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Jiving and Utilizing Gamification Activities in Science (JUGAS): An Intervention in Improving Grade 11 Students' Conceptual Understanding

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A B S T R A C T

This action research explores the effectiveness of Project JUGAS in enhancing Grade 11 HUMSS students' understanding of Earth and Life Science. Using an explanatory sequential design, the study assessed pretest and posttest scores of students engaged in gamification activities—cabbage relay, geologic crossword puzzles, science mystery stations, and impromptu speech spinners—over four weeks. Results show a significant improvement in mean scores (p=0.00***) with a large effect size (d=0.92). Qualitative analysis identified six key themes: fun and interactive, engaging and motivating, challenging, collaborative, mastery of learning, and progression with rewards. The joint display confirmed that these qualitative themes support the quantitative data, demonstrating Project JUGAS's effectiveness as a pedagogical strategy.

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INTRODUCTION

A common sentiment among students is the difficulty and disinterest they experience with science subjects. This reflects a broader issue: students often struggle with the complexity of scientific concepts, the impact of the pandemic on learning, and the inherent boredom of abstract ideas (Toma, 2020; Syahputra et al., 2022). Many scientific concepts involve phenomena that are not immediately observable or tangible, such as plate tectonics or the greenhouse effect, which require higher levels of abstraction and critical thinking (Bybee & Landes, 1990, as cited in Eroglu & Bektas, 2022). This challenge is compounded by traditional teaching strategies, which may fail to effectively engage students or address their learning needs, leading to a sense of being left behind and contributing to widespread difficulties in mastering these concepts.

Moreover, low scores of Filipino students in international assessments like TIMSS (Trends in International Mathematics and Science Study) and PISA (Programme for International Student Assessment) have raised significant concerns about the state of science and math education in the Philippines. Data from the 2019 TIMSS showed that the country ranked among the lowest-performing nations in science and math, with fourth-grade students scoring below the international average in both subjects (Mullis et al., 2019). Similarly, the 2018 PISA results indicated that the Philippines was one of the lowest-performing countries, with students scoring far below the global average in math and science (OECD, 2019). Extended school closures and remote learning led to concerns about learning loss, particularly among students from marginalized backgrounds (Kuhfeld et al., 2020).

According to Marzano (2010), games lead to increased students' academic achievement. Educational games are highly motivating and accomplish the same objectives. (Glendon & Ulrich, 2005). In addition, incorporating games in teaching, according to Dewey, 1916 plays a significant role in teaching methodology. Likewise, the Experiential Theory of Rogers (1987) expounds that significant learning occurs when the activities are relevant to the student's interests. Therefore, teachers must always consider using varying teaching strategies like cooperative and fun game activities to teach the lesson concepts. Moreover, the Department Order No. 73 series of 2012 entitled Guidelines on the Assessment and Rating of Learning Outcomes under the K+12 Basic Education Curriculum, states that assessment is not necessary to be written all the time. Games can be incorporated into the lesson to reinforce understanding.

Earth and Life Science is a core subject in Senior High School that equips students with knowledge of the Earth's physical and natural processes. This action research explores the use of engaging and interactive games as a tool to enhance student learning. By incorporating these games, the research aims to make the educational experience more enjoyable and motivating, thereby improving students' conceptual understanding of complex scientific concepts.

However, while these strategies show promise, there remains a gap in empirical evidence regarding their effectiveness in improving students'

conceptual understanding in Earth and Life Science. Specifically, there is limited research on how targeted gamification interventions impact learning outcomes amidst the challenges of remote and hybrid learning environments. Therefore, further investigation is needed to evaluate how gamification can address these educational challenges and enhance students' grasp of complex scientific concepts, making the learning experience more engaging and effective.

THEORETICAL REVIEW

Constructivism and Active Learning

Constructivism is a key educational theory that emphasizes the importance of active participation in the learning process. According to constructivist theories (Piaget, 1952; Vygotsky, 1978), learners build their understanding through hands-on experiences and by actively engaging with content. Gamification aligns with this framework by providing interactive environments where students can explore scientific concepts, experiment with different outcomes, and learn through trial and error.

In science education, constructivist learning experiences encourage students to create mental models based on observations and experimentation. When students engage in gamified learning activities, such as simulations or problem-solving games, they can directly interact with scientific phenomena, leading to deeper conceptual understanding.

Self-Determination Theory (SDT)

Self-Determination Theory (SDT) by Deci and Ryan (1985) explains human motivation through three fundamental psychological needs: autonomy, competence, and relatedness. Gamification strategies in education can address these needs by offering students choices (autonomy), opportunities to demonstrate mastery (competence), and collaborative activities that foster a sense of community (relatedness). When students feel motivated and engaged, they are more likely to participate actively in learning activities, which can result in improved understanding of scientific concepts.

SDT suggests that motivation is key to learning. By introducing game mechanics, such as earning badges, progressing through levels, or receiving immediate feedback, gamified activities can increase intrinsic motivation. This is particularly relevant for improving conceptual understanding, as motivated students are more likely to invest time and effort in grasping difficult scientific concepts.

Cognitive Load Theory

Cognitive Load Theory (Sweller, 1988) focuses on the mental effort required to process information. It posits that learning is most effective when instructional materials are designed to minimize unnecessary cognitive load, allowing students to focus on understanding core concepts. Gamified learning environments can reduce cognitive load by breaking complex information into manageable chunks, allowing students to engage with content incrementally.

Additionally, immediate feedback in gamification helps learners correct misconceptions in real-time, preventing cognitive overload.

In science education, this theory is crucial because students often encounter challenging concepts, such as physics laws or chemical reactions, which require deep cognitive processing. Gamification can make these concepts more accessible by simplifying them into interactive, visual formats that facilitate better comprehension.

Bloom's Taxonomy and Higher-Order Thinking

Bloom's Taxonomy (1956) categorizes cognitive skills into six levels: remembering, understanding, applying, analyzing, evaluating, and creating. Gamified learning activities can help students progress through these levels by promoting higher-order thinking. For example, in a science-based game, students might start by recalling basic facts (remembering), then apply these facts to solve problems (applying), and eventually design experiments or predict outcomes (creating).

Gamification fosters an environment where students not only memorize scientific facts but also apply them in practical scenarios. This scaffolding approach helps students move from lower to higher levels of cognitive processing, which is essential for developing a deep conceptual understanding of scientific principles.

Experiential Learning Theory

Kolb's Experiential Learning Theory (1984) suggests that learning is a cyclical process involving four stages: concrete experience, reflective observation, abstract conceptualization, and active experimentation. Gamification in science education fits within this model by offering experiential learning opportunities. Students can engage in hands-on virtual experiments or simulations (concrete experience), reflect on their performance (reflective observation), adapt their strategies based on feedback (abstract conceptualization), and then apply their new knowledge in further gameplay (active experimentation).

This cycle mirrors the scientific method and encourages students to actively participate in their own learning, making connections between their actions and underlying scientific concepts.

Flow Theory

Flow Theory, developed by Csikszentmihalyi (1990), describes a state of deep focus and immersion in an activity. When students are fully engaged in a task, they enter a state of "flow," where they are motivated to continue learning and improving. Gamification aims to create this flow state by balancing challenge and skill, offering students tasks that are neither too difficult nor too easy.

In a science classroom, gamified activities can create flow by presenting progressively more challenging tasks that align with students' growing understanding of the subject matter. By keeping students in this flow state,

gamification can lead to sustained engagement and, consequently, improved conceptual understanding.

Feedback and Formative Assessment

One of the essential elements of gamification is the provision of immediate feedback. According to formative assessment theory (Black & Wiliam, 1998), timely feedback helps students understand their progress and identify areas for improvement. Gamified learning environments often provide instant feedback on performance, allowing students to adjust their strategies and correct errors on the spot.

In science education, feedback is crucial for conceptual understanding because it helps students identify misconceptions and gaps in their knowledge. By incorporating formative assessment through game mechanics, educators can create a more responsive and supportive learning environment.

Theoretical Framework

The theoretical framework for the study is rooted in well-established educational principles that support the integration of gamification into learning. The use of games as an instructional tool is based on the premise that they enhance academic achievement by promoting student engagement and motivation. It even significantly improved the critical thinking (Qian & Clark, 2016), creative thinking (Behnamnia et al., 2020; Qian & Clark, 2016), knowledge acquisition and context understanding Connolly et al., 2012; Vlachopoulos & Makri, 2017, and even perceptual skills (Connolly et al., 2012; Lamb et al., 2018; Vlachopoulos & Makri, 2017). In the context of this study, gamified learning serves not only to capture students' interest but also to facilitate a deeper understanding of scientific concepts by providing a more interactive and enjoyable learning experience.

Educational games have been shown to meet instructional goals while offering a more dynamic approach compared to traditional methods. The active participation that games encourage is aligned with constructivist theories, which emphasize the importance of students engaging directly with the material in order to build meaningful knowledge (Boggu & Sundarsingh, 2019). By incorporating gamification into the JUGAS intervention, the study leverages this principle, allowing students to interact with and explore scientific content in a hands-on manner.

Furthermore, experiential learning theories suggest that students achieve significant learning when the content is relevant to their interests and experiences (Woods et al., 2019; Helle et al., 2007). The gamification activities in this study are designed to align with students' natural curiosity and desire for exploration, thus making the learning process more engaging and personally meaningful. This alignment with student interest not only enhances motivation but also fosters a deeper connection to the subject matter allowing positive modifications in academic education, which is critical for improving conceptual understanding (Kolb & Kolb, 2017; Guo et al., 2016).

The combination of gamification with these theoretical foundations provides a comprehensive framework for this intervention. By utilizing educational games, the study seeks to create a learning environment that is both motivating and effective in promoting conceptual understanding in science. The theoretical framework thus supports the premise that gamification can serve as a powerful pedagogical tool in enhancing student outcomes in science education.

Innovation, Intervention, And Strategy

Gamification activities can be tailored to fit different settings to boost engagement, motivation, and educational outcomes. Steinkuehler and Duncan (2008) investigated how game-based environments can promote the development of students' scientific ways of thinking. Their findings highlighted the potential of game-based learning to enhance critical thinking skills and provide students with authentic learning experiences.

Games are among the oldest and most respected tools for education, having evolved as an essential educational mechanism through natural selection. According to Crawford (1982), playing games serves an important educational purpose for any learning-capable being. Additionally, McFarlane (2002) described games, historically referred to as "edutainment," as products that claim to be precise, relevant to formal education, and effective in developing specific knowledge and skills through enjoyment, motivation, retention, and competition.

In this action research, the researcher implemented gamification activities to enhance students' conceptual understanding through a project called JUGAS. JUGAS, which stands for "Jiving and Utilizing Gamification Activities in Science," was developed by the researcher and includes fun, engaging, and challenging activities designed to support and improve learning. In Project JUGAS, students are placed at the center of the teaching-learning process, working collaboratively and interactively. Their learning experiences are guided by game-based activities under the teacher's supervision on a weekly basis.

The following are the gamification activities used by the researcher to improve the conceptual understanding of Grade 11 HUMSS students in Earth and Life Science:

1. The cabbage relay is played by passing an improvised ball made of cabbage while the music plays. When the music stops, the student holding the cabbage must peel off one strip from it and then answer the question inside.
2. The Geologic Crossword Puzzle is an engaging educational activity designed to review geological vocabulary and reinforce students' knowledge of key geological terms and concepts.
3. The "Science Mystery Investigation Station" is an educational activity or station designed to engage students by allowing them to take on the roles of detectives, scientists, or researchers. They solve science-related mysteries or challenges through hands-on, inquiry-

based learning within the context of solving science-related problems.

4. The Impromptu Speech Spinner Activity is a dynamic and engaging exercise that aims to boost spontaneous communication skills. The activity provides a platform for participants to think on their feet, articulate ideas clearly, and practice structuring speeches quickly.

Project JUGAS utilized gamification activities to enhance the conceptual understanding of Grade 11 HUMSS students. Each activity had a set time frame and included assessments to monitor students' progress. All assessments, instructional activities, and quizzes were quality-assured.

Before implementing the intervention, the teacher prepared all the necessary materials and administered a pretest. In the first week of implementation, the teacher administered the pretest and introduced the learning competencies. The gamified activities, such as the cabbage relay and geologic crossword puzzle, were conducted, and at the end of the week, a short quiz was given to monitor the progress of Project JUGAS. To reinforce the concepts, the teacher provided feedback and asked other students to reiterate the ideas or concepts. Rubrics were also used to assess the accuracy and precision of the students' answers.

During the second week, crossword puzzles and the Science Mystery Investigation Station were implemented as interventions, followed by a short quiz at the end of the week. The Science Mystery Investigation and impromptu speech spinner activities were also utilized, and the teacher administered a quiz to evaluate their progress. In the final week, the impromptu speech spinner and cabbage relay were the chosen activities, and a posttest was given at the end of the week to assess the improvement in students' conceptual understanding.

After four weeks of implementing the intervention, the teacher-researcher conducted a Focus Group Discussion (FGD) with the students to gather feedback on the intervention and to solicit suggestions for further improvement. All the collected data were then analyzed.

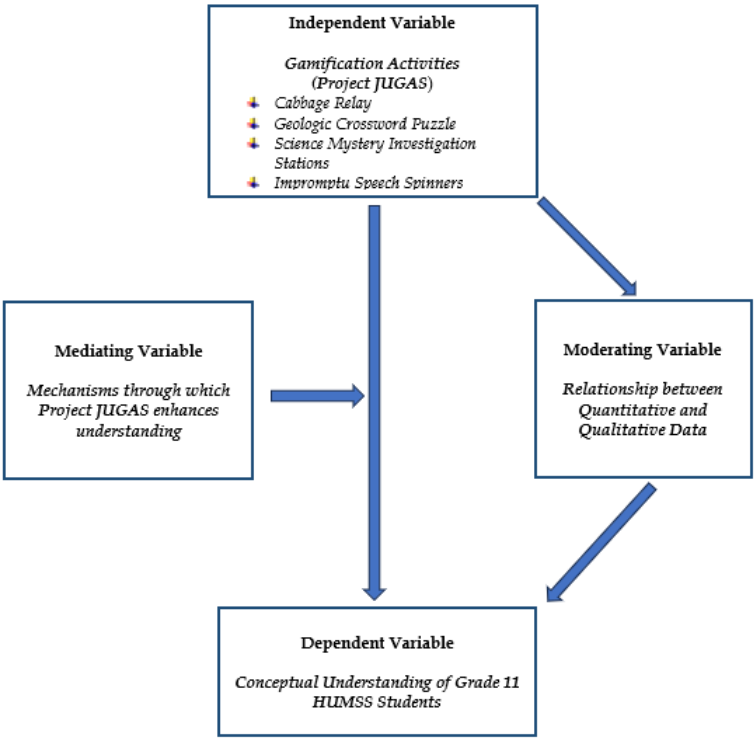

Figure 1. Conceptual Framework

METHODOLOGY

This study employed an explanatory sequential research design, a mixed-methods approach involving two distinct phases: first, the collection and analysis of quantitative data, followed by the collection and analysis of qualitative data (Creswell & Creswell, 2018). Conducted at i-Link College of Science and Technology, Inc., Poblacion 8, Midsayap, Cotabato, the study involved 61 Grade 11 HUMSS students enrolled in Earth and Life Science subject.

Prior to the intervention, a 30-item multiple-choice test was developed, aligned with the Most Essential Learning Competencies (MELCs) for Earth and Life Science subject. This test, along with gamification activities instructional materials, underwent face and content validation by the High School Department Curriculum Coordinator, the school research coordinator, and an English teacher to ensure validity (Obenza-Tanudtanud & Obenza, 2024; Obenza et al., 2024). The pretest was administered, and the results were collected, checked, and recorded.

Following the pretest, participants engaged in three weeks of gamification activities. After this intervention, the same 30-item test was administered as a posttest, and results were again collected, checked, and recorded. Additionally, a Focus Group Discussion (FGD) was conducted using an interview guide questionnaire with open-ended questions related to Project JUGAS to capture the needed data for the completion of this research (Tagare & Villaluz, 2021). All data were handled with strict confidentiality (Cayang & Ursabia, 2024).

Ethical considerations included obtaining approval from the school principal for the intervention, informing subject teachers and advisers, and

ensuring the confidentiality of participants' personal information (Ortega & Sumayo, 2024; Royeras & Sumayo, 2024, Esto, 2024). Students were assured that no harm or risk would result from their participation, which was voluntary.

For data analysis, mean percentage scores were calculated for both pretest and posttest results. A t-test for correlated samples was used to determine the significance of the difference between these scores, while Cohen's d quantified the effect size, indicating the standardized difference between the two mean scores. Thematic Analysis (Creswell, 2007) was used to analyze the FGD data. Finally, a joint display narrative was presented to provide a comprehensive understanding of how Project JUGAS enhanced students' conceptual understanding.

RESULTS AND DISCUSSION

Table 1.
Pretest and Posttest Mean Scores of 11 HUMSS students in Earth and Life Science

Groups	SD	Weighted Mean	Verbal Description
Pretest	4.38	21.74	Good
Posttest	3.81	25.52	Very Good

Range of Means	Description
24-30	Very Good
17-23	Good
10-16	Average
9 below	Poor

Table 1 presents the mean percentage scores of Grade 11 students on the 30-item pretest and posttest in Earth Science. The results indicate that Grade 11 students achieved higher weighted means in the posttest compared to the pretest. The mean score for the pretest was 21.73, suggesting that the students generally had a good level of conceptual understanding in Earth and Life Science. However, the posttest results showed an increased weighted mean of 25.52, which signifies that the Grade 11 students attained a very good level of conceptual understanding after the implementation of Project JUGAS.

The findings suggest that incorporating gamification activities, as demonstrated in Project JUGAS, can significantly enhance students' conceptual understanding in Earth Science. The increase in mean scores from the pretest to the posttest indicates that these interactive, game-based learning strategies are effective in engaging students and promoting deeper comprehension of scientific concepts. This implies that active learning approaches, which involve students in hands-on and participatory activities, can improve learning outcomes by making the content more accessible and memorable. Additionally, the results highlight the importance of assessing both initial knowledge and progress over time to evaluate the effectiveness of teaching methods. Overall, these findings support the use of diverse instructional strategies to cater to different learning styles, thereby reinforcing understanding and fostering student growth.

Mayer (2002) discusses the importance of building upon existing cognitive structures, noting that students' prior knowledge serves as a foundation for learning new information in Earth Science. Similarly, Guskey (2000) underscores the need to evaluate not only students' performance but also their growth and progress over time. Furthermore, research by the National Research Council (NRC, 2012) highlights the effectiveness of active learning strategies in science education.

Table 2.

Paired T-test of Significance between Pre-test and Post-test scores of Grades 11 HUMSS students in Earth and Science

Groups	SD	Mean	p-value	Description
Pretest	4.38	21.74	0.00***	Very Highly Significant
Posttest	3.81	25.53		

As shown in Table 2, a comparison of the pretest and posttest scores of the group was conducted to determine if there were significant differences between the means and the gain scores. The results indicate that after implementing the Project JUGAS intervention, there is a significant relationship between the pretest and posttest scores ($p = 0.00^{***}$). These findings highlight that there are notable differences between the pretest and posttest results, suggesting that Project JUGAS effectively improved the conceptual understanding of Grade 11 HUMSS students. This outcome is consistent with the study by Vega et al. (2009), which investigated the effectiveness of game-based strategies in teaching chemistry to third-year students at EARIST Laboratory School. Their study also found a statistically significant difference between the students taught using games and those taught without games, demonstrating the positive impact of gamification on learning outcomes.

Furthermore, active learning through gamification is recognized as one of the most effective educational strategies, as it allows students to learn by playing games and engaging more actively with the content. Research by Mohd et al. (2020) supports this, showing that training groups using video games experienced a significant increase in their conceptual understanding and knowledge retention. Overall, these findings underscore the value of integrating gamification into the classroom to enhance student learning and comprehension.

Table 3.

Effect size of Project JUGAS on Grade 11 HUMSS students in Earth and Life Science

Groups	SD	Mean	Effect Size	Description
Pretest	4.38	21.74	*d= 0.92*	Large
Posttest	3.81	25.52		

Cohen's effect size	Interpretation
0.80- higher	Large
0.50	Medium
0.20	Small
0.0-0.19	Trivial

As shown in Table 3, the pretest and posttest scores of Grade 11 students were compared to determine the effect size of the Project JUGAS intervention. The results indicate a large effect size (d = 0.92) after the implementation of Project JUGAS. These findings highlight that the intervention had a substantial impact on the students' conceptual understanding. The large effect size suggests that Project JUGAS significantly enhanced the conceptual understanding of Grade 11 HUMSS students.

The findings imply that Project JUGAS has a substantial positive impact on students' conceptual understanding, as indicated by the large effect size. This suggests that gamification strategies can be highly effective in improving educational outcomes. Educators might consider integrating similar gamified approaches into their teaching to enhance student engagement and learning.

Table 4.
Essential Themes and Core Ideas of Participants' Positive Experiences in Project JUGAS

Significant Statements	Code	Frequency	Formulated Meanings	Theme Cluster
The teacher is really fun and motivating. They encourage students to be vocal about their thoughts and maintain a positive classroom atmosphere, never showing stress and always aiming to keep the class happy. *The games are very helpful, Sir. Although they are challenging, they are interactive and make it easier for us to remember the topics and lessons because of the activities.*	Sci10, Sci3	4	Fun and interactive learning experiences have become increasingly important in education. They can significantly enhance engagement, motivation, and retention of knowledge.	Fun and Interactive
The activities are challenging and motivating, making it easier for us to answer quizzes effectively. *I have nothing more to add, Sir. I know you work hard on the*	Sci1, Sci9	3	Engagement and motivation are two essential factors in education and various aspects of life. They play a	Engaging and Motivating

activities, and your teaching style is very effective for me. Thank you so much for teaching us.			significant role in driving individuals to participate, learn, and perform at their best.	
Every activity you presented, Sir, was mysterious, fun, and challenging. The way you entertain and explain things is unique. Everyone participates in the lessons, with no one left out. *The activities are genuinely entertaining and challenge our brains. Your activities are very nice.*	Sci4, Sci6	6	Entertaining and challenging learning experiences can have a profound impact on education. They combine the elements of enjoyment and intellectual stimulation, making the learning process more engaging and effective.	Entertaining and Challenging
They have strengthened our friendships and collaboration, especially during discussions about activities like crossword puzzles. *Our bond with classmates involves either arguing or brainstorming ideas together to find the answers.*	Sci7, Sci8, Sci10	3	Collaboration and cooperation are both essential aspects of working together in a team or group.	Collaborative and Cooperative

Yes, it has a big impact on us since the lessons become easier to understand. *Even when the lessons are difficult, when paired with enjoyable activities and good teaching, they become more fun and easier to master. The concepts are easy to understand, and I can quickly catch up with the lessons through your games.*	Sci4, Sci3, Sci 2	4	Mastery of learning refers to the attainment of a high level of proficiency and understanding in a particular subject or skill.	Mastery of Learning
I always get excited when you give points while we answer questions. It motivates me to study every night to answer questions well. *Students are engaged with the games because of the points we accumulate. This is a great system, Sir.*	Sci2, Sci3	3	Progression and rewards are a concept often associated with gamification and various systems where users are engaged through incentives and achievements.	Progression and Rewards

The Table 4 above revealed the six essential themes which were derived from the focus group discussion with the participants. The themes were fun and interactive, engaging and motivating, entertaining and challenging, collaborative and cooperative, mastery of learning, and progression and reward. These themes highlight how Project JUGAS effectively improved students' conceptual understanding of the lessons. The teacher's role as a facilitator, combined with the implementation of various games, played a crucial part in enhancing the learning experience.

Table 5.
The Joint Display Between Quantitative and Qualitative Data Of The Study.

Quantitative Data	Qualitative Data	Joint Display	Implication
The effect size of 0.92 denotes a "Large Effect"	Mastery of Learning	Similar ideas	This implies that Project JUGAS is very effective in improving the conceptual understanding of Grade 11HUMSS students.
The p-value (0.00***) signifies "Very Highly Significant"	Progression and Reward	Similar ideas	This implies that Grade 11HUMSS students' conceptual understanding progressed by analyzing the data of pre-test and post-test.

Project JUGAS is highly effective in improving students' conceptual understanding, as supported by both qualitative and quantitative data. The quantitative results reveal an effect size of 0.92, indicating a large effect, which aligns with the qualitative data reflecting mastery of learning. This finding implies that Project JUGAS significantly enhances the conceptual understanding of Grade 11 HUMSS students in Earth and Life Science.

Moreover, the p-value of 0.00***, which signifies a "Very Highly Significant" result, corresponds with the themes of progression and reward. This indicates that the conceptual understanding of Grade 11 HUMSS students progressed as evidenced by the analysis of pre-test and post-test data.

The integration of effective teaching strategies and science activities has proven to bring out the best in students. Overall, Project JUGAS has successfully facilitated and enhanced the conceptual understanding of Earth Science among Grade 11 HUMSS students.

CONCLUSIONS AND RECOMMENDATIONS

Project JUGAS was effective in enhancing students' conceptual understanding through the use of various gamification activities such as Cabbage Relay, Crossword Puzzle, Science Mystery Investigation Station, and Impromptu Speech Spinner Activity. The implementation of these activities not only motivated students but also fostered collaboration and engagement. The approach demonstrated a significant impact on students' learning, reflecting improvements in their speaking and comprehension skills. The positive outcomes observed suggest that Project JUGAS can be a valuable tool in promoting holistic development across different subjects offered in senior high school.

It is recommended to apply the Project JUGAS approach across various fields and subject areas, especially that a new curriculum, the MATATAG curriculum is currently implemented in the Department of Education. Its

flexibility and effectiveness in improving students' skills make it a beneficial method for diverse educational settings. Collaboration among teachers, curriculum planners, and educational researchers is essential to continually refine and expand the Project JUGAS. Such collaboration can lead to the creation of comprehensive resources and practical insights for implementing Project JUGAS effectively and efficiently.

FURTHER STUDY

While the study demonstrates the effectiveness of Project JUGAS in honing students' conceptual understanding, several limitations should be acknowledged. The research was conducted with a specific group of Grade 11 HUMSS students, which may limit the generalizability of the findings to other educational contexts. Additionally, the short duration of the intervention—just four weeks—means that the long-term sustainability of the observed improvements is not fully assessed. There was no other form of test administered after some time has elapsed. Variability in the effectiveness of individual gamification activities was not explored, and while student feedback was collected, it may not represent the experiences of all students comprehensively.

To address these limitations, further research should focus on several key areas. Exploring the opportunity to use the Project JUGAS to other strands and year level, getting insights to its possible effectiveness in developing their conceptual understanding. Adding delayed posttest could also give insights in understanding long-term learning outcomes and effectiveness of the proposed intervention after some time has elapsed. Correlational studies are needed to examine the relationship between gamification activities and factors such as academic grit and self-efficacy. Long-term studies could assess the enduring impact of gamification strategies on students' conceptual understanding and academic development. Additionally, ongoing engagement with students to gather more detailed feedback can offer a deeper understanding of the effectiveness of various activities and modify teaching strategies and techniques.

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