meta-analysis. Elsevier Ltd, 1-25. <https://doi.org/10.1016/j.compedu.2020.103897>

Hussein, H. (2023). Global trends in mathematics education research. International Journal of Research in Educational Sciences, 6(2), 309-319. DOI:10.29009/ijres.6.2.9

Hwang, S., & Son, T. (2021). Students’ attitude towards mathematics and its relationship with mathematics achievement. Journal of Education and e-Learning Research, 8(3), 272-280. doi: 10.20448/journal.509.2021.83.272.280

Jarrah, A., Almassri, H., Johnson, J., & Wardat, Y. (2022). Assessing the impact of digital games-based learning on students’ performance in learning fractions using (ABACUS) software application. EURASIA Journal of Mathematics, Science and Technology Education (EJMSTE), 18(10), 1-10. <https://doi.org/10.29333/ejmste/12421>

Larita, S., Gajo, R., Larita, R., Cabanes, V., & Villanueva, G. (2024). Using of DAMATH in remedial class in improving pupils numeracy skills in key stage 1: Inputs to the In-service training plan. International Multidisciplinary Journal of Research for Innovation, Sustainability and Excellence, 1(10), 248-253. doi: 10.5281/zenodo.13913720

Magsombol, E. (2021). The effectiveness of DAMATH in enhancing the earning process of four fundamental operations of whole numbers in Mathematics for elementary pupils. International Journal of Academic Multidisciplinary Research, 5(1), 133-136.

Martus, J., Alburo, C., Carangue, P., Dayupay, C., Lapay, J., Calinao, J., Gorres, S., & Cano Jr., A. (2024). DAMATH integration in teaching mathematics: Inputs on teaching styles. Psych Educ, 19(7), 852-863. doi:10.5281/zenodo.11173321

Mbarute, E S., & Ntivuguruzwa, C. (2022). Factors Affecting Students’ Performance in Mathematics in Upper Secondary Schools in Gicumbi District, Rwanda. Journal Research Innovation and Implication in Education (JRIIE), *6*(3), 13 – 17.

Mozahem, N., Boulad, F., & Ghanem, C. (2021). Secondary school students and self-efficacy in mathematics: Gender and age differences. International Journal of School & Educational Psychology, 9(1), 142–152.  
https://doi.org/10.1080/21683603.2020.1763877

Mullis, I., Martin, M., Foy, P., Kelly, D., & Fishbein, B. (2020). TIMSS 2019 International Results in Mathematics and Science. TIMSS & PIRLS International Study Center, Boston College. <https://timssandpirls.bc.edu/timss2019/international-results/>

OECD (2023), PISA 2022 Results (Volume I and II) - Country notes: Philippines, PISA, OECD Publishing, Paris. <https://www.oecd.org/en/publications/pisa-2022-results-volume-i-and-ii-country-notes_ed6fbcc5-en/philippines_a0882a2d-en.html>

Ocampo, E., Mobo, F., & Cutillas, A. (2023). Exploring the relationship between mathematics performance and learning style among Grade 8 students. International Journal of Multidisciplinary: Applied Business and Education Research, 4(4), 1165 – 1172. <http://dx.doi.org/10.11594/ijmaber.04.04.14>

Okigbo, E. C., & Onoshakpokaiye, E. O. (2023). Relationship between academic motivation and academic performance of secondary school students in Mathematics. Indonesian Journal of Learning Education and Counseling, 6(1), 10-16. doi.org/10.31960/ijolec.V6i1.2058

Oluwadamilare, A., Olufemi, S., & Oluwadaisi, O. (2024). Effects of Motivation on Students’ Academic Performance in Mathematics in Lagos Metropolis. Al-Hikmah Journal of Education, 11(1), 32-38.

Pina, V., Martella, D., Moscoso, S., Saracostti, M., & Cortes, J. (2021). Gender-based performance in mathematical facts and calculations in two elementary school samples from Chile and Spain: An exploratory study. Front. Psychol. *12:703580*. doi: 10.3389/fpsyg.2021.703580

Ramirez, C. L., & Mercado, H. A. R. (2023). Mathematical achievements with or without games in Hinangutdan Public Secondary High School, Samar, Philippines. Jurnal Pendidikan Progresif, 13(2), 461-470. doi: 10.23960/jpp.v13.i2.202323.

Ramos, S., Legaspi, I., Sabal, J., & Doroja, G. (2018). Mobile DaMath: A game for basic numeracy exercise. Int. J. Arts and Technology (IJAT), 6(3), 246–254.

Shah, N. H., Nazir, N., Arshad, M., & Akhter, K. (2023). Effect of students’ attitude towards Mathematics on their mathematical achievement at secondary school level. International Journal of Engineering and Technology (IJET), 18(12), 178-191. https://doi.org/10.3991/ijet.v18i12.38765

Sun, L., Chen, X., & Ruokamo, H. (2021). Digital game-based pedagogical activities in primary education. A review of ten years’ studies. International Journal of Technology in Teaching and Learning (IJTTL), 16(2), 78-92. <https://jitp.commons.gc.cuny.edu/issues/>

Taber, K. S. (2018). The use of Cronbach’s alpha when developing and reporting research instruments in science education. Research in science education, 48(6), 1273-1296.

Tanghal, A. (2020). IGC: A Play-based Approach to Improve Concept and Operations on Integers. ASEAN Multidisciplinary Research Journal, 6. <https://www.paressu.org/online/index.php/aseanmrj/article/view/259>

Tavakol, M., & Dennick, R. (2011). Making sense of Cronbach's alpha. International journal of medical education, 2, 53.

Triantafyllou, S. (2022). Constructivist learning environments. 5th International Conference on Advanced Research in Teaching and Education. 1-6.

Türkoğlu, B. (2019). A mixed method research study on the effectiveness of board game based cognitive training programme. International Journal of Progressive Education (IJPE), 15(5), 315-344. doi: 10.29329/ijpe.2019.212.21

Wakhata, R., Mutarutinya, V., & Balimuttajjo, S. (2023). Secondary school students’ attitude towards mathematics word problems. Humanities and Social Sciences Communications*,* 1-11. https://doi.org/10.1057/s41599-022-01449-1

Wang, X., Perry, L., Malpique, A., & Ide, T. (2023). Factors predicting mathematics achievement in PISA: A systematic review. Large-scale Assessments in Education, 11(24), 1-24. <https://doi.org/10.1186/s40536-023-00174-8>

Xie, G., & Liu, X. (2023). Gender in mathematics: How gender role perception influences mathematical capability in junior high school. The Journal of Chinese Sociology,10(10), 1-23. https://doi.org/10.1186/s40711-023-00188-3

Xi, N., & Hamari, J. (2019). Does gamification satisfy needs? A study on the relationship between gamification features and intrinsic need satisfaction. International Journal of Information Management, 46, 210-221. https://doi.org/10.1016/j.ijinfomgt.2018.12.002