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Abstract

A multiple regression analysis was conducted to investigate what variables may predict the student's self-perceived proficiency in mathematics. Hence, this quantitative cross-sectional survey design aimed to explore the factors predicting the student's self-perceived proficiency in mathematics using gamified instruction. Two hundred twenty-five (225) students from elementary school, specifically grade 5 from Cebu, Philippines, participated in the survey. Confirmatory factor analysis was used to test the validity and reliability of the instrument prior to the dissemination of the research instrument. It was found that the instrument is found to be valid and reliable. The valid and reliable instruments were then distributed to the 225 students for the regression analysis. In the result, it was found out that prior knowledge, positive reinforcement, feedback and rewards, self-awareness, and goal-setting are statistically significant predictors of a student's problem-solving skills. It is then recommended that teachers should give importance to all of the significant predictors to enhance student's problem-solving skills and self-perceived proficiency in mathematics.

Introduction

As Bandura (1997) defined, "perceived self-efficacy" refers to beliefs about one's ability to organize and execute the steps required to accomplish particular objectives. According to Bovermann and Bastiaens (2020), students' motivation is significantly impacted by their positive self-perception of their competence, which improves it. Mathematical learners' realistic and positive perceptions of their skill set are influenced by their self-perception, according to Palacio and Lafortune (2000). Students' self-efficacy has been demonstrated to have an impact on their learning. According to Ahmad and Safaria (2013), students who feel confident in their abilities can handle challenging tasks and have the self-assurance to understand and solve mathematical problems. This is a significant factor influencing students' mathematical interest. Students' perceptions of their mathematical ability are influenced by how they engage with mathematical concepts (Boyer & Mailloux, 2015). Students with solid self-efficacy have confidence in their ability to comprehend lessons, solve difficulties in the classroom, and finish assignments, according to Mamolo & Sugano (2020). Unlike students with poor self-efficacy, they think they can comprehend and solve mathematics issues.

Zainuddin (2018) defines gamified learning as blending gamification with traditional classroom instruction to enhance student learning potential. Teachers frequently come up with new online learning activities for teaching through electronic websites, platforms, and channels (Amar et al., 2024). Gamified learning typically incorporates technology and offers a student-centered learning environment. These components, generally utilized in an educational context, include leaderboards, badges, and quests (assignments), as Kingsley and Grabner-Hagen (2015) noted. Additionally, gamification promotes creativity and student choice, boosts peer rivalry, which can increase engagement, and gives students quick feedback so they can monitor their progress toward the learning objectives. Due to their competitive nature, students may be encouraged to participate and do well in gamified learning environments (Nicholson, 2012).

Furthermore, according to Guerrero et al., (2023) gamification can be an effective way to make learning more inclusive and engaging for students with learning disabilities. It allows for the integration of pedagogical practices that enhance a more holistic approach to pupils' challenges, especially for learners with Specific Learning Disorder (SLDs) (Stuart-Chaffoo, 2024). Additionally, Hussein et al., (2024) claims that gamified instruction enhances several skills among individuals with disabilities, including learning, cognitive, and behavioral skills, as well as life skills.

In the national setting, gamification has become a cutting-edge teaching strategy nationwide. Caballero et al. (2022) claim that gamification positively affects students' academic performance, improving their learning outcomes. Through gamified multiple-choice quizzes, gamification was also demonstrated to help raise students' motivation compared to students completing regular quizzes (Antonio & Tamban, 2022). Additionally, one of the most significant learning outcomes is how satisfied students are with their education. This suggests that students with positive school experiences and a high level of academic success (Martirosyan et al., 2014), as well as general life satisfaction and well-being (Suldo et al., 2012), reported better levels of mental and physical health (Huebner et al., 2012). According to research conducted in Cebu, Philippines, gamified instruction increases students' enthusiasm and participation. According to Derasin (2024), gamification can improve student motivation and engagement by introducing play, competitiveness, and challenge elements into the educational process. According to Cabanilla et al. (2023), gamified instruction offers students good experiences that allow them to learn mathematics engagingly without much effort. This improves and generates meaningful learning experiences.

On the other hand, many study engagement failures have been attributed to students' need for more interest in their studies (Lumby, 2011). However, Derasin (2024) asserts that students who are initially disinterested in learning mathematics become more enthusiastic and driven when provided with a gamified learning strategy that allows them to view and experience the lesson differently. Wang & Zeng (2021) found that students' perceptions of their academic achievement and self-efficacy were improved by gamification. As a result, to inspire and engage students, gamified education includes game features such as winning games, competing, and accomplishing learning objectives (Swacha, 2021). Accordingly, students will compete to boost their internal motivation, motivating them to learn and advance academically, as gamification of education fosters a sense of self-efficacy (Banfield & Wilkerson, 2014).

Recently, there has been a lot of interest in the gamification of instruction in educational contexts, with many teachers investigating how it can improve student motivation and engagement. However, few studies have explored the influence of gamified instruction on students' perception of their mathematical abilities, potentially overlooking the effectiveness of gamification for elementary students' self-perceived proficiency. Moreover, limited studies are determining the factors that mainly influence the student's self-perceived proficiency in mathematics. This study aims to address this gap by investigating the effectiveness of incorporating gamification in enhancing students' mathematical skills and confidence. By examining students' perceptions, the research seeks to understand how gamified instruction influences students' self-assessment of their mathematical abilities.
Gamified instructions have become increasingly popular to enhance students' academic performance in mathematics (Smith, 2018). However, fostering students' proficiency and confidence in mathematics is a perennial challenge. Self-perceived proficiency has a crucial role in students' engagement in mathematics class. The factors affecting the student's self-perceived proficiency should be carefully studied.

Hence, this study aims to provide a comprehensive understanding of the factors that influence gamified instruction on the self-perceived mathematical abilities of the students. This study seeks to develop and validate an instrument to assess factors affecting the student's self-perception proficiency in mathematics regarding cognitive, behavioral, and affective factors. Specifically, this study aims to answer the following questions:

1. What are the factors that influence the students' problem-solving skills in mathematics?
2. Is there a significant causal relationship between the students problem-solving skills in mathematics and among the following factors;
    - 2. 1 Prior Knowledge
    - 2.2 Positive Reinforcement
    - 2.3 Feedback and Rewards
    - 2.4 Self-awareness
    - 2.5 Goal-setting
3. What psychometric properties can be established on:
    - 3.1 Convergent Validity
    - 3.2 Discriminant Validity
    - 3.3 Internal Consistency

Theoretical Framework

This study were grounded on different theories that provide insights into the factors that influence students' perception in using Gamified Instruction in Teaching Mathematics, namely, constructivism, operant conditioning, and self-regulation theory, aiming to contribute to the understanding of the effects of gamification on students' academic performance in mathematics. This can be related to educational laws and policies in the Philippines.

The Department of Education (DepEd) in the Philippines is essential in establishing rules for teaching techniques and academic standards. The study is in line with the DepEd's mandate to improve student learning outcomes by integrating innovative teaching methods to raise the standard of education.

Furthermore, the study's focus on variables affecting students' academic performance aligns with the more general educational objectives outlined in Philippine legislation, such as the Enhanced Basic Education Act of 2013 (Republic Act No. 10533), which attempts to give all Filipino students access to high-quality education. Regression analysis examines the variables that affect students' self-perceived competency, with the students' self-perceived proficiency as the dependent variable. This study adds to the ongoing efforts in the Philippines to enhance mathematics education and students' proficiency. Figure 1 shows the theoretical framework of the study.

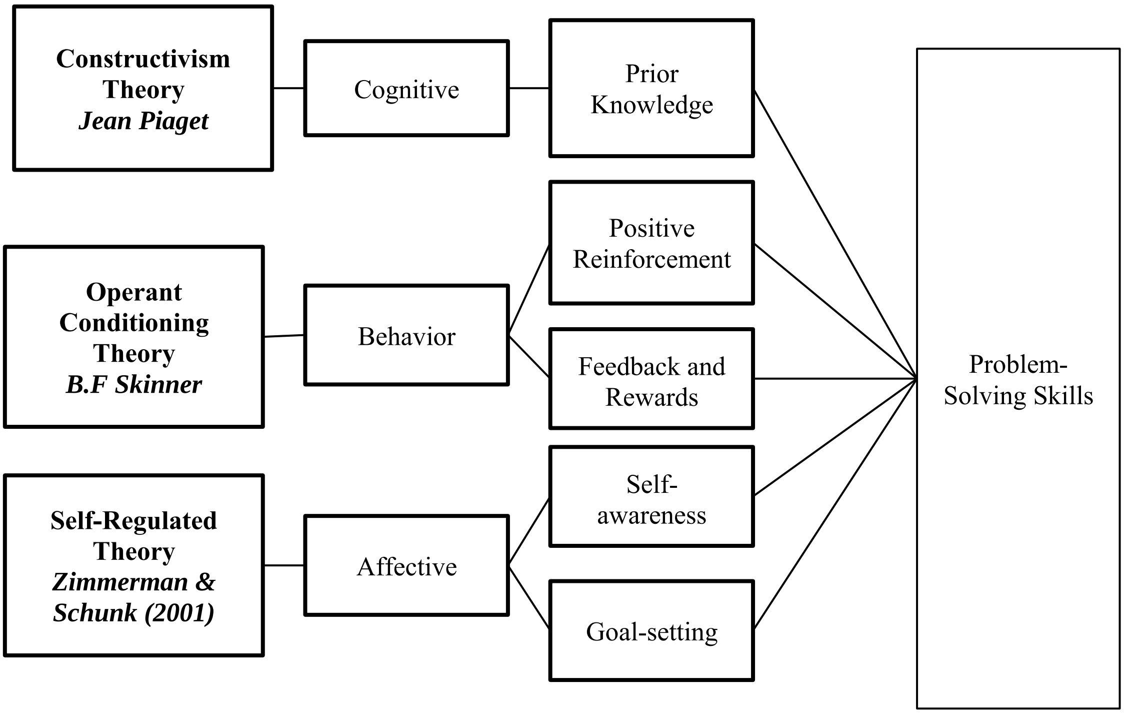

Figure 1. Theoretical and Conceptual Framework on Student's Problem-Solving Skill

Constructivism Theory

This study was grounded on the constructivist theory developed by Jean Piaget. According to Chomsky (1968, 1971) and Piaget (1953, 1970, 1971), cognitive structures that are either innate or the result of developmental construction are the tools used to construct knowledge, and Piaget's constructivist theory can be classified as a cognitive position (Noddings, 1973). Biggs (1993) points out that constructivism emphasizes that 'people construct knowledge for themselves, resulting in their understanding. This theory promotes student-centered learning, which motivates and engages students to participate actively in their learning process. It can be enhanced through gamified instruction, making learning more interactive and enjoyable. Therefore, by promoting active learning, constructivism can help improve students' self-perceived proficiency in mathematics and ultimately lead to better academic outcomes (Bermejo et al., 2021).

Operant Conditioning Theory

In a gamified setting, students are motivated to succeed through conditioning and reinforcement, where rewards are crucial in driving learning behaviors (Kim & Castelli, 2021). According to Landers (2015), rewards are utilized to encourage active participation and sustain high rates of behavior, with points serving as reinforcements to stimulate external motivation and engagement. Feedback and rewards can encourage students to engage in the desired activities, accumulate experience, and foster motivation and progress in mathematics (Hadijah et al., 2022). In addition, Smith (2018) states that integrating operant conditioning theory in gamified instruction influences students' self-perceived proficiency in mathematics by leveraging rewards, positive reinforcement, feedback mechanisms, and motivation to enhance learning outcomes and sustain student engagement.

Self-Regulated Theory

According to Zimmerman (2001), self-regulated learning transforms students' intellectual prowess into task-relevant academic capabilities. Students are considered self-regulated when participating in metacognitive, motivational, and behavioral components of their education, consistent with Zimmerman's (2008) findings. According to other studies, knowledge (about the subject, the task, the context in which they will be learning, and themselves), motivation to know, and volition (the capacity to manage and withstand distractions) are the three general factors that influence students' ability to learn self-regulated (Worfolk, 2004).

Self-regulation is essential to gamified integration because it fosters intrinsic motivation, self-efficacy, and other psychological requirements, improving student motivation, engagement, and learning outcomes. Thus, these theories empower students to analyze their learning experiences towards mathematics effectively. It helps students enhance their engagement and improve their academic performance. Understanding how these theories intersect within the gamified context through rewards, feedback mechanisms, and motivational strategies effectively fosters students’ self-perceived proficiency in mathematics.

Table 1. *Research Hypotheses*

Hypothesis Number	Hypothesis Statement
Ho_1	There is no significant causal relationship between students' problem-solving skills in mathematics and prior knowledge.
Ho_2	There is no significant causal relationship between students' problem-solving skills in mathematics and positive reinforcement.
Ho_3	There is no significant causal relationship between students' problem-solving skills in mathematics and feedback and rewards.
Ho_4	There is no significant causal relationship between students' problem-solving skills in mathematics and self-awareness.
Ho_5	There is no significant causal relationship between students' problem-solving skills in mathematics and goal setting.

Method

Research Design

This study used a cross-sectional quantitative research design to investigate cognitive, behavioral, and affective factors influencing students' self-perceived proficiency in gamified mathematics instruction. This research design simultaneously collects data at a single point, providing a snapshot of the population's perceptions and attitudes toward mathematics (Setia, 2016). In this design, the data was collected through structured surveys or questionnaires, and statistical analysis was used to identify the relationships and patterns in the data.

Sample Design, Respondents, and Environment

The study used a purposive sampling strategy to select participants purposively, mainly focusing on Grade 5 students who experienced gamified instruction in mathematics. Purposive sampling is used to select respondents that are most likely to yield appropriate and useful information (Kelly, 2010). With this technique, the researchers selected two hundred twenty-five (225) students in elementary schools within Cebu, Philippines, to obtain statistically significant validity of inferences and data reliability results. To provide reliable and dependable results in quantitative research, sampling sizes usually begin around 200 to a secure confidence interval (Jones, n.d.). Table 2 indicates the distribution of students.

Table 2. Distribution of Students (n=225)

Variables	**n**	**%**
Age		
9	2	0.9%
10	60	26.6%
11	132	58.6%
12	26	11.6%
13	4	1.8%
16	1	0.4%
Year Level		
Grade 5	225	99.9%
Sex at Birth		
Female	110	43.9%
Male	115	50.7%

Research Instrument

To create the study's instrument, a comprehensive and systematic review of the literature was conducted. A literature review helps prepare the research for its argument and questions by gathering appropriate and timely research on a particular subject and synthesizing it into a coherent overview of the existing body of knowledge (McCombes, 2023). When creating a questionnaire, it was important to consider a variety of literature sources to make sure the instruments reflect the factors impacting students' perceptions of their own mathematical skill. A 5-point Likert scale was used in this study where one is Strongly Disagree, and five is Strongly Agree. This increases the reliability and validity of the instrument as it allows for more detailed responses and reflects the student's perceptions (Simply Psychology, 2023).

The psychometric properties of the instrument were checked. This refers to the characteristics, including validity, reliability, and other measurement-related qualities. This ensures the credibility and trustworthiness of the research findings (Taherdoost, 2016). Furthermore, a confirmatory factor analysis (CFA) was used to assess the validity of the hypothesized measurement model by confirming whether the observed variables align with the underlying constructs (Tavakol & Wetzel, 2020). Table 3 indicates the research-made instruments in self-perceived using gamification.

Table 3. Research-Made Instrument on Student's Problem-Solving Skills Using Gamified Instruction

Construct	Item Code	Question	Source
Prior Knowledge	PK1	1. I know gamified instruction.	Jaftha et al. (2021)
	PK2	2. I believe that my prior knowledge of gamified instruction has impacted me in my learning experience	Smith, N. (2018)
	PK3	3. I believe that my prior knowledge has helped me in knowing gamified instruction.	Dong et al. (2020)
	PK4	4. My confidence in knowing gamified instruction has helped me a lot.	Cabanilla et al., (2023)
	PK5	5. I believe in my knowledge skills before gamified instruction	Kmglen (2019)
Problem-Solving Skill	PSS6	6. I feel confident in solving math problems using gamified instruction.	Orbon and Sapin (2022)
	PSS7	7. I enjoy solving math problems through gamified instruction.	Smith, N. (2018)
	PSS8	8. I believe gamified instruction helps me learn math more effectively.	Orbon and Sapin (2022)
	PSS9	9. Gamified instruction helps me develop my problem-solving skills in math.	Orbon and Sapin (2022)
	PSS10	10. I believe gamified instruction is an effective way to improve my math proficiency.	Karamert & Vardar (2021
	PSS11	11. I believe that gamification helps me solve complex mathematical problems.	
	PSS12	12. I believe gamified instruction enhanced my critical thinking skills in problem-solving tasks.	Jutin & Maat (2024)
	PSS13	13. I learned a lot of problem-solving strategies through	Jutin & Maat (2024)

Construct	**Item Code**	**Question**	**Source**
		gamified instructions.	
	PSS14	14. I believe that gamified instructions have increased my motivation to tackle challenging mathematical problems	Elket (2021)
	PSS15	confidently. I believe that gamified instruction improves my ability to collaborate and solve problems with peers.	Karamert & Vardar (2021 Smith, N. (2018)
Positive Reinforcement	PR16	16. I feel confident learning math through gamified instructions.	Chan, S., & Lo, N. (2022)
	PR17	17. I find gamified instructions helpful in learning math.	Jett, M. B. (2020)
	PR18	18. I am motivated to learn math through gamified instructions.	Karabıyık, Ü. (2024)
	PR19	19. I believe gamified math instructions have helped me improve my understanding of math concepts.	Liu and Razali (2023)
	PR20	20. The overall impact of gamified instructions in math is beneficial in enhancing my learning experience.	Stoyanova et al. (2018)
Feedback and Rewards	FR21	21. I am motivated when engaging in gamified math activities	Solekhah et al. (2023) Smith, N. (2018).
	FR22	22. I am more confident in my problem-solving skills when using gamified learning approaches	Wichadee & Pattanapichet (2018)
	FR23	23. I engage more when I receive immediate feedback during gamified activities.	Jutin & Maat (2024) Adamma et al. (2018)
	FR24	24. Rewards like badges and leaderboards influence my learning experience in math	
	FR25	25. Recognition through rewards impact my engagement with math content	
Self-Awareness	SA26	26. I believe gamified instruction has helped me increase my awareness of my learning preferences.	Zainuddin et al. (2018)
	SA27	27. I believe in my ability to improve my math skills through gamified instruction	Yanuarto and Hastinasyah (2023)
	SA28	28. I am confident in my problem-solving skills in mathematics	Gurat (2018) Li et al. (2023)
	SA29	29. I believe gamified instruction has helped me recognize my strengths and weaknesses in the learning process	
	SA30	30. I know the areas in math where I need improvement.	Yeh et al. (2019)

Construct	Item Code	Question	Source
Goal Setting	GS31	31. I believe gamified instructions have positively influenced my ability to set academic goals.	(Zeisler, 2018)
	GS32	32. I am motivated to set higher goals in math because of gamified instruction.	(Dotson, 2016)
	GS33	33. I believe that gamified instructions help me boost my self-esteem in achieving my academic goals.	(Tondello et al., 2018)
	GS34	34. I believe that gamified instructions have improved my ability to stay focused on achieving my academic goals.	Rueckert and Griffin (2023)
	GS35	35. Gamified instruction increases my engagement and interest in pursuing academic goals.	Krath et al. (2021)

Data Gathering Procedure

In this study, the researcher submitted an approval form from the Research Ethics Committee before the data-gathering procedure began. The developed instrument tackles the cognitive, behavioral, and affective factors influencing a student's self-perceived proficiency. Three experts validated the instruments. After the validation, the psychometric properties of the instruments are tested through the validity and reliability of the instruments and are checked after pilot testing. Confirmatory factor analysis is being utilized. The instruments are distributed through a survey questionnaire and are given to the respondents physically. After collecting 225 responses, the data were analyzed through multiple regression analysis. This is used to predict the relationship between two or more independent variables and one dependent variable (Bevans, 2023).

Data Analysis

The development of the 35-item questionnaire was validated using confirmatory analysis. Three (3) experts on the topic are chosen to check the instrument's validity. Face validity describes the researchers' subjective assessments of the instrument's presentation, organization, and effectiveness, specifically focusing on whether the items in the instrument seem relevant, suitable, reasonable, transparent, and clear (Taherdoost, 2016). By reviewing the components the study should contain, content validity ensures that the questionnaire will adequately select items that match and address the construct (Zamanzadeh et al., 2015). By assuring how well it measures the concept of the instrument, construct validity assesses whether the scores or outcomes from a measurement tool behave the way they should, based on existing theories or constructs (Arslan, 2023). According to Tavakol and Dennick (2011), internal consistency evaluates the relationship between several items in a test that are meant to measure the same construct as guaranteeing the consistency of such items.

In analyzing the respondent's responses concerning self-perceived proficiency in mathematics using gamified instruction, JAMOVI software is used to conduct the multiple regression analysis. A statistical technique called multiple regression analysis is used to examine the relationship between one dependent variable and several independent factors to use the independent variables whose values are known to find the value of a single dependent variable (Schneider et al., 2010). Each predictor value is given a significance level that denotes the degree to which it influences the final result (Palmer et al., 2009).

Ethical Consideration

The ethical considerations were secured before the study was conducted to ensure protocols were followed and carried out ethically and responsibly. The study abides by the moral standards and laws established by pertinent institutions or regulatory authorities to ensure that the research protocol complies with ethical standards and that the rights and welfare of the respondents are protected and sent to the appropriate ethics committee for review and approval. The participants were given an assent form and were informed that the information gathered would remain confidential and would not be shared with anybody else or used in any way that could lead to their identity. The purpose and procedure of the study were included and provided in the consent letter to inform the respondents. Moreover, participants received food as gratitude for giving their time.

Results and Discussion

The scale's psychometric properties were examined by conducting a Confirmatory Factor Analysis. This statistical technique confirms whether the data fits a hypothesized model (Statistics Solutions, 2024). It assessed the fit between the observed data and a theoretical model specifying the relationship among latent variables and their corresponding observed indicators. CFA was run to yield the model data fit indices, convergent and internal consistency, and discriminant validity.

Model fit indices are statistical indicators to assess how well the hypothesized measurement model aligns with the observed data - standard fit indices include the comparative Fit Index (CFI), Tucker-Lewis Index (TLI), Root Mean Square Error of Approximation (RMSEA), Standardized Root Mean Square Residual (SRMR), and Chi-square/df ratio. These fit induced in Confirmatory Factor Analysis (CFI, TLI, RMSEA, SRMR, and Chi-square/df ratio) collectively assess the alignment between a hypothesized model and observed data, providing researchers with quantitative measures to determine the goodness of fit and reliability of the measurement models. Table 4 presents the model data fit indices results.

Table 4. Model Data Fit Indices Results

Model Fit Indices	**Proposed Threshold**	**Source**	**Resulting Value**
CFI	>0.80	Garson, 2006	0.828
TLI	>0.85	Sharma, et al.,2005	0.812
RMSEA	<0.08	Kenny et al.,2014	0.0572
SRMR	≤0.08	Hu & Bettler, 1999	0.0516
Chi-square/df ratio	<3.00	Hair et al.,2009	1.59

Table 4 presents the model fit indices for a proposed statistical model, comparing the resulting values against established thresholds from various sources. The Comparative fit index (CFI) value of 0.828 is above the proposed threshold of 0.80, which indicates a good fit, according to Garson (2011). This suggests a good relationship between the proposed model and the data, indicating that the model adequately reproduces the covariance pattern among the observed variables. The Tucker-Lewis Index (TLI) assesses the relative fit of the proposed model compared to a null model. A value greater than 0.85 is typically considered indicative of an acceptable fit. However, the resulting TLI value of 0.812 falls slightly below this threshold but still suggests a reasonable fit (Ene, 2020). The Root Mean Square Error of Approximation (RMSEA) measures the discrepancy between the proposed model and the observed data, with values less than 0.08 generally indicating a close fit. With a value of 0.0572, the RMSEA falls well below the threshold of 0.08 (Kenny et al.,2014), suggesting a close fit between the proposed model and the data.

The Standardized Root Mean Square Residual (SRMR) assesses the average discrepancy between the observed and predicted correlations in the model (Olivares, 2017). A value less than or equal to 0.08 indicates a good fit. The resulting SRMR value of 0.0516 falls below the threshold, suggesting a good fit for the proposed model. The chi-square/df ratio evaluates the goodness of fit by considering the ratio of the chi-square statistic to the degrees of freedom (Alavi et al., 2020). A ratio of less than 3.00 is generally indicative of an acceptable fit. The resulting ratio of 1.59 suggests that the proposed model fits the data reasonably well, as it falls below the threshold (Alavi et al., 2020).

Most fit indices indicate that the proposed model fits the observed data reasonably well, with only TLI slightly below its threshold. However, considering the overall pattern of the fit index, the model can be deemed to have an acceptable fit. Table 5 presents the results of the concurrent and internal consistency analysis of the scale used in the study.

Table 5**.** Convergent and Internal Consistency Result of the Scale.

Constructs	**Indicator**	**Estimate**	**Average Variance Extracted**	**Composite Reliability**
PK	PK 1	0.284	0.187	0.525
	PK 2	0.500		
	PK 3	0.504		
	PK 4	0.453		
	PK 5	0.378		
PSS	PSS 6	0.533	0.276	0.743
	PSS 7	0.659		
	PSS 8	0.574		
	PSS 9	0.412		
	PSS 10	0.504		
	PSS 11	0.512		
	PSS 12	0.544		
	PSS 13	0.586		

Constructs	Indicator	Estimate	Average Variance Extracted	Composite Reliability
	PSS 14	0.515		
	PSS 15	0.353		
PR	PR16	0.613	0.280	0.654
	PR 17	0.384		
	PR 18	0.629		
	PR 19	0.517		
	PR 20	0.465		
FR	FR 21	0.558	0.293	0.673
	FR 22	0.568		
	FR 23	0.487		
	FR 24	0.542		
	FR 25	0.546		
SA	SA 26	0.514	0.273	0.649
	SA 27	0.531		
	SA 28	0.591		
	SA 29	0.409		
	SA 30	0.549		
GS	GS 31	0.406	0.233	0.593
	GS 32	0.595		
	GS 33	0.590		
	GS 34	0.374		
	GS 35	0.397		

The table shows that most constructs have high standardized estimates, indicating a high correlation between the indicators and the corresponding latent constructs. A high Average Variation Extracted (AVE) value denotes strong convergent validity, meaning that the latent construct and each construct`s indicators share a substantial percentage of the indicator variation (Kosiek et al., 2021). However, the results show that the Average Variance Extracted (AVE) has a low score which indicates that the questions or items used in the study have an issue with its relevance and clarity on what it intends to measure (Middleton, 2023). Furthermore, high composite reliability scores also show that each construct has good internal consistency (Cheung & Thomas, 2023). This implies that they accurately measure the relevant latent constructs of the observable indicators.

The table presents a low Average Variation Extracted (AVE) and high Composite reliability combination which suggests that the indicators are reliable but not necessarily accurate in measuring the intended constructs (Cheung et al., 2023). This implies that the observed indicators are reliable in measuring the latent constructs, but they may not be capturing the intended construct effectively. Discriminant Validity analysis evaluates how the model`s various constructs are different from one another (Jain & Chetty, 2021). This guarantees that every latent construct assesses one specific aspect of the investigated phenomena. The discriminant validity of the model is shown in

Table 6.

Table 6. Discriminant Validity

	PK	PSS	PR	FR	SA	GS
PK	1					
PSS	0.612	1				
PR	0.528	0.738	1			
FR	0.493	0.701	0.632	1		
SA	0.476	0.696	0.674	0.650	1	
GS	0.492	0.678	0.616	0.605	0.691	1
AVE	0.187	0.276	0.280	0.293	0.273	0.233
√AVE	0.43	0.53	0.53	0.54	0.52	0.48

Sqt. AVE > correlation coefficient

The table presents the results of the Discriminant Validity analysis for the variable in the model. The table also shows the correlation coefficient between each pair of variables. The square root AVE is provided as the measure of reliability. Higher values indicate more excellent reliability. To assess discriminant validity, the researchers looked for lower correlations between variables than the square root of their respective AVE (Hamid, Sami, & Sidek, 2017). The correlation must have a lower correlation with other variables than their √AVE values, which suggests good discriminant validity (Nikolopoulou, 2023). PK has a correlation of 0.612 with PSS, which is higher than PK's √AVE of 0.43. PSS correlates 0.738 with PR, which is higher than PSS's √AVE of 0.53. PR has a correlation of 0.632 with FR, which is higher than PR's √AVE of 0.53. FR correlates 0.650 with SA, which is higher than FR's √AVE of 0.54. SA has a correlation of 0.605 with GS, which is higher than SA's √AVE of 0.52. The √AVE values also indicate the reliability of each construct. Higher √AVE values suggest more excellent reliability in measurement. The result has shown that variables in the model have a lack of discriminant validity, meaning that the constructs are not clearly differentiated and may be measuring overlapping concepts (Roemer et al., 2021). Based in Fornell-Lacker criterion the square root of each construct's AVE should have a greater value than the correlations with other latent constructs (Hamid et al., 2017). This implies that the research questions used in the study do not measure the intended concepts, resulting in a lack of discriminant validity (Rönkkö & Cho, 2020). The model fit measures are indicated in Table 7, and the multiple regression with problem-solving skills as the dependent variable is shown in Table 8.

Table 7. Model Fit Measures

Model	R	R2	Adjusted R2	AIC	BIC	RMSE	F	df1	df2	p
1	0.841	0.707	0.701	147	171	0.327	104	5	215	<.001

This table provides essential data for assessing the significance of the independent and dependent variables. Regression analysis was used to create the model fit measure for this investigation, shown in Table 6. As evidenced by the results, which show moderate to strong correlations between the independent and dependent variables, the adjusted R-squared values are 0.701 and 0.707, respectively. The Root Mean Square Error (RMSE) of 0.327 indicates that the model's predictions are reasonably accurate in predicting the dependent variable, with average values near the actual values (Miller, 2024). This is an important consideration for practical applications, as it suggests that users can safely predict the dependent variable using this model (Spiliotis et al., 2021). The model's high significance, as indicated by the p-value of less than 0.001 and an F-statistic of 104, suggests statistical significance in the multiple regression model and that the independent variable in the model has a meaningful impact on the dependent variable (Frost, 2023). The regression model shown in the table has significant explanatory power, good prediction accuracy, and statistical significance, making it a useful tool for figuring out how the independent and dependent variables relate (Kassambra, 2018). This demonstrates how effectively the model captures the relationships between the independent and dependent variables and fits the data (Hair et al., 2010). Hence, the model's results indicate that the independent variables, prior knowledge, positive reinforcement, feedback and rewards, self-awareness, and goal setting, seem to have a good fit and strong correlations, indicating that they can predict students' self-perceived proficiency in problem-solving skills when they receive gamified mathematics instruction. The individual coefficients and associated p-values must be considered to ascertain which specific independent variables are significant, as shown in Table 6. Furthermore, the data does not significantly depart from a normal distribution for the assumption checks with a statistic of 0.988 and a p-value of 0.066. Thus, it suggests that the data follows a normal distribution (Chen, 2024).

Table 8: Multiple Regression of Problem-Solving Skills

Predictor	Estimate	SE	t	p
Intercept	0.0789	0.1615	0.489	0.626
Prior Knowledge	0.2028	0.0469	4.321	<.001
Positive Reinforcement	0.2720	0.0518	5.255	<.001
Feedback and Rewards	0.2010	0.0477	4.216	<.001
Self-awareness	0.1333	0.0544	2.449	0.015
Goal-setting	0.1530	0.0510	3.000	0.003

The regression equation is:

Student's Problem-solving Skills = 0.0789 + 0.2028(PR) + 0.2720(PR) + 0.2010(FR) + 0.1333(SA) + 0.1530(GS)

The estimate represents the change in the dependent variable associated with a one-unit change in the independent variable while holding all other variables constant. It quantifies the strength and direction of the relationship between the independent and dependent variables. The standard error (SE) measures the precision or uncertainty of the coefficient estimate (Smith, 2015). Minor standard errors indicate greater precision, while more significant ones suggest greater uncertainty (Bhandari, 2020). The t-statistic quantifies how many standard errors the coefficient estimate is away from zero. The t-statistic is used to assess whether the coefficient is statistically significant. The p-value associated with the t-statistic measures the probability of observing an at-statistic as extreme as the one calculated, assuming the null hypothesis that the coefficient equals zero. Smaller p-values suggest more substantial evidence against the null hypothesis, indicating that the coefficient is statistically significant (Bevans, 2023). Table 9 shows the summary of Decision Rule for Hypothesis.

Table 9. Summary of Decision Rule in Hypothesis

Hypothesis Number	Hypothesis Statement	Accept p > 0.05	Reject p < 0.05
Ho1	There is no significant causal relationship between students' problem-solving skills in mathematics and prior knowledge.		/
Ho2	There is no significant causal relationship between students' problem-solving skills in mathematics and positive reinforcement.		/
Ho3	There is no significant causal relationship between students' problem-solving skills in mathematics and feedback and rewards.		/
Ho4	There is no significant causal relationship between students' problem-solving skills in mathematics and self-awareness.		/
Ho5	There is no significant causal relationship between students' problem-solving skills in mathematics and goal-setting.		/

If $p < 0.05$ - reject null hypothesis, If $p > 0.05$ - accept null hypothesis

Five out of five independent variables have statistically significant relationships with the dependent variable; these factors have less than 0.05 p-value, which indicates that these five (5) factors are important in determining the student's self-perceived proficiency on gamified mathematical instruction. The following are (1) prior knowledge has a p-value of <.001, (2) positive reinforcement has a p-value of <.001, (3) feedback and rewards has a p-value of <.001, (4) self-awareness has a p-value of 0.015, and the (5) goal-setting has a p-value of 0.003. These variables show significant associations with the outcome being measured.

Prior Knowledge

The findings of the multiple regression analysis show the statistical significance of prior knowledge in predicting students' self-perceived proficiency in mathematics in gamified instruction. The above factor has an estimated regression coefficient of 0.2028 and an estimated standard error (SE) of 0.0469. These values indicate the precision of the regression coefficient estimate, which suggests that prior knowledge is an integral factor in gamified instruction in mathematics teaching (Hui & Mahmud, 2023). Teachers should consider students' previous knowledge to help increase students' scores in mathematics (Karamert & Vardar, 2021). Moreover, the computed t-statistic value of 4.321, along with the p-value of <.001, suggests compelling evidence linking the variable *prior knowledge* to a high level of significance in terms of student's self-perceived proficiency in mathematics (Andrade, 2019). It implies that students are more likely to remain motivated to do mathematics if they already have the knowledge and skills to use gamified activities in learning mathematics (Yan, 2023).

Positive Reinforcement

Positive reinforcement is statistically significant in predicting students' self-perceived proficiency in mathematics in gamified instruction. The above factor has an estimated regression coefficient of 0.2720 and a standard error (SE) of 0.0518. These values indicate the precision of the regression coefficient estimate, which implies that teachers will have to use positive reinforcement in conducting mathematics classes, and students will likely remain motivated (Saadati & Celis, 2022). On the other hand, there is compelling evidence that the variable *positive reinforcement* is significant in a student's self-perceived proficiency in mathematics, as indicated by the computed t-value of 5.255 and the p-value of <.001. This implies that positive reinforcement helps increase students' motivation, engagement, and self-efficacy in mathematics (Adam, 2023). As a result, positive reinforcement has a positive impact on students' learning in mathematics.

Feedback and Rewards

The feedback and rewards variable is statistically significant in predicting students' self-perceived proficiency in mathematics on gamified instruction. As indicated in the p-value of less than .001. The p-value assesses the evidence against a null hypothesis, typically implying no association between the predictor and the outcome in the context of regression. A p-value of <.001 is considered strong evidence against the null hypotheses, suggesting that feedback and rewards are related to problem-solving skills (Beers, 2024). The estimate for feedback and rewards is 0.2010, representing the student increase in self-perceived proficiency in mathematics for every one-unit increase in feedback and rewards, assuming all the variables in the model are held constant. The positive coefficient suggests a positive relationship, meaning the higher the feedback and rewards are associated, the higher the level of self-perceived proficiency in mathematics. The estimated error (SE) is 0.0477, which measures the precision of the regression estimate. A more standard minor mistake indicates a more precise estimation of the coefficient. The t-statistics is 4.216, calculated as the regression coefficient divided by its standard error. This statistic determines if the coefficient significantly differs from zero (implying no effect). The large t-statistic here further confirms the strong evidence against the null hypothesis. Given its relatively large coefficient, feedback and rewards are statistically significant and likely practically meaningful. This suggests that providing feedback and rewards is positively associated with self-perceived proficiency in mathematics (Mata et al., 2012).

Self-awareness

Self-awareness is statistically significant in predicting students' self-perceived proficiency in mathematics based on gamified instruction. The above factor has an estimated regression coefficient 0.1333 and a standard error (SE) of 0.0544. These values indicate the precision of the regression coefficient estimate, which suggests that teachers should consider utilizing gamified instruction that promotes self-awareness to enhance students' perception of their mathematical abilities (Smith, 2020). On the other hand, there is compelling evidence that the variable self-awareness is critical in a student's self-perceived proficiency in mathematics, as indicated by the computed t-statistic value of 2.449 and the p-value of 0.015. This means that self-awareness helps students better understand their strengths and weaknesses, leading to improved performance and confidence in mathematics (Lee et al., 2021).

Goal-Setting

Goal-setting is statistically significant in predicting students' self-perceived proficiency in mathematics on gamified instruction. As the table above indicates, the factor has an estimated regression coefficient of 0.1530 and an estimated standard error (SE) of 0.0510. These values indicate the precision of the regression coefficient estimate, which suggests that establishing goals can significantly affect students' self-efficacy and accomplishment because it gives them a direction to track their learning progress and concentrate on their intended academic results (Sides & Cuevas, 2020). On the other hand, there is compelling evidence that the variable goal-setting is critical to a student's self-perceived proficiency in mathematics, as indicated by the computed t-value of 3.000 and the p-value of 0.003. This reveals that goal-setting is positively associated with self-perceived proficiency in mathematics, as it helps students stay motivated and committed to reaching their goals, strengthening their learning in mathematics (Velez & Abuzo, 2024).

Theoretical and Managerial Implications

The table presents significant implications for the field of education. It highlights the effectiveness of gamification in enhancing students' motivation, engagement, and academic performance in mathematics. By incorporating game design elements into learning activities, educators can create a more interactive and immersive learning environment that fosters students' interest and participation. The studies emphasize the positive impact of gamified instruction on student growth, proficiency, and self-perceived proficiency in mathematics. These findings suggest that gamification can be a valuable tool for educators to improve student outcomes and experiences in mathematics education, ultimately contributing to a more engaging and effective learning process (Hellín et al., 2023).

Conclusion and Recommendation

The multiple regression analysis on factors influencing Elementary students’ self-perception of mathematics revealed that all five predictors, prior knowledge, positive reinforcement, feedback, rewards, self-awareness, and goal-setting, emerged as statistically significant contributors to problem-solving skills. This indicates that gamified instruction effectively enhances students’ self-perceived proficiency in mathematics using gamified instruction.

Moreover, the study did not meet the standardized estimate which means it failed to measure the intended measurement of the factors in the discriminant validity. Hence, this study suggested that;

1. There is a need to delete some items in the questionnaire to increase the factor loadings of the instrument. Future researchers to delete construct labels and conduct an exploratory factor analysis to identify new constructs. Then, run Confirmatory Factor Analysis (CFA).
2. Teachers seeking to use gamified instruction as a strategy in mathematics should emphasize the importance of prior knowledge, reinforcement, feedback, rewards, self-awareness, and goal-setting to enhance students' problem-solving skills and self-perception in mathematics.
3. Teachers must also ensure that instructional guidance is provided to clarify the relevance of games and learning objectives in gaming incorporation.
4. Future studies should explore the use of gamified mathematical instruction to investigate the significant predictors further and conduct qualitative research for a more thorough analysis.

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