STUDENTS' PROBLEM-SOLVING SKILLS AND MOTIVATION IN LEARNING MATHEMATICS VIA GAME-AIDED INSTRUCTION

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ABSTRACT: *Teachers find a way to improve students' skills by utilizing varied pedagogies in teaching. This study examined whether Game-Aided Instruction (GAI) affects the students' problem-solving skills and motivation in learning Mathematics. It identifies the level of students' problem-solving skills in their pretest and post-test and whether there is a significant difference between the result of students exposed to GAI and those exposed to non-GAI, the level of students' motivation in Mathematics in terms of intrinsic value, self-regulation, self-efficacy, utility value, and test anxiety and test if a significant difference exists between the two-group exposed to GAI and those exposed to non-GAI were presented in terms of problem-solving skills and motivation. A quasi-experimental research design was used in the study with 37 grade 11 students from two intact sections as participants for one grading period. Results revealed that the mean score of the students' problem-solving skills exposed to GAI is higher than the mean scores of those exposed to non-GAI. It implies that there is a significant difference in the students' problem-solving in Mathematics after the intervention. However, the student's level of motivation in terms of intrinsic value, self-regulation, self-efficacy, utility value, and test anxiety shows no significant difference between the two groups. Thus, the GAI enhances the students' problem-solving skills in learning Mathematics.*

Keywords: problem-solving skills, motivation, game-aided instruction

1. INTRODUCTION

In the Philippines, Mathematics is taught as a general education subject in primary and higher education, and students are expected to understand and appreciate its principles as they are applied to problem-solving, critical thinking, communicating, reasoning, making connections, representations, and decisions in everyday life [1]. Students' problem-solving skills in Mathematics have been the focus of many education studies. Because of its low performance in the national, international, and local arenas, every mathematics researcher emphasizes finding latent variables that could explain this performance.

According to the Department of Education (2013), despite research studies and training that were conducted to find ways to implement strategies and improve the pedagogy in teaching Mathematics and students' problem-solving skills, students in the Philippines performed poorly in mathematical problem-solving when compared to students in other countries [2].

One of the most crucial components of any curriculum and a key component of teaching Mathematics is inspiring students to be eagerly responsive or get students motivated. Due to its connection to students' attitudes and achievement, increasing students' motivation in Mathematics classes is vital for teachers and researchers [3]. Effective teachers give equal attention to motivated and unmotivated students [4].

Additionally, poor performance in Mathematics is another cause of learners' inadequate motivation. It has been noted that teachers need help bridging the gap between expectations for student achievement and what transpired during instruction. Through sufficient incentive and intervention from the teachers, this needs to be developed and improved by the students.

Following the National Achievement Test (NAT) 2018 results with 36.66% MPS, the nation's education quality was scrutinized in 2019. Filipino students scored the lowest overall among the 79 participating nations and nearly last in science and Mathematics [5]. This result demonstrates that the student's performance was well below the MPS. In addition to the NAT findings, DepEd also disclosed the PISA results from the Organization for Economic Co-operation and Development (OECD).

Games can encourage student participation, promote social and emotional learning, and encourage students to take risks in the classroom [6]. Additionally, it gives teachers another teaching strategy to consider while planning lessons for their students in the classroom [7]. The expectation is that the student's mathematical awareness will rise if games are implemented in the classroom [8]. Students who took part in instruction using simulation games demonstrated more significant interest in the subject than those who did not [9].

Numerous studies have been conducted on teaching pedagogies [10-14], student preferences and readiness [15, 16], student motivation and attitude [17-20], teachers' skills, competencies, and challenges [21-23], assessment techniques and tools [24-30], and other related factors [31-34] to improve students' learning outcomes; however, little research has been conducted on game-aided instruction in this part of the region.

In connection with those mentioned above, this study was conducted because the researchers felt that game-aided instruction could improve the student's problem-solving skills and motivation in Mathematics.

2. MATERIALS AND METHODS

The study assessed the students' problem-solving skills and motivation in learning Mathematics via Game-Aided Instruction at Kuya National High School Grade 11 HUMMS Students. The study made use of a quasi-experimental research design.

The instrument used was a mathematics motivation questionnaire that helped us gather the students' motivation in mathematics. The questionnaire used was pilot-tested. The questionnaire consists of 4 questions each of motivation factors, intrinsic value, self-regulation, self-efficacy, utility value, and test anxiety, and ranges from 1 to 5. A reverse scoring procedure is done for negative statements.

The researchers prepared a 5-item teacher-made problem-solving test that covered the Simple Interest, Compound Interest, Annuities, Stocks, and Bonds topics in the Midterm, First Semester S.Y 2022-2023. Items were scored based on the DepEd Order No. 8 s. 2015

The participants of the study were the Grade 11 HUMSS students of Kuya National High School. Before the start of the experiment, a pretest on problem-solving skills and motivation in Mathematics was administered to the students. The experiment was conducted for two months during the first semester of the school year. After the intervention, the students took the same test which served as the posttest. The result of these tests determined the difference in the student's problem-solving skills and motivation in Mathematics of Kuya National High School Grade 11 HUMSS students.

The collected data were tabulated and analyzed using appropriate statistical tools a statistical software. Descriptive statistics like mean, standard deviation, frequency, and percentage were used to answer the questions on the descriptive levels. Mann Whitney U-Test was used to investigate if there is a significant difference between the pretest and posttest in students' problem-solving skills and motivation in mathematics when exposed to game-aided instruction.

The following rating scale was used to better understand the data:

3. RESULTS AND DISCUSSIONS

This chapter presents the analysis and interpretation of data

Range	Descriptive Rating	Descriptive Interpretation
90-100	Outstanding	Very High Problem-Solving Skills (VH)
80-89	Very Satisfactory	High Problem-Solving Skills (H)
70-79	Satisfactory	Moderate Problem-Solving Skills (M)
60-69	Fairly Satisfactory	Low Problem-Solving Skills (L)
Below 59	Did Not Meet Expectations	Very Low Problem-Solving Skills (VL)

Scale	Range	Descriptive Rating	Qualitative Interpretation
5	4.51-5.00	Always	Highly Positive
4	3.51-4.5	Usually	Positive
3	2.51-3.5	Sometimes	Moderately Positive
2	1.51-2.5	Rarely	Negative
1	1-1.5	Never	Highly Negative

gathered from the student's scores relevant for testing the hypothesis of the study. The order of presentation follows the arrangement of the problems identified in the study.

3.1 Problem-Solving Skills in Mathematics before and after intervention

The pretest and posttest results are shown in Table 1 for the two randomly selected groups, the GAI group and the non-GAI group. With the relative frequencies, students are classified according to the level of their problem-solving skills in Mathematics.

Table 1. Problem-Solving Skills of students exposed to GAI Group and exposed to non-GAI Group.

RANGE	PRETEST				POSTTEST				QI
	GAI (n=20)		Non-GAI (n=17)		GAI (n=20)		Non-GAI (n=17)		
	F	%	F	%	F	%	F	%	
90%-100%	0	0%	0	0%	11	55%	1	5.88%	VH
80%-89%	0	0%	0	0%	3	15%	0	0%	H
70%-79%	1	5%	2	12%	6	30%	7	41.18%	M
60%-69%	3	15%	0	0%	0	0%	0	0%	L
59% and below	16	80%	15	88%	0	0%	9	52.94%	VL
MPS		43.50%		41.18%		89.50%		63.24%	

As shown in the data, out of 20 students in the experimental group, 16 or 80% of the students were classified with "Very Low Problem-Solving Skills," three (3) or 15% of the students fell into the classification with "Low Problem-Solving Skills, "and one (1) or 5% of the students was classified with "Moderate Problem-Solving Skills." On the other hand, out of 17 students in the control group or the students exposed to non-GAI, 15, or 88%, were classified with "Very Low Problem-Solving Skills," and two (2) or 12% of the students were classified with "Moderate Problem-Solving Skills."

The students exposed to GAI have an MPS of 43.50%, while those exposed to non-GAI have an MPS of 41.18%. The above result implies that most students in both groups are classified with "Very Low Problem-Solving Skills." This result reflects the problem-solving rubric used that signifies the "Developing" level of students in terms of defining the problem, process, evaluation, and construct representation.

From the above data, after the intervention, there were 11 or 55% of the students exposed to non-GAI were classified with "Very High Problem-Solving Skills," three (3) or 15% of the students were classified with "High Problem-Solving Skills," and six (6) or 30% of the students were classified with "Moderate Problem-Solving Skills." The Mean Percentage Score of the students exposed to GAI is 89.50%, which means students have "Very High Problem-Solving Skills" in learning Mathematics. On the other hand, out of 17 students exposed to non-GAI, nine (9), or 52.94% of the students were classified with "Very Low Problem-Solving Skills," seven (7), or 41.18% of the students were classified with "Moderate Problem-Solving Skills," and one (1) or 5.88% of the student were classified with "Very High Problem-Solving Skills." The students exposed to non-GAI have an MPS of 63.24%, which falls in the "Low Problem-Solving Skills."

The results indicate that the students exposed to GAI are better than those exposed to non-GAI. Lastly, there is an improvement in the classification of students' levels of problem-solving skills in Mathematics after the intervention, particularly exposed to the GAI group. The students exposed to GAI have more excellent problem-solving skills than those exposed to non-GAI. These results mean students are more active and productive in solving problems through mathematical instructional games.

We can see from Table 1 that most students fall into "very low problem-solving skills" before the intervention indicating a lack of mastery level of problem-solving in Mathematics. Other studies revealed that students get a low score in the pretest [1].

Problem-solving ability is significantly influenced by creativity, learning attitude, and attitude toward game-assisted instruction [35]. Mathematical problem-solving is well-acknowledged to have a significant role in classroom management. The issues we encounter daily are a type of issue, and those problem-solving abilities allow people to resolve these types of problems. Therefore, problem-solving abilities should be incorporated into 21st-century teaching strategies since they are crucial in Mathematics and daily life [36]. Problem-solving enhances students' understanding of mathematical concepts and promotes the development of critical thinking, reasoning, and creativity [37]. Studies have shown a positive correlation between students' problem-solving abilities and their achievement in Mathematics [38,39].

Implementing formative assessment practices provides valuable feedback to students, guiding their problem-solving progress. Teachers can use rubrics, checklists, and structured feedback to assess students' problem-solving approaches, identify misconceptions, and provide targeted guidance. Regular feedback and opportunities for self-reflection help students refine their strategies and enhance their problem-solving skills [40].

Problem-solving skills are a cornerstone of mathematical proficiency, facilitating deep understanding and application of mathematical concepts. Educators can nurture students' problem-solving abilities by implementing problem-centered instruction, meta-cognitive strategies, modeling, authentic contexts, and formative assessment. Empowering students as proficient problem solvers equips them with lifelong skills for success in Mathematics and beyond.

3.2 Students' Motivation in Mathematics

Table 2 shows the degree of students' motivation in Mathematics in terms of intrinsic value as exposed in GAI and those exposed in non-GAI before and after the intervention. This table offers the qualitative descriptions and the weighted mean for each statement relating to intrinsic value.

Before the intervention, the four (4) statements, namely, "I enjoy learning Mathematics," "I find learning Mathematics interesting," "I like Mathematics that challenges me," and "Mathematics is a very interesting subject," are classified as "moderately positive" with the mean 3.20, 3.25, 2.85, and 3.45, respectively for the students exposed to GAI. Moreover, the overall mean of the statements is 2.93, classified as a "moderately positive" intrinsic value towards Mathematics. On the other hand, for the students exposed to non-GAI, the four (4) statements mentioned above are classified as "positive" with the means 2.88, 4.24, 4.12, and 4.35, respectively. Then, the control group has the overall mean of the statements 3.65 and is classified as a "positive" level of intrinsic value.

Table 2. Students' Intrinsic Value towards Mathematics exposed to GAI and exposed to non-GAI.

Students' Intrinsic Value towards Mathematics	BEFORE				AFTER			
	GAI (n=20)		Non-GAI (n=17)		GAI (n=20)		Non-GAI (n=17)	
	$\bar{x}$	QI	$\bar{x}$	QI	$\bar{x}$	QI	$\bar{x}$	QI
I enjoy learning Mathematics	3.20	MP	3.88	P	4.35	P	3.88	P
I find learning Mathematics interesting	3.25	MP	4.24	P	4.35	P	4.24	P
I like Mathematics that challenges me	2.85	MP	4.12	P	4.10	P	4.12	P
Mathematics is a very interesting subject.	3.45	MP	4.35	P	4.40	P	3.71	P
Overall Mean Interpretation	2.93	MP	3.65	P	4.30	P	3.74	P

Looking back to the result, the intrinsic value of the students exposed to GAI is lesser than those exposed to non-GAI. It means students exposed to GAI have more effort to exert in improving the intrinsic value of motivation in Mathematics.

After the intervention, all four (4) statements answered by the students exposed to GAI, namely, "I enjoy learning Mathematics," "I find learning Mathematics interesting," "I like Mathematics that challenges me," and "Mathematics is a very interesting subject" are classified as "positive" with the mean 4.35, 4.35, 4.10, 4.40, and 4.30, respectively are classified with "positive" intrinsic value towards Mathematics. The overall mean of the statements by the students exposed to GAI is 4.30, classified with a "positive" level of intrinsic value. On the other hand, all statements that describe intrinsic value by the students exposed to non-GAI are classified as "positive" with mean of 3.88, 4.24, 4.12, and 3.71, respectively. The overall mean of the statements by students exposed to non-GAI is 3.74 and classified as "positive."

This data suggests that both groups fall into the "positive" level classification. However, based on the mean score of the statements, the students exposed to GAI have greater intrinsic value towards Mathematics than those exposed to non-GAI.

The intrinsic value of Mathematics lies in its ability to develop critical thinking and problem-solving skills and foster creativity among students. Through mathematical exploration, students acquire the tools to analyze complex problems, approach challenges with a structured mindset, and think creatively. The benefits extend beyond the classroom, empowering students to tackle real-life situations, contribute to advancements in various fields, and become lifelong learners. Recognizing the intrinsic value of Mathematics, educators, and policymakers must prioritize mathematics education, providing students with opportunities to engage with the subject and unlock their full potential.

The use of games by teachers in the classroom also impacts how students view Mathematics and school [41]. Students' perceptions of school and Mathematics are impacted by teachers' usage of games in the classroom. Games could help students feel more at ease while learning Mathematics by changing their perspective on the subject's difficulty. By altering how students perceive how tough Mathematics is, games might make them feel more at ease while learning it. If a behavior is repeatedly paired with a reward, it may develop intrinsic value and become a "secondary reinforcer" [42].

Learning will be effective and enjoyable if teachers use the appropriate teaching techniques following the subject matter and the needs of their students [43]. Even though Mathematics is a difficult subject, adopting the play-based learning strategy enables students' negative views of learning to be changed into positive ones. students enjoy Mathematics because it is a subject, they will use in their daily lives now and in the future.

If the teacher's method of instruction provokes the students' attention, they will have favorable perceptions of the subject being taught. In addition, game-based learning could influence certain aspects of student motivation for learning and provide favorable perceptions [44].

Table 3. Students' Self-Regulation towards Mathematics exposed to GAI and those in non-GAI

Students Self-Regulation towards Mathematics	BEFORE				AFTER			
	GAI (n=20)		Non-GAI (n=17)		GAI (n=20)		Non-GAI (n=17)	
	$\bar{x}$	QI	$\bar{x}$	QI	$\bar{x}$	QI	$\bar{x}$	QI
I put enough effort into learning Mathematics.	3.60	P	4.12	P	4.10	P	4.12	P
If I am having trouble learning Mathematics, I try to figure out why.	3.55	MP	4.29	P	4.45	P	4.24	P
I use strategies that ensure I learn Mathematics well.	3.35	MP	3.94	HP	4.60	HP	4.06	P
I prepare well for Mathematics tests and quizzes.	3.25	MP	3.71	HP	4.70	HP	3.82	P
Overall Mean Interpretation	3.44	MP	4.01	P	4.46	P	4.06	P

Before the intervention, one (1) out of five statements that is "I put enough effort into learning Mathematics," has a mean of 3.60, was classified as a "positive" level by the students exposed to GAI before the intervention. The three (3) statements, namely, "If I am having trouble learning Mathematics, I try to figure out why," "I use strategies that ensure I learn Mathematics well," and "I prepare well for Mathematics tests and quizzes," were classified with "Moderately positive" and has the mean of 3.55, 3.35, and 3.25, respectively. The four (4) statements that described self-regulation towards Mathematics have an overall mean of 3.44, classified as "Moderately Positive." On the other hand, there are two (2) statements by the students exposed to non-GAI that were classified as "highly positive," namely, "I use strategies that ensure I learn Mathematics well" and "I prepare well for mathematics tests and quizzes" with the mean of 3.94 and 3.71, respectively after the intervention. Moreover, another two (2) statements were classified with a "positive" level of self-regulation towards Mathematics, namely "I put enough effort into learning Mathematics" and "If I am having trouble learning Mathematics, I try to figure out why," with a mean of 4.12 and 4.29, respectively. The self-regulation statements by the students exposed to non-GAI have an overall mean of 4.01 and are classified as "positive."

After the intervention, as shown above, two (2) statements by the students exposed to GAI were classified with a "positive" self-regulation level towards Mathematics. These are "I put enough effort into learning Mathematics," with a mean of 4.10, and "If I am having trouble learning Mathematics, I try to figure out why," with a mean of 4.45. Additionally, there are two (2) statements, namely "I use strategies that ensure I learn Mathematics well" and "I prepare well for Mathematics tests and quizzes," were classified with a "highly positive" level of self-regulation after the intervention. The overall mean of the student's responses to GAI is 4.46, classified as "positive." On the other hand, all four (4) statements that described the self-regulation of the students exposed to non-GAI, as mentioned above, were classified as "positive" with the means 4.12, 2.24, 4.06, and 3.82, respectively. The overall mean score of the statements by the students exposed to non-GAI is 4.06 and classified with a "positive" level.

The overall mean of the responses of the students exposed to GAI and those in non-GAI shows the improvement in self-regulation towards Mathematics. However, students in the GAI group have higher mean scores of responses than the non-GAI group. Therefore, the self-regulation of the students exposed to GAI is better than those exposed to non-GAI. It is observed that students' interest and enjoyment given a task is improved. They are innately driven to engage in activities that are at least relatively interesting, enjoyable, and demanding. Learning becomes personally relevant when students' prior knowledge and varied experiences are combined with their everyday learning experiences. Students bring a diversity of experiences and interests to the classroom.

On mathematics problems, those with better self-regulation have been found to reply more quickly, which may be related to their increased ability to tune out distractions and concentrate on the subject at hand [45].

Self-regulation positively predicts students' achievement in Mathematics. Students who can effectively regulate their learning processes, such as setting goals, planning, monitoring their progress, and adapting their strategies, are more likely to achieve higher Mathematics success levels [46].

Self-efficacy, the belief in one's capabilities to accomplish tasks, is closely related to self-regulation. Students with high self-efficacy in Mathematics are more likely to engage in self-regulatory behaviors, persist in challenging tasks, and seek support when needed. The role of self-efficacy in Mathematics achievement. Students who have confidence in their abilities can better regulate their learning, overcome obstacles, and ultimately achieve higher levels of mathematical proficiency [47].

Students' self-regulation in Mathematics plays a significant role in their academic success, problem-solving skills, and mindset development. By nurturing academic autonomy, self-regulation empowers students to take ownership of their learning and actively participate in their mathematical journey. The ability to regulate cognitive, metacognitive, and affective processes enhances problem-solving skills, enabling students to tackle mathematical challenges effectively. Moreover, self-regulation promotes a growth mindset, fostering a belief in the malleability of mathematical abilities and the value of effort.

Table 4. Students Self-Efficacy towards Mathematics exposed to GAI and those in non-GAI

Students Self-Efficacy towards Mathematics	BEFORE				AFTER			
	GAI (n=20)		Non-GAI (n=17)		GAI (n=20)		Non-GA I (n=17)	
	$\bar{x}$	QI	$\bar{x}$	QI	$\bar{x}$	QI	$\bar{x}$	QI
I am confident I will do well on Mathematics assignments and projects.	3.60	P	3.76	P	4.55	HP	3.71	P
I am confident I will do well on mathematics tests.	3.15	MP	3.47	MP	4.10	P	3.47	MP
I believe I can master the knowledge and skills in the mathematics course.	2.95	MP	3.76	MP	4.40	P	3.94	P
I believe I can earn the highest grade in the mathematics subject.	2.45	N	2.65	MP	4.00	P	3.71	P
Overall Mean Interpretation	3.04	MP	3.41	MP	4.26	P	3.71	P

As shown in the table, before the intervention, students exposed to GAI had one (1) out of four (4) statements that described the self-efficacy towards Mathematics that was classified as "positive" and has a mean of 3.60. This statement is, "I am confident I will do well on mathematics assignments and projects." Moreover, there are two (2) out of four (4) statements, namely "I am confident I will do well on mathematics tests" and "I believe I can master the knowledge and skills in the mathematics course," were classified as "moderately positive" with the mean of 3.15 and 2.95, respectively. Furthermore, one (1) statement, "I believe I can earn the highest grade in the mathematics subject," was classified as "negative" with a mean of 2.45. On the other hand, three (3) out of four (4) statements by the students exposed to non-GAI, namely, "I am confident I will do well on mathematics tests" and "I believe I can master the knowledge and skills in the mathematics course" and "I believe I can earn the highest grade in the mathematics subject" were classified with "moderately positive" with the mean of 3.47, 3,76, and 2.65, respectively. One (1) of four (4) statements that describe the self-efficacy of the students was classified as "positive," that is, "I am confident I will do well on mathematics assignments and projects," which has a mean of 3.76. Three (3) out of four (4) statements were classified as "moderately positive." These are "I am confident I will do well on mathematics tests," "I believe I can master the knowledge and skills in the mathematics course," and "I believe I can earn the highest grade in the mathematics subject" with the mean 3.47, 3.76, and 2.65, respectively. Thus, students exposed to GAI and those exposed to non-GAI were classified as "moderately positive," with a mean of 3.04 and 3.41 before the intervention.

As observed from the data, after the intervention, out of four (4) statements, one (1) statement, "I am confident I will do well on mathematics assignments and projects," was classified as "highly positive" with a 4.55 descriptive mean. Three (3) statements, namely, "I am confident I will do well on mathematics tests," "I believe I can master the knowledge and skills in the mathematics course," and "I believe I can earn the highest grade in the mathematics subject," were classified with "positive" level of self-efficacy towards Mathematics. The mean of the above three (3) statements were 4.10, 4.40, and 4.00, respectively. The overall mean of the self-efficacy of the students exposed to GAI is 4.26 and was classified as "positive."

One (1) out of four (4) statements that described the elf-efficacy of the students exposed to non-GAI was classified as "moderately positive." This statement is "I am confident I will do well on mathematics tests," which has a mean of 3.47. Three (3) statements, namely, "I am confident I will do well on mathematics assignments and projects," "I believe I can master the knowledge and skills in the mathematics course," and "I believe I can earn the highest grade in the mathematics subject" were classified with "positive" self-efficacy that has a mean of 3.71, 3.94 and 3.71, respectively. The overall mean of the statements by the students exposed to non-GAI is 3.71 and was classified as "positive."

The two groups exposed to GAI and those in non-GAI both classified with "positive" self-efficacy towards mathematics after the intervention. However, the students exposed to GAI are better than those exposed to non-GAI. This result means that students are confident to do well on Mathematics assignments, projects, and tests; students also believe they can master the knowledge and skills and can earn the highest grade in Mathematics after the intervention.

Students' levels of self-efficacy have an impact on their actions, efforts, perseverance, flexibility about differences, and achievement of their goals when they participate in an investigative process [48,49,50]. Motivation affects students' self-efficacy because motivated learners have confidence in their abilities [51].

Student mathematics achievement and mathematical self-efficacy are highly associated. Once more, a student's level of mathematical self-efficacy can be used to predict their mathematics performance [52]. As a result, improving students' mathematical self-efficacy positively affects their mathematics performance. This research has made it more crucial to consider how students' mathematical self-efficacy affects their achievement.

Self-efficacy in Mathematics is critical in motivating students' engagement and persistence in the subject. Higher self-efficacy students exhibit greater intrinsic motivation, interest, and enjoyment in Mathematics [53]. They approach mathematical tasks with a sense of mastery and view setbacks as opportunities for growth rather than signs of failure [54]. Students' belief in their abilities fuels their intrinsic motivation, leading to increased effort and a sustained commitment to learning Mathematics.

The concept of a growth mindset, popularized by Dweck [55] posits that individuals' beliefs about intelligence and abilities shape their learning outcomes. Students' self-efficacy in Mathematics is closely linked to developing a growth mindset. A study [56] demonstrated that students with higher self-efficacy are likelier to adopt a growth mindset toward Mathematics. They perceive challenges as opportunities to learn and embrace effort and perseverance. Such a growth mindset fosters a belief in the malleability of mathematical abilities, enhancing students' willingness to engage in deliberate practice and pursue mastery of Mathematics.

In creating a supportive learning environment, teachers should strive to create a classroom environment that supports students' self-efficacy development. Encouraging collaboration, promoting positive social interactions, and creating a safe space where students feel comfortable making mistakes and seeking help foster a sense of belonging and competence [57]. Teachers can cultivate an environment that nurtures self-efficacy beliefs by valuing effort and emphasizing the process of learning rather than solely focusing on correct answers.

Introducing students to successful role models in Mathematics, both within and outside the classroom, can inspire and enhance self-efficacy. Sharing stories of individuals who have overcome challenges and achieved success in Mathematics instills the belief that similar achievements are possible for students themselves. Furthermore, providing opportunities for students to observe and learn from peers who demonstrate strong self-efficacy can also be influential [58].

Table 5. Students' Utility Value towards Mathematics exposed to GAI and those exposed to non-GAI.

Students' Utility Value towards Mathematics	BEFORE				AFTER			
	GAI (n=20)		Non-GAI (n=17)		GAI (n=20)		Non-GAI (n=17)	
	$\bar{x}$	QI	$\bar{x}$	QI	$\bar{x}$	QI	$\bar{x}$	QI
I think about how Mathematics will be helpful to me.	3.75	P	3.94	P	4.55	P	4.06	P
I think about how I will use the Mathematics I learn.	3.70	P	4.18	P	4.25	P	4.12	P
I think about how learning Mathematics can help me get a good job.	3.65	P	4.41	P	4.35	P	4.41	P
I think about how learning Mathematics can help my career.	3.45	MP	4.18	P	3.80	P	4.18	P

Looking at the table, before the intervention, one (1) out of four statements was classified as "moderately positive," where the students exposed to GAI thought of how learning Mathematics can help their careers. This statement, "I think about how learning Mathematics can help my career," has a mean of 3.45. Three (3) of the statements, namely "I think about how Mathematics will be helpful to me," "I think about how I will use Mathematics I learn," and "I think about how learning Mathematics can help me get a good job," were classified with "positive" where students usually thought about how Mathematics will be helpful to them, thought about how to use the knowledge they learned, and thought about how learning Mathematics can help them get a good job. The three (3) statements above, classified as "positive," have a mean of 3.75, 3.70, and 3.65, respectively. The overall mean of the statements describing the students' utility value towards Mathematics exposed to GAI is 3.45, classified as "positive." On the other hand, all four (4) statements by the students exposed to non-GAI were classified as "positive" with an overall mean of 4.18. The statements and each corresponding mean are as follows; "I think about how Mathematics will be helpful to me" with a mean of 3.94, "I think about how I will use Mathematics I learn" has a mean of 4.18, "I think about how learning Mathematics can help me get a good job" has the mean of 4.41, and "I think about how learning Mathematics can help my career" has a mean of 4.18.

The students exposed to GAI and non-GAI were classified with a "positive" level of utility value towards Mathematics before the GAI and non-GAI exposure. However, the students exposed to non-GAI have a greater perception of mathematics' importance than those exposed to GAI.

As shown in the data, after the intervention, one (1) out of four (4) statements that describe the students exposed to GAI utility value was classified as "highly positive" with a mean of 4.55. This result means students thought about how Mathematics will be helpful to them. Three (3) statements, namely, "I think about how I will use the Mathematics I learn," "I think about how learning Mathematics can help me get a good job," and, "I think about how learning Mathematics can help my career" were classified with "positive" that has the mean of 4.25, 4.35, and 3.80, respectively. The overall mean of the students' utility value towards Mathematics as exposed to GAI is 4.24 was classified as "positive." On the other hand, the students exposed to non-GAI four (4) statements that described the utility value towards Mathematics were all classified as "positive" with the following mean: 4.06, 4.12, 4.41, and 4.18, respectively.

It is observed that both students exposed to GAI and those exposed to non-GAI were classified as "positive," with an overall mean of 4.24 (GAI) and 4.19 (non-GAI). However, the experimental group (GAI) is better than the control group (non-GAI) regarding utility value towards Mathematics after the GAI and non-GAI exposure. In addition, students exposed to the GAI group have a better improvement in their perception of how personally important Mathematics is to their lives or potential careers than the students exposed to non-GAI. It means that the intervention has a great impact on the students who are exposed to it.

Utility value is related to students' behavior, motivation, and achievement [59,60]. When there is a better utility value, there is better student behavior, motivation, and performance in Mathematics. The advent of utility-value treatments, with promising outcomes from short-term interventions on students' interest, particularly in higher education, was a significant step in fostering their interest [61]. Most utility-value treatments have been built on explicitly communicated teacher explanations or sought student explanations [62].

Students who perceive Mathematics as relevant and useful have a higher propensity to adopt a growth mentality toward the subject [63]. Recognizing the utility value of Mathematics enhances students' belief in their capacity to improve and succeed, supporting the development of a growth mindset.

Students' utility value towards Mathematics is vital in shaping their interest and enjoyment. When students perceive Mathematics as relevant to their personal and academic goals, they are more likely to develop a positive attitude and intrinsic interest in the subject [64]. Recognizing mathematics' practical applications and real-life relevance cultivates curiosity and engagement, making the subject more enjoyable and meaningful for students [65]. The perception of Mathematics as useful and applicable fosters a sense of purpose and promotes sustained interest in learning Mathematics.

Table 6. Students' Test Anxiety towards Mathematics exposed to GAI and Non-GAI.

Students Self-Efficacy towards Mathematics	BEFORE				AFTER			
	GAI (n=20)		Non-GAI (n=17)		GAI (n=20)		Non-GAI (n=17)	
	$\bar{x}$	QI	$\bar{x}$	QI	$\bar{x}$	QI	$\bar{x}$	QI
I become anxious when it is time to take a mathematics test.	3.35	MP	3.75	P	4.55	HP	3.71	P
I am nervous about how I will do on the mathematics tests.	4.10	P	4.00	P	4.10	P	3.47	MP
I worry about failing mathematics tests.	4.35	P	4.06	P	4.40	P	3.94	P
I am concerned that the other students are better in Mathematics.	3.20	MP	3.94	P	4.00	P	3.71	P
Overall Mean Interpretation	3.75	P	3.94	P	4.26	P	3.71	P

As shown above, before the intervention, two (2) out of four (4) statements mentioned above which are "I become anxious when it is time to take a mathematics test" and "I am concerned that the other students are better in Mathematics" were classified with "moderately positive" with the mean of 3.35 to both statements before the exposure of GAI. Next, two (2) statements, namely, "I am nervous about how I will do on the mathematics tests" and "I worry about failing mathematics tests," were classified with a "positive" level of utility value towards Mathematics with a mean of 4.10 and 4.35, respectively. The overall mean of the test anxiety level of the students before the exposure to GAI is 3.75, which is classified as "positive." This result means students were sometimes anxious when it was time to take tests in Mathematics; they usually got nervous about their performance on tests, they usually worried about failing the subject, and students were sometimes concerned that the other students were better at Mathematics.

It is shown that all statements above by the students before the exposure to non-GAI were classified with a "positive" level of test anxiety in Mathematics. The first statement, "I become anxious when it is time to take a mathematics test," has a mean of 3.75; the second statement, "I am nervous about how I will do on the mathematics tests," has a mean of 4.00, followed by the statement "I worry about failing mathematics tests" has the mean of 4.06, and the last statement "I am concerned that the other students are better in Mathematics" has the mean of 3.94. It means the students exposed to non-GAI were anxious and worried about taking math tests before the intervention.

The two groups (GAI and non-GAI group) were classified with "positive" responses about test anxiety in Mathematics with a mean of 3.75 and 3.94, respectively. Students exposed to non-GAI have greater test anxiety towards Mathematics than those exposed to GAI.

After the intervention, one (1) out of four (4) statements that described the test anxiety of the students exposed to GAI were classified as "moderately positive," with a mean of 2.80. Students usually worry about failing mathematics tests after the intervention. Three (3) statements, namely, "I become anxious when it is time to take a mathematics test," "I am nervous about how I will do on the mathematics tests," and "I am concerned that the other students are better in Mathematics" were classified with "negative" test anxiety level with the mean of 1.85, 1.95, and 2.25, respectively. The overall mean of the statements above implies that students exposed to GAI have a low-test anxiety level after the intervention with a classification of "negative."

All four (4) statements above that described the students' test anxiety exposed to non-GAI were classified as "positive" with a mean of 3.76, 4.00, 4.06, and 3.94. Having the overall mean of the statements of 3.94, which is classified as "positive," implies that the students were usually anxious about failing math tests after the intervention.

Students who score well in Mathematics also see the subject favorably [66]. Extremely interested students may be encouraged to train and work without their teacher's consent. One must be engaged in and at ease with Mathematics to comprehend how to manage mathematics anxiety and ultimately obtain positive test results. It will affect how one performs in Mathematics. Reducing anxiety will strengthen students' confidence when solving mathematical problems, motivate them to ask for help when needed, and increase their perseverance [67].

Additionally, test anxiety severely impacts students' performance [68]. For instance, Barrows, et al. [69] found a significant correlation between exam grades, self-efficacy, and test anxiety. Student's self-esteem, mathematics anxiety, and anxiety are all negatively correlated. The student's personality traits, mathematics anxiety, and the teacher's personality traits are significantly correlated [70].

Test anxiety has negatively impacted students' mathematics performance and achievement. Research conducted in recent years has consistently shown that high levels of test anxiety are associated with lower scores, decreased problem-solving abilities, and reduced engagement in mathematical tasks [71, 72].

Students who perform well in Mathematics also have a favorable attitude. Deeply interested students might be encouraged to work and train without the teacher's permission. One must be interested in and confident in this area to understand how to deal with mathematics anxiety and eventually achieve good exam results. This interest will affect how well one performs in Mathematics [66].

Encouraging collaboration, providing constructive feedback, and celebrating progress rather than solely focusing on grades can help reduce the pressure associated with assessments [73]. Moreover, fostering a growth-oriented mindset, emphasizing effort over outcomes, and reframing mistakes as opportunities for growth can help students develop resilience and reduce test anxiety [74].

3.3 Mann Whitney U-test of students' Problem-Solving Skills in Mathematics when exposed to Game-Aided Instruction

As the table presented, the student's problem-solving skills exposed to GAI scored a mean of .888 with a standard deviation of .122, while the students' problem-solving skills exposed to non-GAI had a "gain score" mean of .314 with a standard deviation of .307.

Table 7. Comparison of students' problem-solving skills in Mathematics.

Group	Posttest (Gain Score)		Mean Rank	Sum of Ranks	Sig. (2-tailed)
	Mean	SD			
GAI	.888	.122	26.75	535.00	.000
Non-GAI	.314	.307	9.88	168.00	

4 **P< Highly Significant at 0.01 level

It is observable in Table 7 shows a significant difference between the two groups. The calculated mean rank in the gain scores for Mathematics problem-solving skills exposed to GAI is 26.75, while non-GAI has a mean rank of 9.88. The GAI group has a greater sum or rank (535.00) than the non-GAI group, with 168.00.

The result shows a significant difference (p-value of 0.00) between students' problem-solving skills exposed to GAI and those exposed to non-GAI. Thus, it indicates that the group exposed to GAI has much higher Mathematics problem-solving skills than the group not exposed to GAI. As a result, the null hypothesis, which suggested no significant difference between the two groups, is rejected.

Mathematical games provide learners with a structure and process for problem-solving engagement that can be used to interact with them and achieve the desired results [75]. Hence, game-aided instruction, compared to a learner-centered teaching technique, substantially impacts students' learning since it can cover various topics briefly. Game-aided instruction offers a teaching method that promotes active learning, interaction, and creative problem-solving while being interesting and enjoyable for the students because games are interactive. In the same way that using logical-mathematical games can improve students' capacity for critical thought with the teacher's guidance and feedback, game-assisted instruction can improve students' academic performance and capacity for critical thought if the games are organized in line with the lesson.

Games often involve challenging puzzles, simulations, and problem-solving scenarios that require students to apply mathematical concepts in authentic contexts [76]. They promote active engagement, critical thinking, and decision-making, enabling students to develop problem-solving strategies and transfer mathematical knowledge to real-world situations [77].

Recent research has demonstrated the positive impact of game-aided instruction on students' problem-solving skills in

Mathematics. Studies have reported improvements in problem-solving, including mathematical reasoning, strategy development, and perseverance [78]. Students who engaged in a mathematics game exhibited higher problem-solving abilities than those in a traditional instruction group. Similarly, Mayer [79] conducted a meta-analysis and found that game-based instruction was associated with significant gains in problem-solving performance.

There are strategies for effective integration of games in Mathematics instruction. Teachers carefully select games that align with specific learning objectives and mathematical content. Games provide opportunities for students to practice problem-solving skills relevant to the curriculum, ensuring a meaningful connection between gameplay and learning outcomes [80]. Teachers should provide clear instructions and scaffolded support to help students understand the game mechanics and mathematical concepts. Establishing a strong connection between gameplay and problem-solving strategies enhances students' knowledge transfer from the game to real-world problem-solving situations [81].

Games provide an appropriate balance between challenge and support, ensuring students experience the difficulty that promotes engagement and fosters growth. Adapting game difficulty based on students' performance and offering scaffolded hints or feedback help maintain a productive learning environment [82].

The impacts of games in the classroom have been the subject of research. However, their impacts differ between study contexts, and the most effective ways to use them still need to be evident [83]. A wide variety of knowledge can be accessed through well-designed games, allowing students to collaborate with other students, understand rather than memorize, explore ideas, and test their theories.

Game-aided instruction holds promise for enhancing students' problem-solving skills in Mathematics. By leveraging the unique features of games, such as interactivity, engagement, and immediate feedback, educators can create dynamic learning environments that promote active problem-solving, critical thinking, and mathematical reasoning. Integrating games effectively into mathematics instruction requires thoughtful selection, alignment with learning objectives, clear guidance, collaborative opportunities, and a balance between challenge and support. Through game-aided instruction, we can foster students' problem-solving abilities and equip them with essential skills for success in Mathematics and beyond.

3.4 Mann Whitney U-test of students' Motivation in Mathematics when exposed to Game-Aided Instruction

The data presented in Table 8 compare the two selected groups' levels of students' motivation for Mathematics throughout the exposure to GAI and non-GAI. The key descriptive data, including the mean score and standard deviation of the students' "gain score" and the sum of ranks, are shown. Information on whether the measured difference is significant enough to back up the researchers' hypothesis is provided.

Table 8. Comparison of students' motivation in Mathematics.

Group	Posttest (Gain Score)		Mean Rank	Sum of Ranks	Sig. (2-tailed)
	Mean	SD			
GAI	.004	.010	21.75	435.00	.086
Non-GAI	.001	.002	15.76	268.00	

**P< Highly Significant at 0.01 level

Table 8 shows the mean "gain score" for students' motivation in Mathematics as exposed to GAI is .004, with a standard deviation of .010. However, the mathematics motivation gain score for students exposed to non-GAI had a mean of .001 and a standard deviation of .002. It is clearly shown that students exposed to non-GAI have a higher mean rank of 21.75 (sum of ranks = 435.00) compared to those exposed to non-GAI with a mean rank of 15.76 sum of ranks of 268.00. However, the p-value is .086, which suggests the failure to reject the statement, "There is no significant difference in the student's motivation in learning Mathematics when exposed to Game-Aided Instruction and Non-Game-Aided Instruction."

The teachers try to motivate the students best, but some introverted students sometimes need to participate in the learning process actively. In this way, the teacher should reinforce the needs and appreciate the positive behavior of such students.

Games have a positive impact on student's motivation, engagement, emotions, and attitudes toward learning Mathematics [84]. Consequently, students find learning to be more engaging when teachers add well-designed mathematics games into their lesson plans. Increased motivation in students positively impacts their academic achievement [85].

The motivating processes that could strengthen and sustain classroom activities are multidimensional, including the student's needs, expectations or beliefs, and goals [86]. Students will be motivated to learn when all their needs and expectations are met. They then show the following behaviors: class participation, repeating knowledge, relating to their existing knowledge, and asking questions. In short, there is an eagerness to learn.

Game-aided instruction provides students with numerous opportunities to grow personally in their knowledge and skill sets in an entertaining way. Students socially interact with their friends while also connecting the mathematical concepts they are learning to actual life problems with the aid of games. However, it does not always guarantee that students get motivated when games are introduced. The level of games may vary to suit the interests of the students. Students are surely engaged in the intervention, having seen their full participation in the activities; however, it does not assure the increase of their motivation in Mathematics.

5 CONCLUSIONS AND RECOMMENDATIONS

Based on the above findings, the conclusion was drawn as follows:

Students exposed to Game-Aided Instruction have a significantly higher posttest score compared to pretest scores. Thus, there is a highly significant difference in the problem-solving skills in Mathematics of grade 11 students of Kuya National High School exposed to Game-Aided Instruction between pretest scores and posttest scores. There is no difference between the pretest and posttest in the motivation level of the students in Mathematics when exposed to Game-Aided Instruction.

Based on the conclusion, Mathematics teachers need to learn to utilize Game-Aided Instruction to improve the students' problem-solving skills in mathematics since it is noted in the study that there is an increase in the performance of the students before and after the intervention.

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