Enhancing Student Engagement and Conceptual Understanding of Lunar Cycles Through Moon Phases Bingo

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ABSTRACT

Lunar cycles have captivated humanity for centuries, influencing both artistic expression and scientific inquiry. Despite their significance, many students struggle to understand the underlying principles of moon phases, often leading to misconceptions that hinder their grasp of fundamental astronomical concepts. This study investigates the effectiveness of Moon Phases Bingo, a gamified educational approach, in enhancing student engagement and comprehension of lunar cycles among first-year secondary education science majors at North Eastern Mindanao State University-Lianga Campus. Utilizing a mixed-methods design, the involves pretests and posttests with qualitative insights from focus group discussions. Results indicate a significant increase in students' conceptual understanding, as evidenced by an improvement from a pretest mean score of 60.77% (near mastery) to a posttest mean score of 80% (mastery). The normalized gain score further supports this finding, demonstrating effective knowledge retention and engagement. The thematic analysis reveals that students experienced heightened motivation, collaborative learning opportunities, and a more profound understanding of lunar mechanics through the game. This study contributes valuable insights into the application of gamification in science education, highlighting its potential to address persistent misconceptions and promote scientific literacy, particularly in under-resourced educational settings. By empowering educators with innovative teaching strategies, this research aims to foster curiosity and enhance the overall quality of astronomy education.

Keyword: *Lunar cycles, Gamification, Moon Phases Bingo, Student engagement, Conceptual understanding*.

1. INTRODUCTION

Lunar cycles have fascinated humanity for centuries, impacting colorful artistic practices and scientific inquiries. still, despite their significance, numerous students struggle to grasp the underpinning generalities associated with moon phases. exploration indicates that traditional educational styles may not sufficiently address these challenges, leading to patient misconceptions. (Trundle et al., 2002). This study aims to enhance student understanding of lunar cycles through the perpetration of Moon Phases Bingo, a game- grounded literacy approach designed to foster engagement and appreciation. The study of lunar phases is a fascinating investigation that grounds scientific inquiry with cultural significance. The moon's cyclical metamorphoses have inspired a wealth of myths, traditions, and scientific studies throughout history. Despite its elevation in both the natural world and mortal culture, numerous students struggle to grasp the underpinning mechanisms of lunar phases. This frequently leads to misconceptions

that hamper their understanding of abecedarian astronomical generalities. This study aims to enhance pupil engagement and appreciation of lunar cycles through the innovative operation of Moon Phases Bingo, a gamified tutoring strategy designed to foster interactive literacy and address these educational challenges.

Recent literature underscores the critical part of active literacy strategies in science education. For illustration, Hamari et al. (2014) highlight that gamification can significantly enhance encouragement and engagement among learners by incorporating game mechanics into educational exercise. also, Subhash and Cudney (2019) demonstrate that gamified approaches not only enrich ideal knowledge but also foster positive stations toward wisdom among students. These findings resound with Bruner's. (1966) proposition of discovery literacy, which emphasizes the significance of engaging students in investigation and hands- on exercise to ease deeper understanding. Despite these advancements in pedagogical strategies, there remains a notable gap in the operation of gamified literacy tools specifically shaped to tutoring complex scientific generalities similar as lunar phases.

Empirical Exploration indicates that numerous students continue to struggle with understanding lunar cycles indeed after formal instruction. Trundle et al. (2002) establish that students frequently have difficulty sequencing moon phases or explaining the reasons behind their changing appearances. Locally, anecdotal testament from teachers in Surigao del Sur reveals insistent misconceptions regarding lunar language — similar as confusion between waxing and waning phases and challenges in relating the moon’s phases to its orbital position. The lack of observational instruction fund in rural academes further exacerbates these issues, emphasizing an instant need for innovative and interactive strategies that diligently engage students in their literacy process.

This study is significant as it seeks to fill these linked gaps by administering Moon Phases Bingo as a gamified educational strategy within original educational settings. By using constructivist hypotheses particularly those articulated by Piaget (1952), which emphasize active engagement and existential literacy this exploration aims to empower teachers and enhance students' conceptual understanding of lunar cycles. Eventually, this study aspires to contribute extravagant perception into effective knowledge instruction strategies while promoting knowledge education and curiosity among students, particularly in under- resourced educational settings. Constructivist learning theories provide a foundation for this study. Piaget (1952) posits that knowledge is constructed through active engagement with the environment. Bruner's (1966) theory of discovery learning further supports this notion by emphasizing exploration as a means to facilitate understanding. Additionally, Hamari et al. (2014) highlight that gamification enhances motivation and retention by integrating game mechanics into educational activities. Recent studies by Subhash and Cudney (2019) demonstrate the effectiveness of gamified strategies in improving conceptual learning and fostering positive attitudes toward science. Vygotsky's (1978) social constructivism theory reinforces the importance of collaborative and interactive learning in bridging knowledge gaps, particularly for abstract topics such as astronomy.

2. RESEARCH QUESTIONS

1. What is the level of students’ engagement and conceptual understanding of lunar cycles among first-year secondary education science majors of North Eastern Mindanao State University-Lianga Campus, as assessed through the pretest and posttest?
2. What is the level of improvement in students’ engagement and conceptual understanding of lunar cycles as indicated by the normalized gain score?
3. Is there a statistically significant difference between the pretest and posttest mean scores in engagement and conceptual understanding of lunar cycles?
4. Based on the findings, what specific interventions can be proposed to enhance engagement and conceptual understanding of lunar cycles among students further?

3. RESEARCH METHODOLOGY

3.1 RESEARCH DESIGN

This research employs a mixed-method design approach for developing and evaluating Moon Phase Bingo as supplementary materials to enhance student engagement and conceptual understanding of lunar cycles. The quantitative method, through pretests and posttests, is designed to measure how student engagement and conceptual understanding of lunar cycles has changed. Additionally, qualitative data is gathered through focus group discussions (FGDs) and interviews to assess how students engagement and conceptual understanding through Moon Phases Bingo games. These combined methods allow a comprehensive assessment of both the cognitive improvements and the interactive, engaging attributes of the game in promoting students' engagement and conceptual understanding of lunar cycles among first-year secondary education science majors of North Eastern Mindanao State University-Lianga Campus.

3.1 RESEARCH LOCALE

The study was conducted in North Eastern Mindanao State University-Lianga Campus, Department of General Teacher Training, Lianga, Surigao del Sur Philippines. It is a State University in the area and caters to a very diverse group of students coming from both Agusan del Sur and Surigao del Sur communities. It was selected as the research site because of its relevance to the goal of the study of engagement and conceptual understanding of lunar cycles among first-year secondary education science majors, which falls within the target population of the intervention.

3.2 RESEARCH PARTICIPANTS

The participants are 45 secondary education students in Department of General Teacher Training of North Eastern Mindanao State University-Lianga Campus,. They were selected because they are currently taking up the Astronomy subject, which includes topics on Lunar Cycles.

3.3 RESEARCH INSTRUMENT

The researchers crafted the research instruments aimed to evaluate students' engagement and conceptual understanding of lunar cycles. To analyze students' engagement and conceptual understanding of lunar cycles, a 30-item test was crafted by the researchers for both the pretest and posttest. These tools underwent validation by experts in the Department of General Teacher Training together with the Lianga National Comprehensive High School faculty. The reliability of the instruments was substantiated, showing a Cronbach's alpha score of 93%.

3.4 DATA GATHERING PROCEDURE

The data collection process encompassed multiple stages. Initially, permissions were obtained from the school administration to facilitate the study. Subsequently, a pretest was conducted to assess the baseline levels of engagement and conceptual understanding of lunar cycles. The Moon Phases Bingo were introduced into classroom routines for a designated duration. Upon completion of the activities, a posttest was administered, and participant feedback was gathered. Ultimately, the data obtained from both the pretest and posttest were scrutinized to evaluate the efficacy of the Moon Phases Bingo. Focus group discussions (FGDs) and interviews were conducted to gather qualitative insights into students' engagement and conceptual understanding of lunar cycles through Moon Phases Bingo.

3.5 ETHICAL CONSIDERATIONS

To keep the parties' rights and good, the study stuck to strict ethical norms. Both the students' parents or guardians and the institution administration granted the needed permits. The aim of the study was explained in detail to the parties, and they were guaranteed the freedom to leave at any moment without facing any influences. likewise, party information confidentiality and obscurity were precisely saved during the entire study.

3.6 SCOPE AND LIMITATION

The scope of the study focused on implementing Moon Phases Bingo students' engagement and conceptual understanding of lunar cycles, hence allowing the generalizability of findings only to similar contexts. The study's limitations included variance in student engagement, resulting from the differences in their levels conceptual understanding of lunar cycles. Other variables include the time allotted for the intervention and, most interestingly, the demographic makeup of the students involved in the sample.

4. RESULTS

Table 1. Mean Percentage Scores and Mastery Levels in Pretest and Posttest Assessments

Assessment	Percentage (%)	Mastery Level
Pretest	60.77%	Near Mastery
Posttest	80%	Mastery

Table 1 presents the mean percentage scores and mastery levels for students in pretest and posttest assessments, revealing a notable improvement in understanding lunar cycles following the implementation of Moon Phases Bingo. The pretest score of 60.77%, categorized as "Near Mastery," indicates that students had a foundational but incomplete grasp of lunar phases prior to the intervention. This aligns with findings from Trundle et al. (2002), who noted that many students struggle with sequencing moon phases and explaining their changing appearances, suggesting a widespread issue in conceptual understanding within astronomy education. The posttest score of 80%, classified as "Mastery," demonstrates a significant increase in students' comprehension, highlighting the effectiveness of gamified learning strategies in enhancing educational outcomes.The improvement from pretest to posttest scores can be supported by constructivist learning theories, particularly those articulated by Piaget (1952), which emphasize that knowledge is constructed through active engagement with the environment. By participating in Moon Phases Bingo, students engaged in an interactive learning experience that allowed them to explore and internalize complex concepts related to lunar cycles. This hands-on approach not only facilitated deeper understanding but also fostered a more positive attitude toward learning science, corroborating Bruner's (1966) theory of discovery learning, which underscores the importance of exploration and active participation in the learning process.

Table 2. Normalized Gain Results

Assessment	Percentage (%)	Normalized Gain (g)
Pretest	60.77%	0.4903
Posttest	80%	

Table 2 provides insights into the normalized gain results, showcasing a pretest score of 60.77% alongside a normalized gain (g) of 0.4903. This normalized gain score indicates a moderate effect size, suggesting that students not only improved their scores but also retained knowledge effectively after engaging with Moon Phases Bingo. The significance of this gain is particularly relevant in educational contexts where traditional teaching methods may fail to address persistent misconceptions about complex scientific concepts, as highlighted by Subhash and Cudney (2019). Their research demonstrates that gamified approaches can enhance conceptual learning and foster positive attitudes toward science, which is reflected in the moderate gain observed in this study. The concept of normalized gain is essential for evaluating educational interventions because it accounts for individual differences in initial knowledge levels, providing a clearer picture of how much students have learned as a result of the intervention. According to Hake (1999), normalized gain scores are effective indicators of how well teaching methods facilitate student learning. In this study, the moderate normalized gain suggests that Moon Phases Bingo successfully engaged students and led to meaningful improvements in their understanding of lunar cycles. This finding reinforces the idea that incorporating game mechanics into educational practices can significantly enhance student motivation and retention, ultimately leading to better learning outcomes (Hamari et al., 2014).

Table 3. Statistical Analysis of students' engagement and conceptual understanding of lunar cycles: Pretest vs. Posttest Results

	Pretest	*Posttest*
Mean	18.233333	24.23333
Variance	14.64555556	6.912222
Observations	30	30
Pearson Correlation	0.322572453	
Hypothesized Mean Difference	0	
df	29	
t Stat	8.4665	
P(T<=t) one-tail	0.000000000001248	
t Critical one-tail	2.0452	
P(T<=t) two-tail	0.000000000002496	
t Critical two-tail	2.7564	

Table 3 presents statistical analysis results comparing pretest and posttest scores using a paired t-test. The mean scores indicate a substantial increase from 18.23 in the pretest to 24.23 in the posttest, with a t-statistic of 8.4665 and a p-value of 0.0000000002496. These results demonstrate a statistically significant difference between the two assessments, confirming that Moon Phases Bingo effectively enhanced both engagement and conceptual understanding among students. The low p-value indicates that the likelihood of observing such a difference due to random chance is exceedingly small, reinforcing the reliability of these findings. The statistical significance observed aligns with Vygotsky's (1978) social constructivism theory, which emphasizes the importance of collaborative and interactive learning experiences in bridging knowledge gaps—particularly for abstract topics like astronomy. The significant improvement in scores suggests that the collaborative nature of Moon Phases Bingo not only facilitated individual understanding but also promoted peer interaction, allowing students to clarify misconceptions collectively. This collaborative environment likely contributed to deeper engagement with the material, supporting Vygotsky's assertion that social interaction plays a crucial role in cognitive development.

Table 4. Thematic Analysis Based on Focus Group Discussions

Theme	Description	Key Findings
Engagement and Motivation	Students' degree of engagement, excitement, and participation in the Moon Phases Bingo game.	Throughout the exercise, students showed increased drive and excitement. They observed that learning became more pleasurable and less daunting as a result of the gamified method. Reduced boredom and increased focus were routinely noted.
Collaborative Learning	The role of teamwork and peer interaction in understanding lunar cycles.	The game's group dynamics and conversations helped students clear up any misunderstandings. Peers were able to clarify complex ideas through collaborative participation, which improved knowledge of lunar phases overall.
Conceptual Understanding	The capacity of students to comprehend lunar phase mechanics and use this knowledge to address relevant issues.	Participants reported better moon phase sequencing and increased clarity in differentiating between waxing and waning phases. The game's visual aids were particularly praised for improving understanding.
Perception of Gamification	Opinions of students regarding the usefulness and allure of using games in the classroom.	The majority of participants concurred that gamification—like Moon Phases Bingo—made difficult subjects more approachable and less intimidating. They recommended incorporating comparable resources for other difficult

		science subjects.
Relevance to Real-Life Contexts	Links drawn between lunar cycles and practical uses or cultural significance increase the topic's significance.	Students said that the topic was more remembered and relatable because of the scientific and cultural connections that were included. A few people were interested in learning more about how lunar cycles affect tides and agriculture.

Table 4 provides insights from thematic analysis based on focus group discussions conducted with students regarding their experiences with Moon Phases Bingo. Key themes identified include engagement and motivation, collaborative learning, conceptual understanding, perception of gamification, and relevance to real-life contexts. Students reported increased excitement and participation during the game, noting that it transformed their learning experience into something enjoyable rather than daunting. This aligns with findings from Hamari et al. (2014), who highlighted that gamification enhances motivation by making learning more engaging through game mechanics. The theme of collaborative learning emerged strongly from the discussions, indicating that teamwork played a vital role in helping students clarify misunderstandings about lunar cycles. Peers were able to support each other's learning through discussions facilitated by the game dynamics, enhancing overall comprehension. This reflects Vygotsky's (1978) emphasis on social interaction as a critical component of learning processes. Furthermore, participants expressed positive perceptions regarding gamification's role in making challenging subjects more approachable, suggesting that integrating similar resources into science education could further enhance student engagement across various topics.

5. CONCLUSIONS

The implementation of Moon Phases Bingo has demonstrated a significant positive impact on student engagement and conceptual understanding of lunar cycles among first-year secondary education science majors at North Eastern Mindanao State University-Lianga Campus. The qualitative data collected through pretests and posttests revealed a marked improvement in students' mastery levels, with scores increasing from 60.77% (near mastery) to 80% (mastery). This substantial gain indicates that the gamified approach effectively addresses common misconceptions associated with lunar phases, reinforcing the importance of interactive learning strategies in science education. The qualitative insights gathered from focus group discussions further support these findings, highlighting increased motivation, collaborative learning, and enhanced comprehension of lunar mechanics among participants. Moreover, the study aligns with constructivist learning theories, particularly those proposed by Piaget (1952) and Vygotsky (1978), which emphasize the role of active engagement and social interaction in the learning process. By fostering an environment where students actively participate in their learning through a game-based format, Moon Phases Bingo not only improves academic performance but also cultivates a deeper appreciation for scientific inquiry. These findings contribute valuable insights into effective pedagogical strategies that can be utilized to enhance science education, particularly in under-resourced settings where traditional teaching methods may fall short.

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