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Modeling the Predictors of Perceived Usability of InteRaid: A Structural Equation Approach to Student Satisfaction

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Abstract. Mathematics is an essential subject as it develops critical thinking and problem-solving skills, but many junior high school students have difficulty with the abstract concepts of mathematics, especially integer operations. Thus, this research investigates the diverse factors influencing how student users of InteRaid: The Battle of Numbers perceive their experience within the game, as determined by Structural Equation Modeling (SEM). A quantitative descriptive-evaluative research design was utilized and involved 150 junior high school participants who participated through a stratified random sample and were assessed using validated instruments. In addition to using validated instruments to collect data on usability (i.e., assessing knowledge and perception and attitude and satisfaction measured through playability, narrative, enjoyment and creativity, audio-visual properties of aesthetics, personal gratification, social connection, and visual aesthetics), researchers assessed descriptive statistics (mean and standard deviation) using Jamovi software as well as utilizing SEM to assess model performance and determine predictive power. Researchers determined that participants found the game to be usable and provided satisfaction for every aspect evaluated. SEM results indicated that satisfaction could be predicted by combining knowledge, perception, and attitude, with knowledge being the strongest predictor. The structural model has demonstrated to have both acceptable model fit and predictive power. The study concludes that enhancing the usability features in interactive math games can lead to a large increase in both student satisfaction and their level of engagement while learning integer operations.

Keywords: Game-based learning; InteRaid; Satisfaction; Usability

Introduction

Mathematics plays an important role in the development of logical reasoning and thinking skills, but unfortunately, some students experience difficulties in arithmetic operations, especially in integer operations, which may lead to poor performance in the subject and the development of unfavorable attitudes toward it. Globally, even in the Philippines, students still lag behind in math proficiency as shown in Programme for International Student Assessment (PISA). In 2022, the Philippines had a score of 355 in math, which is still below the OECD average in math proficiency, which is 472 (Organization for Economic Co-operation and Development [OECD], 2023). Hence, the Department of Education advocates contextualized, interactive, and technology-based approaches in teaching methodologies (DepEd Memorandum No. 55, s. 2016; DepEd Order No. 21, s. 2019) in establishing an engaging classroom for the students.

In particular, students at Malintubonan National High School still experience difficulties in integer operations as shown in their Mean Percentage Scores (MPS) for the past years, which have been between

65% and 70%. Although the conventional approach is frequently implemented, it is possible that the conventional approach may not fully meet the needs. In fact, research findings indicate that using game-based learning and incorporating technology can have a significant positive effect on students' engagement, particularly for students who are having difficulties with abstract concepts (Ke, 2008; Plass et al., 2015).

Game-based learning, according to some studies, has proven to be an effective approach in improving students' motivation, engagement, and problem-solving abilities (Kebritchi et al., 2017; Qian & Clark, 2016). However, the incorporation of instructional games in public secondary schools remains in its introductory phase. Therefore, the researchers created an interactive math game, titled *InteRaid: The Battle of Numbers*, in order to create an engaging learning environment that would improve the students' understanding of integer operations in a dynamic and technology-driven way.

The study is anchored on the theories of Game-Based Learning (Gee, 2003) and Behaviorist Learning Theory (Skinner, 1953), which focus on the importance of engaging, repetitive, reinforcing, and immediately rewarding learning activities as essential components of an effective learning process. *InteRaid* embodies these learning theories with its levels of difficulty, real-time feedback, scoring, and interactive features that promote active learning and interest.

The primary purpose of this study was to create and validate a structural model that would account for the relationship between the usability factors and the level of satisfaction that students derive from the interactive math game. More particularly, the study aimed to determine the ways in which the students evaluate the usability of the game in terms of the knowledge gained, perceptions, and attitudes, and the ways in which these would affect the level of satisfaction and attitudes that the students derive from the game in terms of the following dimensions: playability, narratives, play engrossment, enjoyment, creativity, audio aesthetics, personal gratification, social connectivity, and visual aesthetics.

To address the need for a thorough evaluation of educational games, this study used Structural Equation Modeling (SEM) to examine the relationships between different factors, particularly how game usability affects students' satisfaction. SEM was chosen because it allows for the analysis of multiple related variables, which helps to clarify how different game elements contribute to a better learning experience. As a result, this research was able to identify key predictors of satisfaction, which were used to create an effective, engaging, and student-friendly educational game that would promote mathematical knowledge and motivation.

Research Questions

This study examines students' evaluations of usability and satisfaction while playing *InteRaid: The Battle of Numbers* for the school year 2025-2026.

Specifically, it aims to answer the following questions:

1. How do students evaluate the overall usability of *InteRaid* in terms of:
 - 1.1 knowledge
 - 1.2 perception; and
 - 1.3 attitudes?
2. What is the level of students' satisfaction and attitude towards *InteRaid* in terms of:
 - 2.1 Playability
 - 2.2 Narratives
 - 2.3 Play Engrossment
 - 2.4 Enjoyment
 - 2.5 Creative Freedom
 - 2.6 Audio Aesthetics
 - 2.7 Personal Gratification
 - 2.8 Social Connectivity; and
 - 2.9 Visual Aesthetics?
3. Does students perceived usability (knowledge, perception, and attitudes) of *InteRaid* significantly influence their overall satisfaction with the interactive math game?
4. Does the proposed structural equation model demonstrate acceptable model fit, predictive relevance, and explanatory power for evaluating an interactive math game?

Scope and Delimitation of the Study

The present investigation assessed the usability of *InteRaid*, focusing on knowledge acquisition, perceptual understanding, and attitudinal responses, alongside student satisfaction, which encompassed playability, narrative quality, play engrossment, enjoyment, creative freedom, audio design, personal gratification, social connectivity, and visual design. Furthermore, the study explored the impact of usability factors on satisfaction levels and constructed a structural model employing Structural Equation Modeling (SEM) techniques. The study included 150 junior high school students from Malintubogan National High School. These students were selected using stratified random sampling. The research used validated

questionnaires and quantitative analysis methods. It was limited to one interactive math game focused on integer operations, used only quantitative data, and was confined to one school, limiting generalizability. It was limited to one math game with integer operations only, used only quantitative data, and was conducted in one school only.

Literature Review

Game-based learning has been widely accepted as an effective approach to improve students' cognitive, effective, and behavioral outcomes. Empirical research and meta-analysis have strongly supported game-based learning as an approach to enhance knowledge, perception, attitudes, and satisfaction in an educational context. In terms of knowledge, game-based learning can play an important role in enhancing students' critical thinking skills. In a meta-analysis study done by Mao et al. in the year 2022, the effectiveness of game-based learning in improving the critical thinking skills of the students was analyzed. It was concluded from the study that the effect of game-based learning on the critical thinking skills of the students is quite high and positive. The result of the study showed that there was a significant positive effect of game-based learning on the critical thinking skills of the students with a g -value of 0.863. Game-based learning was found to have a moderate to large effect on cognitive development, such as memory, attention, problem-solving, etc. This indicates the effectiveness of game-based learning as a strategy for improving knowledge acquisition among learners. In terms of perception, it has been found that game-based learning can increase students' perceived usefulness and effectiveness. Pacheco-Velazquez et al. (2024) discovered that learning environments through games fostered self-directed learning among students. Further, it is discovered that students' attitudes towards GBL are important in motivating their learning. A systematic review done by Soriano-Sánchez (2026) showed that GBL enhances students' motivation, self-efficacy, and performance. This again emphasized the need for students' attitudes in a technology-based learning environment. Regarding students' satisfaction, various aspects are important to ensure optimal experience in GBL. According to research, enjoyment is a primary factor in GBL, which ensures a high level of motivation for learning. For example, Sung and Hwang (2018) proved that an enjoyable GBL environment was highly beneficial in boosting students' motivation and improving their academic performance.

In addition, playing engrossment, or playing immersion, is vital in enhancing students' persistence in GBL. Denis and Jouvelot (2022) demonstrated that an immersive serious game boosted students' persistence in GBL, thus improving their academic performance. Moreover, the importance of creative freedom in GBL is emphasized in literature. According to a study carried out by Lin and Wu (2016), a digital GBL environment was highly beneficial in boosting creativity, curiosity, and exploratory learning. The role of audio-visual aesthetics in the user experience should be noted as well. Research has shown that multimedia components, if designed in an aesthetically pleasing manner, contribute significantly to the learner's experience. For instance, Byun and Loh (2018) showed that audio components significantly contributed to the improvement of learner engagement. Regarding the aspect of personal gratification, it is worth noting that the use of feedback, reward, and progression mechanisms in gamification contributed significantly to the improvement of learner engagement and attitude, as shown by Hanus and Fox (2015). Social interaction is another important dimension. Domínguez et al. (2017) demonstrated that multiplayer and collaborative features in educational games enhanced student interaction, engagement, and peer learning experiences. Finally, the relationship between usability and satisfaction has already been established. Cognitive readiness, positive perceptions, and positive attitudes have a combined influence on satisfaction in a digital learning environment. The research of Khoa et al. (2020) indicated that the perceived usability and design of the system had a significant influence on the satisfaction of students. The literature review indicates that a game-based learning environment with elements of knowledge development, positive perceptions, and positive attitudes results in higher satisfaction, motivation, and learning outcomes for students.

Methodology

Research Design

This investigation employed a quantitative, descriptive-evaluative research design to evaluate students' usability experiences and satisfaction levels concerning InteRaid. The descriptive component investigated usability, encompassing knowledge, perceptions, and attitudes, alongside satisfaction across diverse game dimensions, aligning with established descriptive research methodologies (Creswell & Creswell, 2018). The evaluative dimension then analyzed the correlation between usability and satisfaction, mirroring program evaluation techniques (Patton, 2008). Moreover, Structural Equation Modeling (SEM) was used to find predictive relationships between the variables, and to evaluate how well the model fit the data and how well it explained the results (Hair et al., 2019; Kline, 2016).

Sampling Design

The research utilized stratified random sampling to guarantee proportional representation across different grade levels, thus bolstering reliability and mitigating sampling bias (Creswell & Creswell, 2018). A sample of 150 respondents was randomly chosen from a total population of 278 students, employing the Raosoft sample size calculator to secure a sufficiently large and statistically representative sample. Stratified sampling is frequently advocated for studies involving diverse groups to enhance representativeness (Etikan & Bala, 2017).

Research Locale

The study was conducted at Malintubuan National High School, Malintubuan, Labason, Zamboanga del Norte. This school was the setting for both interactive math game implementation and the data collection.

Research Participants

The study's respondents were 150 junior high school students from Malintubuan National High School. Stratified random sampling was used to select them, ensuring a representative sample from different grade levels. Before completing the evaluation instruments, all participants played the interactive math game.

Research Instrument

Validated survey instruments were adopted in the study. The Survey Instrument on Game-Based Learning Approach (SIGBLA), developed by Quinto (2022), was adopted for use to gauge students' knowledge, perception, and attitude towards the approach. The other survey instrument that was used is Game User Experience Satisfaction Scale (GUESS) as developed by Phan et al. (2016), and it was used to measure students' satisfaction regarding aspects like playability, narration, play engrossment, enjoyment, creativity, audio aesthetics, personal satisfaction, socialization, and visual aesthetics. The two survey instruments were applied on a four-point Likert scale that is typically used in measuring perceptions and attitudes in educational studies (Joshi et al., 2015).

Data Gathering Procedure

InteRaid: The Battle of Numbers was first developed using HTML and then transformed into an Android app, which was further pilot tested for functionality and accuracy. It is usual in educational technology that pilot testing is performed to ascertain functionality and accuracy, after which the technology is made available for use by students (Pressman & Maxim, 2020). Before collecting data, the researcher obtained necessary permissions from the school head, and coordination with the class advisers was also undertaken. Informed consent was sought from the respondents and their parents or guardians, in line with ethical principles in educational research (Creswell & Creswell, 2018). After implementing the mobile app, the respondents answered validated questionnaires regarding their experience with the same. Data obtained were entered and analyzed using Jamovi software through descriptive statistics and structural equation modeling.

Results and Discussions

Problem 1. How do students evaluate the overall usability of InteRaid in terms of knowledge, perception, and attitudes?

Table 1: Overall Usability of InteRaid in Terms of Knowledge

	Knowledge	Mean	SD	Interpretation
1.	I just need a very short time to know how the game is functioning.	2.88	0.732	Agree
2.	These computer games help me to think critically.	2.99	0.665	Agree
3.	I feel very capable and effective when playing.	2.79	0.808	Agree
4.	Solving the given problems is very interesting.	2.94	0.876	Agree
5.	I enjoyed playing mobile educational games very much.	2.83	0.817	Agree
6.	Looking for the answer of questions given is an encouraging activity.	2.88	0.802	Agree
7.	I find it more interesting to learn the subjects through online competitive games.	2.87	0.797	Agree
	Grand Mean	2.88		Agree

Table 1 presents the overall usability of InteRaid in terms of knowledge. The respondents got the highest mean ($M = 2.99$, $SD = 0.665$) on the statement "These computer games help me to think critically,"

with its interpretation as "Agree," implying that the game is very effective in enhancing the critical thinking ability of the students. On the other hand, the respondents got the lowest mean ($M = 2.79$, $SD = 0.808$) on the statement "I feel very capable and effective when playing" which with its interpretation as "Agree" implying that there is some variability on the part of the students regarding their self-efficacy when using the game. The overall mean of 2.88 indicates that the students generally agreed on the game's usability. This suggests that the students had a positive view of the game, particularly regarding its ability to impart knowledge, encourage engagement, and influence their attitudes. Game-based learning can significantly improve students' critical thinking ability suggesting that interactive math games are a very effective educational tool (Mao et al., 2022).

Table 2: Overall Usability of InteRaid in Terms of Perceptions

	Perceptions	Mean	SD	Interpretation
1.	I think learning shouldn't have fun as a necessary requirement.	2.51	0.849	Agree
2.	Online competitive games enable continuous learning.	2.73	0.841	Agree
3.	The points-based incentive system in games is also a contributing factor to continuous learning.	2.77	0.806	Agree
4.	Game-Based Learning could help me learn the knowledge on mathematics.	3.03	0.768	Strongly Agree
5.	This "game-based learning" could help me apply what I learned.	2.94	0.796	Agree
6.	I believe that GBL could extend my knowledge about mathematics.	2.95	0.792	Agree
7.	I think activities/tasks in educational games give me lots of benefits.	2.88	0.843	Agree
8.	I wish I have more opportunities to learn using this game approach.	2.97	0.768	Agree
	Grand Mean	2.84		Agree

Table 2 presents the overall usability of InteRaid in terms of perceptions. The respondents got the highest mean ($M = 3.03$, $SD = 0.768$) on the statement "Game-Based Learning could help me learn the knowledge on mathematics" with its interpretation as "Strongly Agree," implying that the game is highly effective in helping students understand mathematical concepts. On the other hand, the respondents got the lowest mean ($M = 2.51$, $SD = 0.849$) on the statement "I think learning shouldn't have fun as a necessary requirement," with its interpretation as "Agree," implying that some students still hold traditional views about learning and may not fully associate fun with effective learning. Overall, the grand mean of 2.84 indicates that the students generally agreed with the positive perception of game-based learning. This suggests that students have a favorable view of the game, particularly in terms of knowledge acquisition, engagement, and learning experience. Positive perceptions of game-based learning are significantly associated with improved mathematics performance and student engagement (Kalogiannakis et al., 2021).

Table 3: Overall Usability of InteRaid in Terms of Attitudes

	Attitude	Mean	SD	Interpretation
1.	I prefer using games to learn compared to traditional methods in the class.	2.75	0.867	Agree
2.	I would like to learn all education subjects using the educational game.	2.76	0.800	Agree
3.	I hope these educational games will be available online for easy access.	2.81	0.847	Agree
4.	I can learn according to my own pace and sequence.	2.74	0.847	Agree
	Grand Mean	2.76		Agree

Table 3 presents the evaluation of students' attitudes toward the use of InteRaid. The respondents got the highest mean ($M = 2.81$, $SD = 0.847$) on the statement "I hope these educational games will be available online for easy access" with its interpretation as "Agree," implying that students have a strong preference for accessible and flexible game-based learning environments. On the other hand, the respondents got the lowest mean ($M = 2.74$, $SD = 0.847$) on the statement "I can learn according to my own pace and sequence," with its interpretation as "Agree," implying that there is some variability in students' perceptions of self-paced learning when using the game. The overall mean score of 2.76 suggests that students generally agreed with the attitude statements. This implies that students have positive views on using game-based learning, particularly regarding its accessibility, flexibility, and preference over traditional teaching methods. Positive student attitudes are significantly associated with the adoption and effectiveness of game-based mathematics instruction (Kalogiannakis et al., 2021).

Table 4: Summary Table of the Level of Students' Evaluation of the Overall Usability of InteRaid

Students' Evaluation of Overall Usability	Grand Mean	Interpretation
Knowledge	2.88	Agree
Perception	2.84	Agree
Attitudes	2.76	Agree
Average Grand Mean	2.83	Agree

Table 4 summarizes the overall usability assessment of the InteRaid. This indicates that students held favorable opinions of the game, as evidenced by their average scores of 2.88, 2.84, and 2.76 in the areas of knowledge, perception, and attitude, respectively. These scores correspond to the "Agree" rating. Consequently, these findings imply that the game is beneficial in facilitating the learning process, shaping perceptions of game-based learning, and fostering positive attitudes toward learning. Generally, the overall usability of the game was rated at 2.83, and this is an indication that the students agreed on the usability of the game. This is a clear indication that the game is effective in the learning and teaching of mathematical concepts, such as integer operation, and the overall usability is a function of the knowledge, perception, and attitude of the student towards the game. Using games in education improved students' performance, motivation, and attitudes toward mathematics (Kalogiannakis et al., 2021).

Problem 2. What is the level of students' satisfaction and attitude towards the interactive math game in terms of: Playability, Narratives, Play Engrossment, Enjoyment, Creative Freedom, Audio Aesthetics, Personal Gratification, Social Connectivity and Visual Aesthetics?

Table 5: Level of Students' Satisfaction and Attitude InteRaid in Terms of Usability/Playability

	Usability/Playability	Mean	SD	Interpretation
1.	I think it is easy to learn how to play the game.	2.71	0.846	Agree
2.	I find the controls of the game to be straightforward.	2.80	0.714	Agree
3.	I always know how to achieve my goals/objectives in the game.	2.82	0.844	Agree
4.	I find the game's interface to be easy to navigate.	2.76	0.783	Agree
5.	I do not need to go through a lengthy tutorial or read manual to play the game.	2.53	0.800	Agree
6.	I find the game's menus to be user friendly.	2.89	0.787	Agree
7.	I feel the game trains me well in all of the controls.	2.84	0.786	Agree
8.	I always know my next goal when I finish an event in the game.	2.90	0.809	Agree
9.	I feel the game provides me the necessary information to accomplish a goal within the game.	2.91	0.695	Agree
10.	I think the information provided in the game (e.g., onscreen messages, help) is clear.	2.97	0.789	Agree
11.	I feel very confident while playing the game.	2.87	0.753	Agree
	Grand Mean	2.81		Agree

Table 5 presents the evaluation of usability and playability of InteRaid. The respondents got the highest mean ($M = 2.97$, $SD = 0.789$) on the statement "I think the information provided in the game (e.g., onscreen messages, help) is clear" with its interpretation as "Agree," implying that the game effectively provides clear instructions and guidance that support learning. On the other hand, the respondents got the lowest mean ($M = 2.53$, $SD = 0.800$) on the statement "I do not need to go through a lengthy tutorial or read manual to play the game," with its interpretation as "Agree," implying that some students experienced minor difficulty with the game's initial instructions or onboarding process. Overall, the grand mean of 2.81 indicates that students generally agreed with the usability and playability of the game. This suggests that the game provides a smooth, user-friendly, and engaging experience in terms of controls, navigation, and clarity of goals. Higher usability and playability in game-based learning are associated with increased student engagement and sustained learning in mathematics (Kalogiannakis et al., 2021).

Table 6: Level of Students' Satisfaction and Attitude Towards InteRaid in Terms of Narratives

	Narratives	Mean	SD	Interpretation
1.	I think the characters in the game are well developed.	2.94	0.707	Agree
2.	I am captivated by the game's story from the beginning.	2.85	0.772	Agree
3.	I enjoy the fantasy or story provided by the game.	2.89	0.770	Agree
4.	I can identify with the characters in the game.	2.73	0.843	Agree

5.	I am emotionally moved by the events in the game.	2.81	1.739	Agree
6.	I am very interested in seeing how the events in the game will progress.	2.94	0.805	Agree
7.	I can clearly understand the game's story.	2.89	0.773	Agree
Grand Mean		2.86		Agree

Table 6 presents the evaluation of the narrative aspects of InteRaid. The respondents got the highest mean ($M = 2.94$, $SD = 0.707/0.805$) on the statements “I think the characters in the game are well developed” and “I am very interested in seeing how the events in the game will progress,” with the interpretation “Agree,” implying that the game’s storyline and character development effectively engage students. On the other hand, the respondents got the lowest mean ($M = 2.73$, $SD = 0.843$) on the statement “I can identify with the characters in the game,” with its interpretation as “Agree,” implying that some students experienced difficulty relating to the characters despite the overall positive narrative experience. Overall, the grand mean of 2.86 indicates that students generally agreed with the narrative aspects of the game. This suggests that the storyline, progression, and character development contribute positively to engagement and learning. Narrative elements in game-based learning are associated with increased motivation and engagement in mathematics (Kalogiannakis et al., 2021).

Table 7: Level of Students’ Satisfaction and Attitude Towards InteRaid in Terms of Play Engrossment

	Play Engrossment	Mean	SD	Interpretation
1.	I feel detached from the outside world while playing the game.	2.63	0.781	Agree
2.	I do not care to check events that are happening in the real world during the game.	2.41	0.837	Agree
3.	I cannot tell that I am getting tired while playing the game.	2.71	0.909	Agree
4.	Sometimes I lose track of time while playing the game.	2.68	0.771	Agree
5.	I temporarily forget about my everyday worries while playing the game.	2.75	0.819	Agree
6.	I tend to spend more time playing the game than I have planned.	2.79	1.754	Agree
7.	I can block out most other distractions when playing the game.	2.69	0.835	Agree
8.	Whenever I stopped playing the game, I cannot wait to start playing it again.	2.77	0.814	Agree
Grand Mean		2.67		Agree

Table 7 presents the evaluation of play engrossment in InteRaid. The respondents got the highest mean ($M = 2.79$, $SD = 1.754$) on the statement “I tend to spend more time playing the game than I have planned” with its interpretation as “Agree,” implying that the game effectively captures students’ attention and sustains engagement beyond their initial intention. On the other hand, the respondents got the lowest mean ($M = 2.41$, $SD = 0.837$) on the statement “I do not care to check events that are happening in the real world during the game,” with its interpretation as “Agree,” implying that while students are engaged, full immersion or detachment from the real world is somewhat limited. The overall mean score of 2.67 suggests that students generally found the game engaging. This implies that the game offers a moderately immersive experience, which supports continued involvement and interaction. Higher levels of play engrossment in educational games are linked to more time spent on the task and greater persistence in learning (Denis & Jouvelot, 2022).

Table 8: Level of Students’ Satisfaction and Attitude Towards InteRaid in Terms of Enjoyment

	Enjoyment	Mean	SD	Interpretation
1.	I think the game is fun.	2.85	0.857	Agree
2.	I enjoy playing the game.	2.83	0.817	Agree
3.	I feel bored while playing the game.	2.57	0.907	Agree
4.	I am likely to recommend this game to others.	2.96	0.759	Agree
5.	If given the chance, I want to play this game again.	2.89	0.796	Agree
Grand Mean		2.82		Agree

Table 8 presents the evaluation of enjoyment in InteRaid. The respondents got the highest mean ($M = 2.96$, $SD = 0.759$) on the statement “I am likely to recommend this game to others” with its interpretation as “Agree,” implying that students found the game enjoyable and worth sharing with others. On the other hand, the respondents got the lowest mean ($M = 2.57$, $SD = 0.907$) on the statement “I feel bored while playing the game,” with its interpretation as “Agree,” implying that while some students experienced occasional boredom, it was not a dominant aspect of their overall experience. The grand mean of 2.82

suggests that students generally had a positive view of the game. This indicates that the game was engaging, enjoyable, and motivating for them. Moreover, the enjoyment experienced in game-based learning environments is significantly linked to increased motivation and improved learning results (Sung & Hwang, 2018).

Table 9: Level of Students' Satisfaction and Attitude Towards InteRaid in Terms of Creative Freedom

	Creative Freedom	Mean	SD	Interpretation
1.	I feel the game allows me to be imaginative.	2.95	0.727	Agree
2.	I feel creative while playing the game.	2.85	0.754	Agree
3.	I feel the game gives me enough freedom to act how I want.	2.77	0.761	Agree
4.	I feel the game allows me to express myself.	2.83	0.775	Agree
5.	I feel I can explore things in the game.	2.77	0.812	Agree
6.	I feel my curiosity is stimulated as the result of playing the game.	2.91	0.698	Agree
7.	I think the game is unique or original.	3.03	0.695	Strongly Agree
	Grand Mean	2.87		Agree

Table 9 presents the evaluation of creative freedom in InteRaid. The respondents got the highest mean ($M = 3.03$, $SD = 0.695$) on the statement "I think the game is unique or original" with its interpretation as "Strongly Agree," implying that students highly recognize the game's originality and uniqueness as key aspects of their experience. On the other hand, the respondents got the lowest mean ($M = 2.77$, $SD = 0.761/0.812$) on the statements "I feel the game gives me enough freedom to act how I want" and "I feel I can explore things in the game," both interpreted as "Agree," implying that while students experienced autonomy and exploration, these aspects were slightly less emphasized compared to the game's originality. The overall grand mean of 2.87 indicates that students generally agreed with the game's creative freedom. This suggests that the game encourages students to express their creativity, explore ideas, and engage in imaginative learning in mathematics. Digital game-based learning environments significantly enhance students' creativity and curiosity in academic learning (Lin & Wu, 2016).

Table 10: Level of Students' Satisfaction and Attitude Towards InteRaid in Terms of Audio Aesthetics

	Audio Aesthetics	Mean	SD	Interpretation
1.	I enjoy the sound effects in the game.	2.87	0.771	Agree
2.	I enjoy the music in the game.	2.78	0.703	Agree
3.	I feel the game's audio (e.g., sound effects, music) enhances my gaming experience.	2.89	0.687	Agree
4.	I think the game's audio fits the mood or style of the game.	2.85	0.809	Agree
	Grand Mean	2.84		Agree

Table 10 presents the evaluation of audio aesthetics in InteRaid. The respondents got the highest mean ($M = 2.89$, $SD = 0.687$) on the statement "I feel the game's audio (e.g., sound effects, music) enhances my gaming experience" with its interpretation as "Agree," implying that audio elements significantly enhance students' overall gaming and learning experience. On the other hand, the respondents got the lowest mean ($M = 2.78$, $SD = 0.703$) on the statement "I enjoy the music in the game," with its interpretation as "Agree," implying that while students appreciate the audio, the music aspect may be less impactful compared to other sound features. Overall, the grand mean of 2.84 indicates that students generally agreed with the audio aesthetics of the game. This suggests that sound effects and music contribute positively to engagement and user experience. Audio elements in game-based learning environments significantly enhance learner engagement and overall satisfaction (Byun & Loh, 2018).

Table 11: Level of Students' Satisfaction and Attitude Towards InteRaid in Terms of Personal Gratification

	Personal Gratification	Mean	SD	Interpretation
1.	I am in suspense about whether I will succeed in the game.	2.78	0.767	Agree
2.	I feel successful when I overcome the obstacle in the game.	2.89	0.743	Agree
3.	I want to do as well as possible during the game.	2.87	0.720	Agree
4.	I am very focused on my own performance while playing the game.	2.87	0.739	Agree
5.	I feel the game constantly motivates me to proceed further to the next stage or level.	2.91	0.777	Agree
6.	I find my skills gradually improve through the course of overcoming the challenges in the game.	2.89	0.761	Agree
	Grand Mean	2.86		Agree

Table 11 presents the evaluation of personal gratification in InteRaid. The respondents got the highest mean ($M = 2.91$, $SD = 0.777$) on the statement "I feel the game constantly motivates me to proceed further to the next stage or level" with its interpretation as "Agree," implying that the game effectively motivates students to continue progressing and improving. On the other hand, the respondents got the

lowest mean ($M = 2.78$, $SD = 0.767$) on the statement “I am in suspense about whether I will succeed in the game,” with its interpretation as “Agree,” implying that while students feel motivated, the level of suspense or challenge may be slightly less emphasized. Overall, the grand mean of 2.86 indicates that students generally agreed with the personal gratification provided by the game. This suggests that the game supports motivation, achievement, and a sense of progress in learning mathematics. Personal gratification in game-based learning is associated with positive learning attitudes and increased engagement (Hanus & Fox, 2015).

Table 12: Level of Students’ Satisfaction and Attitude Towards InteRaid in Terms of Social Connectivity

	Social Connectivity	Mean	SD	Interpretation
1.	I find the game supports social interaction (e.g., chat) between players.	2.77	0.923	Agree
2.	I like to play this game with other players.	2.88	0.785	Agree
3.	I am able to play the game with other player if I choose.	2.89	0.796	Agree
4.	I enjoy the social interaction within the game.	2.88	0.810	Agree
	Grand Mean	2.85		Agree

Table 12 presents the evaluation of social connectivity in InteRaid. B The respondents got the highest mean ($M = 2.89$, $SD = 0.796$) on the statement “I am able to play the game with other players if I choose” with its interpretation as “Agree,” implying that students value the option for multiplayer interaction and collaborative learning. On the other hand, the respondents got the lowest mean ($M = 2.77$, $SD = 0.923$) on the statement “I find the game supports social interaction (e.g., chat) between players,” with its interpretation as “Agree,” implying that while social features are present, communication tools may be less emphasized or developed. Overall, the grand mean of 2.85 indicates that students generally agreed with the social connectivity of the game. This suggests that the game supports collaboration and peer interaction, contributing to a more engaging learning experience. Social and multiplayer elements in educational games enhance student engagement and interaction (Domínguez et al., 2017).

Table 13: Level of Students’ Satisfaction and Attitude Towards InteRaid in Terms of Visual Aesthetics

	Visual Aesthetics	Mean	SD	Interpretation
1.	I enjoy the game’s graphics.	2.94	0.805	Agree
2.	I think the graphics of the game fit the mood or style of the game.	2.91	0.750	Agree
3.	I think the game is visually appealing.	2.94	0.735	Agree
	Grand Mean	2.93		Agree

Table 13 presents the evaluation of visual aesthetics in InteRaid. The respondents got the highest mean ($M = 2.94$, $SD = 0.805/0.735$) on the statements “I enjoy the game’s graphics” and “I think the game is visually appealing,” both interpreted as “Agree,” implying that the game’s graphics and visual appeal strongly contribute to students’ engagement. On the other hand, the respondents got the lowest mean ($M = 2.91$, $SD = 0.750$) on the statement “I think the graphics of the game fit the mood or style of the game,” with its interpretation as “Agree,” implying that while visuals are highly appreciated, there is slight room for improvement in stylistic consistency. Overall, the grand mean of 2.93 indicates that students generally agreed with the visual aesthetics of the game. This suggests that the game’s graphics and design effectively enhance engagement and learning experience. This is supported by Tan et al. (2021), which states that strong visual aesthetics in game-based learning are associated with increased immersion and improved learning performance.

Table 14: The Summary Table of the Level of Students’ Satisfaction Toward InteRaid

Students’ Satisfaction	Grand Mean	Interpretation
1. Playability	2.81	Agree
2. Narratives	2.86	Agree
3. Play Engrossment	2.67	Agree
4. Enjoyment	2.82	Agree
5. Creative Freedom	2.87	Agree
6. Audio Aesthetics	2.84	Agree
7. Personal Gratification	2.86	Agree
8. Social Connectivity	2.85	Agree
9. Visual Aesthetics	2.93	Agree
Average Grand Mean	2.83	Agree

Table 14 presents the summary of students’ satisfaction in InteRaid. The data indicates that students expressed agreement across all satisfaction dimensions. Specifically, the means were as follows: playability ($M = 2.81$), narratives ($M = 2.86$), play engrossment ($M = 2.67$), enjoyment ($M = 2.82$), creative freedom ($M = 2.87$), audio aesthetics ($M = 2.84$), personal gratification ($M = 2.86$), social connectivity ($M = 2.85$), and

visual aesthetics ($M = 2.93$). These findings suggest a general trend of positive satisfaction with the game. The overall mean score of 2.83 suggests that students generally agreed and were satisfied with the game's features. This indicates the game's engaging and effective nature, with visual appeal being the most important factor in their satisfaction. Furthermore, it implies that a combination of design quality, interactivity, motivation, and sensory elements enhances students' engagement and learning in mathematics. Gamification elements like aesthetics, feedback, and social interaction significantly improve students' motivation, engagement, and learning outcomes (Sailer & Homner, (2020).

Problem 3. Does students perceived usability of InteRaid significantly influence their overall satisfaction with the interactive math game?

Table 15: Direct Effects of Knowledge, Perception, and Attitude on Students' Satisfaction

Hypothesis	β	P-value	SE	f^2
H1a. $K \rightarrow S$	0.397	<0.001	0.075	0.271
H1b. $P \rightarrow S$	0.176	0.013	0.079	0.095
H1c. $A \rightarrow S$	0.325	<0.001	0.076	0.200

Note. β = standardized path coefficient; SE = standard error; f^2 = effect size. Paths represent the hypothesized direct relationships between knowledge (K), perception (P), attitude (A), and satisfaction (S). Significance is evaluated at $p < .05$.

Table 15 below illustrates the results of the structural model, which indicates the influence of knowledge, perception, and attitude on satisfaction. The results indicate that knowledge has a strong positive influence ($\beta = 0.397$, $p < 0.001$; $f^2 = 0.271$) on satisfaction, making it the most influential factor among the three. Similarly, attitude has a positive influence ($\beta = 0.325$, $p < 0.001$; $f^2 = 0.200$) on satisfaction, indicating that positive feelings towards the game increase satisfaction. On the other hand, perception has a weaker influence ($\beta = 0.176$, $p = 0.013$; $f^2 = 0.095$). All the variables have a positive influence on satisfaction, with knowledge being the most influential, followed by attitude and perception. This indicates that satisfaction among students in a game-based learning environment is a function of a combination of factors, which include knowledge, attitude, and perception. This finding is supported by Chen et al. (2020), which indicates that prior knowledge significantly predicts satisfaction among students in a technology-supported mathematics environment.

Problem 4. Does the proposed Structural Equation Model demonstrate acceptable model fit, predictive relevance, and explanatory power for evaluating an interactive math game?

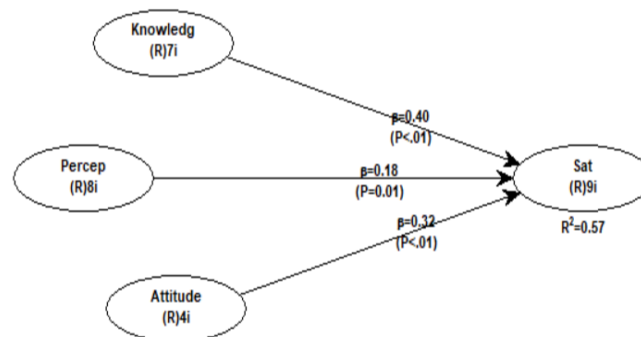


Figure 1. Structural Equation Model Showing the Direct Effects of Knowledge, Perception, and Attitude on Students' Satisfaction

Figure 1 illustrates the structural equation model for the direct effects of knowledge, perception, and attitude on students' satisfaction. The standardized coefficients (β values) and their corresponding p-values reveal the intensity and significance of each construct, whereas the R^2 value represents the variance explained by the model for the dependent variable, i.e., satisfaction. The results showed that knowledge is the factor that influences students' satisfaction the most, followed by attitude and perception, as can be seen in the values of the standardized coefficients (β) and their corresponding p-values in the model. The highest value of the coefficients is related to knowledge ($\beta = 0.40$, $p < 0.01$), followed by attitude ($\beta = 0.32$, $p < 0.01$), and then perception ($\beta = 0.18$, $p = 0.01$). This implies that knowledge, positive attitude, and positive perception of the learning platform contribute significantly to students' satisfaction, and knowledge has the highest impact on it. The results also indicate that the R^2 value of the model is 0.57, which implies that 57% of the variance in satisfaction can be explained by the variables included in the model, and this is a high R^2 value for a regression model. This implies that an effective game-based learning platform should include knowledge, positive perception of usability, and positive attitude, which aligns with the results of the study conducted by Khoa et al. (2020), which found that perceived usability and system design significantly affected student satisfaction in the digital learning environment.

Table 16: Predictive Relevance, Explanatory Power, and Full Collinearity Diagnostics of the Structural Model

Constructs	Full Collinearity VIF	R ²	Q ²
Knowledge	2.156	-	-
Perception	1.599	-	-
Attitude	1.680	-	-
Satisfaction	2.200	0.566	0.565

Note. R² represents the coefficient of determination (explanatory power), Q² denotes Stone–Geisser’s predictive relevance, and FCVIF refers to full collinearity variance inflation factor. R² and Q² values are reported only for endogenous constructs. FCVIF values below 3.3 indicate the absence of multicollinearity and common method bias.

Table 16 below illustrates the evaluation of the structural model based on explanatory power (R²), predictive relevance (Q²), and full collinearity diagnostics (FCVIF). The FCVIF values of knowledge (2.156), perception (1.599), attitude (1.680), and satisfaction (2.200) are below 3.3, thus indicating that multicollinearity does not exist, and common method bias cannot be a threat to the model. The model has strong explanatory power, with an R² of 0.566, thus indicating that 56.6% of the variance of student satisfaction can be explained by the independent variables. Moreover, the model has a strong predictive relevance, with a Q² of 0. The findings suggest that the model demonstrates statistical reliability, thereby exhibiting considerable explanatory capacity. This observation is consistent with Hair et al. (2017), who posit that models characterized by acceptable R², Q², and VIF values possess robust predictive capabilities, and are therefore deemed valid for behavioral research applications.

Table 17: Structural Model Fit and Quality Indices

Model fit and quality indices	Coefficients
APC	0.299, P<0.001
ARS	0.566, P<0.001
AARS	0.557, P<0.001
AVIF	1.651
AFVIF	1.909
Tenenhaus GoF	0.493

Note. APC = Average Path Coefficient; ARS = Average R-squared; AARS = Average Adjusted R-squared; AVIF = Average Variance Inflation Factor; AFVIF = Average Full Collinearity Variance Inflation Factor; GoF = Tenenhaus Goodness of Fit. Significant APC, ARS, and AARS values ($p < .05$), together with AVIF and AFVIF values below 3.3 and a substantial GoF value, indicate an acceptable overall model fit and quality.

Table 17 below illustrates the evaluation of the overall model fit and quality indices of the structural equation model. The results indicate that the Average Path Coefficient (APC = 0.299, $p < 0.001$), Average R-squared (ARS = 0.566, $p < 0.001$), and Average Adjusted R-squared (AARS = 0.557, $p < 0.001$) are statistically significant, indicating that the relationships between the constructs are meaningful. In addition, the results indicate that the collinearity indices, i.e., AVIF (1.651) and AFVIF (1.909), are less than 3.3, which suggests that there is no multicollinearity, hence no common method bias. Moreover, the Goodness of Fit (GoF = 0.493) suggests that the model has a good overall fit. Therefore, the findings support the model's ability to explain students' satisfaction with the interactive math game. This is consistent with Pan et al. (2023), who argued that models with good fit indices, such as SRMR and NFI, are valid in technology-enhanced learning environments.

Ethical Considerations

Ethical guidelines were strictly followed throughout the study. Prior to participation, students were fully informed about the purpose, procedures, and scope of the research. Informed consent was obtained, and participation was entirely voluntary. The participants had the option to leave the study and doing so would not affect them in any way. Confidentiality and anonymity were preserved through the omission of personally identifiable information, with all responses exclusively utilized for research objectives. Furthermore, the study included measures to prevent any physical, psychological, or emotional harm to the participants. To reduce potential risks, such as eye strain from long periods of screen use, appropriate breaks were included in the gameplay sessions.

Conclusion

The study concluded that InteRaid: The Battle of Numbers is an effective and interesting interactive math game that improves students' learning experience for integer calculations. The students showed positive evaluations of usability based on their knowledge, perceptions, and attitudes. The students also showed high levels of satisfaction for playability, narratives, play engrossment, enjoyment, creative freedom, audio aesthetics, personal gratification, social connectivity, and visual aesthetics. Moreover, the results showed that usability has a significant impact on students' satisfaction, and knowledge was identified as the strongest predictor. The proposed Structural Equation Model (SEM) showed good model fit, predictive capability, and explanatory ability. This shows that enhancing usability features of educational games has great potential for enhancing students' engagement, satisfaction, and learning achievement in mathematics.

Recommendations

Based on the findings, it is recommended that teachers utilize interactive learning tools, such as game-based learning tools like InteRaid, in order to improve the engagement of students with the learning of mathematical concepts. Game developers are encouraged to improve the game's features, such as the user interface, difficulty level, and social interaction, to improve the satisfaction of the game's users. Future researchers may expand the study by exploring other mathematical concepts, increasing the number of participants, or the learning environment, as well as using qualitative research methods in order to obtain deeper insights into the students' experiences.

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