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Optimizing Students' Performance through Artificial Intelligence (AI) Technology: A Gamified Approach to Smart Learning Environment

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ABSTRACT

This study tested the application of Artificial Intelligence (AI) technology to optimize students' performance within a smart learning environment, employing a gamified approach. The study assessed the effectiveness of integrating AI-driven gamification techniques in Mathematics in the Modern World classes and their impact on engagement, motivation, and academic achievement. It utilized a descriptive-evaluative and quasi-experimental design. Descriptive analysis gauged student performance in pretest and posttest, while evaluative design identified differences between control and experimental groups. Quasi-experimental design assessed if the treatment caused changes in the dependent variable, measuring pre- and post-treatment variables to observe significant differences. Results showed that there was a significant difference in students' performance in Mathematics in the Modern World classes after the integration of Artificial Intelligence (AI) technology in the instruction in the experimental group. The noteworthy improvement in student performance following the integration of Artificial Intelligence (AI) technology underscores its positive impact on enhancing instructional effectiveness, advocating for broader implementation and exploration in educational settings. However, the study's findings may be context-specific, and generalizability could be limited, as variations in educational settings and technological infrastructure may influence the effectiveness of AI-integrated gamified approaches.

Keywords
Artificial Intelligence
Gamified Approach
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Introduction

Artificial Intelligence (AI) has the potential to revolutionize education by improving learning outcomes, reducing costs, and increasing access to education [1]. However, it is important to ensure that this is used ethically and transparently in grading and assessing students' learning gains and in the teaching and learning process. This can save teachers time and provide more consistent and objective grading. In the context of the Naga College Foundation, the institution transitioned into the digital space to accommodate remote learning during the pandemic. Google Applications such as Google Classroom, Google Forms, and Google Drive were utilized as Learning Management Systems in replace of the traditional classroom setup. They are all AI-based technologies that efficiently aid in managing classes set in the virtual cloud. This is a strong manifestation that the institution has embraced the immense power of AI in education.

In the second semester of the school year 2022-2023, the institution gradually shifted from full implementation of online learning to blended learning. This paved the way for reopening the institution once more for in-person classes. The two-year hiatus from in-person classes made learners more reliant on technology which decreases their motivation to attend their in-person classes. This also affects their attention span and ability to focus inside the traditional classroom. Based on Ref. [2] discussed that gamification, through the integration of game-like elements into non-game contexts, possesses the inherent capacity to stimulate motivation and captivate the active engagement of users.

This study employed artificial intelligence technology in teaching and learning by comparing the experimental group to the control group to optimize students' performance. It answered the following questions:

1. What is the level of learners' performance in the control and experimental groups in terms of pre-test and post-test?
2. Is there a significant difference between the pre-test and post-test results of the control and experimental groups?

3. Is there a significant difference between the control and experimental groups in the pre-test and post-test?

The integration of Artificial Intelligence (AI) technology and gamified strategies forms the cornerstone of this research, aiming to redefine the conventional paradigms of student engagement and academic achievement [3]. By delving into the impact of this novel approach on diverse facets of students' educational experiences, including performance, cognitive abilities, and overall academic achievement, the study seeks to contribute crucial insights to the ongoing discourse on effective educational interventions in the digital era.

Moreover, the study aspires to offer educators, policymakers, and educational practitioners a comprehensive understanding of the potential benefits associated with the integration of AI and gamified approaches. This research, grounded in the transformative potential of technology, stands as a proactive initiative to inform evidence-based decision-making in the design and implementation of educational interventions tailored to the needs of the modern learner. As the study unfolds, it seeks not only to showcase the immediate impacts of AI and gamification on student outcomes but also to contribute to a broader narrative that envisions a new era in education. Through this, the research sets the stage for discussions and reflections on the evolving role of technology in shaping the educational landscape, emphasizing the importance of thoughtful integration to optimize the learning experiences of students in the digital age.

Literature Review

It has been noted by Ref. [4] that AI systems provide excellent assistance for online learning and teaching by customizing learning for students, automating mundane activities for instructors, and powering adaptive evaluations. Thus, understanding how students and instructors perceive the influence of AI systems on their interactions is very much critical for detecting any gaps, obstacles, or hurdles limiting AI systems from reaching their full potential and endangering the safety of these interactions.

Undoubtedly, gamification using AI has the potential to improve student engagement, motivation, and learning outcomes. The personalized feedback and challenges provided by AI can enhance the gamification experience, leading to better academic performance and satisfaction for students. However, the design of gamification using AI must be carefully considered to ensure that it aligns with the curriculum and learning objectives.

Furthermore, gamification is a process of applying game design and elements to non-game contexts such as education to improve student engagement and motivation [5]. The use of artificial intelligence (AI) can enhance gamification by providing personalized learning

experiences and feedback to students [6]. In connection, Ref. [7] found that students who participated in a gamified programming course with AI had higher engagement and motivation levels, as well as better test scores and understanding of the course content. Similarly, Ref. [8] found that gamifying a history class with AI improved student motivation and academic performance since AI can provide personalized feedback to students based on their performance, which can improve their learning outcomes [9]. Moreover, AI can adapt to individual student's learning styles and provide tailored content, resulting in better learning experiences [10]. Gamification using AI can also improve student engagement and retention of content. According to Ref. [11] gamification can provide an immersive learning environment that fosters active participation and retention of information. AI-powered gamification can enhance this effect by providing personalized feedback and challenges [12].

In addition, gamification using AI can increase student motivation and satisfaction with the learning process. As reported by Ref. [13], gamification can create a sense of accomplishment and enjoyment for students, which can lead to improved motivation and satisfaction. This effect can be enhanced by the personalized feedback and challenges provided by AI-powered gamification [14]. However, gamification using AI also has its challenges. As articulated in Ref. [15], gamification can lead to superficial engagement if not designed properly. To avoid this issue, gamification using AI should be designed with clear learning objectives and should align with the curriculum [16].

Some studies have demonstrated the positive effects of Game-based learning on student learning outcomes. For example, a study by Ref. [17] found that it had a significant positive effect on students' mathematics achievement, problem-solving skills, and learning motivation. Similarly, a study by Ref. [18] found that game-based learning had a positive effect on students' engagement and academic performance in a physics course. It can also improve students' collaboration and communication skills. A study by Ref. [19] found that a multiplayer game-based learning approach improved students' communication and teamwork skills. Likewise, a study by Ref. [20] found that a collaborative game-based approach improved students' communication, collaboration, and critical thinking skills.

It can also be used to teach social and emotional skills. Ref. [21] found that a game-based learning approach improved students' empathy and perspective-taking skills. This is related to Ref. [22] wherein the game-based approach improved students' emotional regulation and social skills. However, the effectiveness of it depends on the design of the game and its alignment with learning objectives. As noted by Ref. [23], games must be designed with clear learning objectives and must align with the curriculum to be effective in enhancing

learning outcomes. Additionally, the use of assessment and feedback systems in games can enhance their effectiveness in promoting learning [24].

Game-based learning can also face challenges such as technological barriers and issues with game design. Technological challenges such as connectivity and compatibility can impact the effectiveness of Game-based learning. Similarly, issues with game design such as game mechanics and narrative can also impact the learning experience [25]. While the prospects for AI are exciting, learners and teachers may have a negative perception of the impact of AI systems. For example, students may interpret indiscriminate data gathering and analysis by AI systems as a violation of their privacy, as demonstrated by the Facebook-Cambridge Analytica data scandal [26]. Students may interpret the conduct of AI agents that do not account for the danger of data bias or algorithmic bias as discriminatory [27]. Teachers are concerned that depending too heavily on AI systems would impair students' capacity to learn freely, solve issues creatively, and think critically [28].

The AI in education industry is becoming more interested in the role of AI systems in online education. Ref. [29], for example, advocates for more use of AI systems in student-instructor interactions and education applications outside of the classroom. Simultaneously, Ref. [30] conducted a systematic review of AIEd publications published between 2007 and 2018 and discovered a lack of critical reflection on the ethical impact and risks of AI systems on learner-instructor interaction. There is also possible conflicts between students and instructors, such as privacy issues, shifts in power hierarchies, and overbearing control [31]. Learner-instructor connection is critical in online learning. Ref. [32] revealed that learner-instructor interaction elements such as communication, support, and presence increase student satisfaction and learning outcomes. The learner-instructor connection has an additional impact on students' self-esteem, willingness to study, and confidence in confronting new obstacles [33]. However, little is known about how incorporating AI systems into online learning will affect learner-instructor interaction.

Material and Methods

The study employed a descriptive-evaluative and quasi-experimental design. The descriptive design was used to ascertain the level of student performance in the pretest and posttest. The evaluative design was employed to underscore the significant differences in the pretest and posttest and among the control and experimental groups. The quasi-experimental design allowed the researchers to determine if the independent variable or treatment caused a change in the dependent variable. The researchers measured the dependent variable before and after the treatment compared the two sets of measurements and saw a change.

The study was carried out at Naga College Foundation, Inc. under the supervision of the administrators of the institution. Participants of the study were chosen based on the inclusion criteria identified by the researchers. Participants were students at Naga College Foundation, enrolled for the current semester, taking Mathematics in the Modern World subject, technology literate, and were not part of any similar research. Respondents included in the study were naturally assembled classes. Participants who did not meet the criteria were excluded from the study. This ensured that the study results were not confounded by factors that differ between those who do and do not meet the inclusion criteria. Students were grouped into two. The control group had 40 students and another 40 students were under the experimental group. The study has a total of 80 participants.

The principal instrument for the study was the researcher-made pre and post-tests. The test covered topics under Math in the Modern World which was administered before and after the integration of the artificial intelligence-based technology. After the preparation of the pre and post-test, a pilot testing of the tool was conducted to separate mock respondents to validate the content of the pre and post-test and its relevance to the forgoing study. After the pilot testing, the results were analyzed using Cronbach's Alpha Test to facilitate the revision of items for the best interest of this study.

Table 1. Results of the Reliability Test

Aspects	Number of Items	Reliability Cronbach's Alpha	Interpretation
Higher Order Thinking Skills	20	0.810	Very Reliable
Lower Order Thinking Skills	30	0.807	Very Reliable

Legend: Cronbach's Alpha Score: >0.80-1.00: Very Reliable; >0.60-0.80: Reliable; >0.40-0.60: Quite Reliable; >0.20-0.40: Rather Reliable; 0.0-0.20: Less Reliable

Table 1 shows the results of the conducted pilot testing of the research instrument. It got a reliability score of 0.810 for higher-order thinking skills and for 0.807 lower-order thinking skills which were translated as very reliable. The results indicate a strong internal consistency among the items or variables included in the test. This also implied that the items in the measurement instrument are highly correlated and are collectively measuring the same underlying construct reliably. Researchers are confident that the measurements are stable and that the instrument consistently captures the intended concept.

Results and Discussion

A. Level of Learners' Performance in the Control and Experimental Groups in terms of Pre-test and Post-test

The control group's pre-test result was translated to low performance garnering a mean score of 22.5 and a standard deviation of 6.77. The post-test results, on the other hand, had a

mean score of 24.45 and a standard deviation of 8.05 which was again translated to low performance. The experimental group had a 16.43 mean score and a standard deviation of 5.53 pre-test results spelled as low performance. The post-test result had a 28.35 mean score and a standard deviation of 7.35 which meant a high-performance level which is way higher than the pre-test results of the experimental group. The assessment affirmed that the gamified AI integration in the experimental group had improved the learners' performance level after it was integrated into the instruction.

Table 2. Learners' Performance in the Control and Experimental Groups

Group	Test	Mean	SD	Interpretation
Control Group	Pre-Test	22.55	6.77	LP
	Post-Test	24.45	8.05	LP
Experimental Group	Pre-Test	16.43	5.53	LP
	Post-Test	28.35	7.35	HP

Legend: 37.76 – 50.00: Very High Performance (VHP); 25.51 – 37.75: High Performance (HP); 13.26 – 25.50: Low Performance (LP); 1.00 – 13.25: Very Low Performance (VLP)

The experimental group for Mathematics in Modern World demonstrated a high-performance level following the integration of gamified AI-based technology, underscoring the potent impact of this innovative educational approach. The incorporation of gamification likely introduced elements of challenge, interactivity, and intrinsic motivation, which are known to enhance engagement and learning outcomes. The result may be linked with the findings of Ref. [10] wherein the gamified AI-based technology might have provided personalized learning experiences, adapting to individual learning styles and pacing, thereby optimizing comprehension and retention. Furthermore, the result of the study may be linked to Ref. [23] wherein the interactive nature of the technology could have stimulated a sense of curiosity and competition among participants, fostering a positive learning environment. The real-time feedback and rewards inherent in gamified systems likely contributed to a continuous cycle of motivation and achievement, ultimately resulting in the observed high-performance levels within the experimental group.

B. Significant Difference Between the Pre-Test and Post-Test Results of the Control and Experimental Groups

Mathematics in the Modern World had a degrees of freedom (df) value of 39, a mean difference of 1.9, a t-value of -1.14, and a p-value of 0.13, suggesting that there is no statistically significant difference in the control group. Meanwhile, in the experimental group, it had a degrees of freedom (df) value of 39, a mean difference of 11.92, a t-value of -8.20, and a p-value of 0.00 construed as significant. This means that there is a significant difference in the assessment made in the experimental group.

Table 3. Significant Difference Between Pre-Test and Post-Test

Subject	Group	df	Mean Difference	t-value	p-value	Interpretation
Math in the Modern World	Pre-Test	39	1.9	-1.14	0.13	Not Significant
	Post-Test	39	11.92	-8.20	0.00	Significant

Legend: p<0.05 = Not Significant; p≤ 0.01= Significant

This substantial positive shift in outcomes underscores the effectiveness of this innovative approach, indicating that the gamified AI technology synergistically contributed to the observed improvements. Such a significant impact is particularly noteworthy in classrooms, suggesting that the gamification of content with AI integration can lead to more engaging and effective learning experiences [4]. These findings are also related to Ref. [13] where AI integration not only contributes to the understanding of the specific intervention's efficacy but also holds broader implications for the potential benefits of gamified AI technologies in enhancing performance outcomes in various educational institutions.

C. Significant Difference Between the Control and Experimental Groups

The pre-test resulted in a mean difference of 4.3, a t-value of -3.13, and a p-value of 0.00 spelled as significant. Meanwhile, in the post-test, it was recorded that the mean difference was 3.9, a t-value of -2.26, and a p-value of 0.001 which was again translated to significant.

Table 4. Significant Difference Between the Control and Experimental Groups

Subject	Test	df	Mean Difference	t-value	p-value	Interpretation
Math in the Modern World	Control Group	39	6.12	4.43	0.00	Significant
	Experimental Group	39	3.9	-2.26	0.01	Significant

Legend: p<0.05 = Not Significant; p≤ 0.01= Significant

In totality, the observed significant differences between the control and experimental groups in Math in the Modern World indicate the impact of the implemented intervention, in this case, the integration of gamified AI technology, on the learning outcomes of the participants. In the pre-test, the existence of statistically significant differences suggests that, even before the introduction of the intervention, there were inherent disparities in the knowledge, skills, or abilities between the identified two groups. This baseline dissimilarity underscores the importance of using statistical analyses to account for these initial discrepancies, providing a more accurate assessment of the intervention's effects.

As the study progressed to the post-test phase, the persistence of significant differences between the control and experimental groups implies that the implemented intervention had a discernible impact on the groups' learning trajectories. These results may

be linked with Ref. [17]. The statistically significant results in the post-test indicate that the gamified AI technology contributed to divergent learning outcomes compared to the control group, which did not experience the intervention. This finding strengthens the argument for the efficacy of gamified AI technology in positively influencing the learning outcomes of the experimental group [2].

Moreover, the consistency of these significant differences across both pre and post-tests adds robustness to the study's findings. It suggests that the observed effects are not merely transient but have been sustained over time, demonstrating the durability of the intervention's impact. The persistence of significant differences between the groups in the post-test underscores the lasting influence of gamified AI technology on the experimental group's learning outcomes, providing valuable insights into the potential of such interventions for sustained educational improvements.

The significant differences observed between the control and experimental groups in both pre, and post-tests lend strong support to the hypothesis that the integration of gamified AI technology has a meaningful and lasting impact on learning outcomes. These findings contribute not only to the understanding of the specific intervention's effectiveness but also highlight the potential of innovative teaching methodologies, such as gamified AI technology, in positively shaping educational outcomes [1].

Conclusion

In conclusion, the integration of gamified AI technology in the Mathematics in Modern World instructional approach yielded substantial and lasting improvements in learning outcomes. The experimental group showcased a remarkable shift from low to high performance levels, emphasizing the transformative potential of this innovative educational approach. Statistical analyses confirmed the significance of these differences, indicating the sustained impact of gamified AI technology on learning trajectories. The findings underscore the importance of addressing baseline disparities and highlight the enduring influence of such interventions. The potential influence of external factors, such as varying teacher styles or student engagement levels, remains unexplored. Furthermore, the reliance on quantitative measures alone may overlook qualitative aspects of the learning experience. Despite these limitations, the study provides valuable insights into the potential benefits of gamified AI technology, emphasizing the need for future research to address these constraints and offer a more comprehensive understanding of its applicability and effectiveness in diverse educational contexts.

Limitations and Suggestions

The utilization of the cross-over approach in research has proven to be a valuable method for investigating various phenomena across diverse disciplines. Future researchers may embark on their investigations, considering the adoption of the cross-over design to offer several advantages in terms of experimental control, participant variability, and statistical efficiency.

Conflict of Interest

I hereby declare that I have no conflict of interest in connection with the research project. This declaration encompasses financial, personal, or any other relationships that could potentially influence the objectivity, integrity, or impartiality of the research conducted.

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