Received: 01 September 2023 | Accepted: 18 December 2023 | Published Online: 29 December 2023
Recoletos Multidisciplinary Research Journal Vol. 11 no. 2 (December 2023)
DOI: https://doi.org/10.32871/rmrj2311.02.07

EDUTainment: Effectiveness of Game-based Activities in Teaching Ecosystem Topics

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Abstract

This study utilized four game-based activities (GBAs) developed by the researcher to determine their effectiveness in teaching Ecosystem topics for Grade 7 Biology in terms of (1) conceptual understanding and (2) nature of engagement. This quasi-experimental study used a mixed-method approach. Pre-test and post-test results show that the integration of GBAs in the lessons significantly improved students' academic performance in terms of conceptual understanding. Students' reports and teachers' observations also indicated that GBAs could enhance students' engagement in their lessons and learning process. The results of this study support the relevance of using game-based activities as pedagogical and learning tools as they could improve students' understanding of concepts and engagement in the lessons and learning process. Considering the needs and goals of students can maximize the positive effects of GBA integration.

Keywords: Game-based activities, conceptual understanding, student engagement, mixed method, Philippine science education

1.0 Introduction

Science education gives students access to knowledge and information, which helps them understand basic and complex concepts. Many students also find science interesting despite its difficulties. Considering that science impacts society's economic, health, and social well-being, science education is essential in 21st-century learning. A scientifically literate workforce is vital because it enables people to have meaningful conversations about science and technology and helps fulfill the needs of an information economy (Organization for Economic Cooperation and Development [OECD], 2019). For students to successfully traverse the digital world, appreciate different cultures, and participate in the economy, they must gain scientific literacy (Palines & Cruz, 2021; Valladares, 2021).

The Philippine educational system places a high value on science; however, as indicated by various national and international test results, the current state of science education is still below average (Bernardo et al., 2023). As more efforts are necessary to improve the quality of science education in the Philippines, the use of innovative methods such as game-based activities could be a solution to this issue as they could positively impact the learning process (Pinatil & Ramos, 2023; Azizah et al., 2021).

Games-based activities are becoming more popular in different settings, including social media, education, and job training (Pho & Dinscore, 2015). Games have long been utilized in educational settings to include students in enjoyable and engaging activities to improve learning outcomes (Hui & Mahmud, 2023; Bustard

& Black, 2009). Over the last two decades, a wealth of research has shown the efficacy of games as teaching and learning tools. Studies show that games can integrate different learning theories and pedagogical methods, support various learning objectives, including conceptual understanding and problem-solving skills, and promote knowledge transfer, motivation, self-efficacy, and independent learning (Lasala, 2022; Voulgari et al., 2020; Plass et al., 2015).

Game-based activities effectively promote conceptual understanding among students (Funa et al., 2024; Plass et al., 2015; Voulgari et al., 2020). In a study by Punyasettro and Yasri (2020), students who utilized a card game for their taxonomy class in Biology scored significantly higher on measures of conceptual understanding such as scientific content knowledge, process skills, and self-efficacy as the students exposed to the game were more engaged throughout the lessons. Similarly, Luna (2019) also revealed that modifying games for instructional purposes is as effective as the traditional teaching method in correcting students' misconceptions and improving students' academic performance.

Furthermore, studies also show that the use of game-based activities facilitates conceptual understanding by helping students achieve learning goals and learn scientific knowledge and improving students' problem-solving skills (Wang & Zheng, 2021; Yazicioglu & Güngören, 2021; Li & Tsai, 2013). Likewise, a study by Ikbal et al. (2019) shows that students exposed to a game-based learning environment improved their problem-solving and critical thinking skills as games allowed students to actively participate and decide in the lessons, enabling learned concepts to leave deeper impressions on the students. This finding also relates to the study of Liu and Chen (2013), which asserts that games, like the card game "Conveyance Go, " increase students' conceptual understanding due to their perceived ease of use, making concepts more understandable.

The potential of GBAs in academic contexts also extends to improving students' engagement in the lessons and learning process. Charles et al. (2009), in their study about the level and nature of students' engagement using games, suggested that six (6) engagement elements lead to meaningful learning and help students improve their conceptual understanding, social skills, and motivation to learn. These elements include the observed simultaneous occurrence of elevated fun/enjoyment, social support from others, visible role in the learning environment, competitive drive or challenge encountered by the students, structure, achievement, or feedback experienced during the game-playing. Similarly, Wichadee and Pattanapichet (2018) noted that games increase students' motivation and engagement when designed based on their educational purpose. This premise is also supported by the study of Adipat et al. (2021) about the fundamental concepts of game-based learning, asserting that integrating several capabilities of games into the learning process and game-based activities can increase students' engagement.

Moreover, experts found that GBAs can increase students' persistence and efforts in learning. A study by Rahimi et al. (2021) about the effects of computer games suggested that students who used game-based learning approaches were more persistent and put more effort into learning than those exposed to lecture-based learning environments. According to Amerstorfer and Freiin von Münster-Kistner (2021), engaged students demonstrate behavioral involvement in learning tasks with a positive emotional tone. Students engaged in the learning process select tasks within their competencies, initiate actions when given the opportunity, and show intense effort and concentration when carrying out the learning tasks. During the implementation of GBAs, they generally show positive emotions such as enthusiasm, optimism, curiosity, and interest.

In this context, the researcher believes that game-based activities will improve learners' conceptual understanding and engagement. This study utilized the game-based activities (GBAs) developed by the researcher to determine the effectiveness of game-based activities in teaching Ecosystem topics for Grade 7 Biology.

2.0. Methods

Research Design

Utilizing a mixed-method approach, combining qualitative and quantitative techniques, specifically a Sequential Explanatory design, this study involved collecting quantitative data and then using qualitative data to explain those findings (Toyon, 2021). The approach balanced the weaknesses of both approaches and allowed for a more comprehensive data analysis.

Additionally, the researcher used a quasi-experimental design to determine the effect of the developed game-based activities on students' conceptual understanding. The process involved an experimental group receiving a pre-test, treatment (integration of game-based activities in the lessons), and posttest. At the same time, a non-equivalent control group also received a pre-test and posttest but no treatment between the tests. The researcher obtained data for conceptual understanding from students' answers to the pre-test and posttest. The research design is as follows:

O1 X O3

O2 O4

Where: X- Game-based Activities; O1- Experimental Pretest; O2- Control Pre-test; O3- Experimental Post-test; and O4- Control Post-test

Respondents

This study included sixty-nine (69) Grade 7 students from one of the biggest national high schools in Sorsogon, Philippines, officially enrolled for the academic year 2022-2023. The study involved two randomly-selected classes: 35 students for the experimental group and 34 students for the control group.

In addition, the teacher-observers also served as the respondents of the study. They consist of three (3) Biology Teachers in the school, with two (2) of them as Master Teachers and one (1) Teacher III, who have all been in the service for more than five years. Likewise, the original science teacher of the two groups of respondents was also one of the study's respondents. The teacher-observers participated in the study by facilitating the lessons and providing insights about the conduct of the GBAs and their effects on the student's learning and engagement.

Research Instruments

The researcher utilized different research instruments to collect relevant data for the study and determine the effectiveness of game-based activities in teaching Ecosystem topics.

Developed GBAs. The researcher developed four game-based activities (GBAs) integrating four different lessons in Ecosystem for Grade 7 Biology, namely: (1) The Conquest, (2) Eco-Dama, (3) Eco-Challenge, and (4) Eco-Warrior. These four GBAs were developed and evaluated by experts and students before implementation to ensure their validity and quality. The first game, The Conquest, is a collaborative outdoor game where students participate in a quest as players pass different stations to win. The game is patterned from the classic treasure hunt game to pass the challenges in each station to complete the puzzle first, unravel the hidden picture, and win. Popular games in the Philippines, such as "Match Up" and "Hangman." "Tangram puzzle," and "Pinoy Henyo" became the basis for the stations for the quest. Anchoring on the topic, Components of Ecosystem, with a learning competency of 'Differentiate biotic from abiotic components of an ecosystem' (S7LT-IIh-9), the researcher developed the game to provide learners an opportunity to deepen their existing knowledge and basic cognitive skills about the topic.

Figure 1. *The Conquest board design (left) and students working to solve the challenge given at the station during the game (right)*

The second game, Eco-dama, is a collaborative game using a life-sized Dama board. This game follows the same manner of playing Dama, with an exception for the players of each team getting the roles of being the Dama pieces while being manipulated by the leaders. The concept of this game was adapted from the typical Dama game, which uses a Dama board, rules, and pieces. At the same time, players are to describe the different ecological relationships found in an ecosystem (S7LT-IIh-10) while playing to win and gather opponents' relationship cards, which contain different samples of interaction between the components of the ecosystem with matching descriptions or information such as pictures, name of the organisms and the way they interact.

Figure 2. *Eco-Dame game board design (left) and students listening to the teacher's instruction during the conduct of the GBA (right)*

The third developed game is the Eco-Challenge. Multiple players can play this offline life-sized roll-and-move game board. The first group to cross the finish line wins the game, which entails rolling a die and progressing around the board based on the outcome of the roll. The learning competency "Predict the effect of changes in one population on other populations in the ecosystem" (S7LT-IIh-11) from the curriculum guide was the basis for the game's design. Players may use the customized cards for the game based on different weather conditions that students may have experienced. They contained questions students must answer to improve their problem-solving and analytical skills.

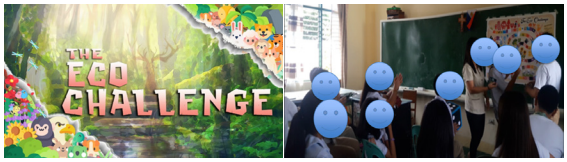


Figure 3. *Eco-Challenge game board design (left) and students cheering for their team member during the conduct of the GBA (right)*

The fourth game, "The Eco-Warrior: Saving the Animals from Extinction," a life-sized role-playing game, was also developed for this study. Players in this game assume the role of eco-warriors and set out on a mission to save as many animals as possible. The object of the roll-and-move game is to collect every animal, secure its life, and transport food to the safe zone in the center of the playing field. The topic "Effects of changes in abiotic factors on the Ecosystem," which focuses on forecasting the effects of changes in abiotic factors on the ecosystem (S7LT-Iii-12), serves as the basis for the game. The game also raises awareness of the importance of human efforts in saving wildlife. The game comes with an eco-warrior box, game mechanics, power badges, playing cards (including question cards, animal riddle cards, and condition cards), customized dice, and a life-sized game arena to increase learning and engagement.

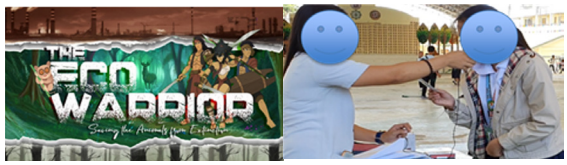


Figure 4. *Eco-Warrior board game design (left) and a student confidently answering the question given to her during the conduct of this GBA (right)*

Pretest and Posttest. Multiple-choice pretests and posttests on the Ecosystem topics include review materials and item banks. Expert teachers evaluated the fifty-item test which covered the competencies in Grade 7 Biology for Ecosystem topics namely; (1) Differentiate biotic from abiotic components of an Ecosystem (S7LT-IIh-9), (2) Describe the different ecological relationships found in the Ecosystem (S7LT-IIh-10), (3) Predict the effect of changes in one population on other populations in the Ecosystem (S7LT-IIi-11), (4) Predict the effects of changes in abiotic factors on the Ecosystem (S7LT-IIj—12). In addition, the researcher conducted pilot testing of the tool and checked its reliability by calculating the test scores using KR20. The test got a statistical value of 0.7153, indicating high reliability. Zaiontz (2017) emphasized that a statistical value that does not exceed 0.90 denotes a heterogeneous test. This result significantly confirmed the different levels of questions indicated in the table of specifications. Both groups of student respondents received the tests at the start and end of the implementation phase.

Student Engagement Walk-through Checklist. The teacher-observers used this checklist during the implementation of the study. This study adopted the Student Engagement Walk-through Checklist (SECW) from the International Center for Leadership in Education, focusing on the observations and perceptions of the teacher on the behavior of students manifesting their level of engagement (Carrabba & Farmer, 2018).

Journal Logs. Students from the experimental group were tasked to keep a journal to record their experiences and learning at the end of each lesson. Each student was given a journal and allowed to write in whatever language they were comfortable expressing themselves. The science teacher checked the students' journal entries before proceeding with the next lesson to ensure that students were doing their tasks. The researcher used the instrument to analyze qualitatively the students' engagement using GBAs in this study.

Data Gathering Procedures

Following the ethical procedure, permission was requested from the school principal to conduct the said undertaking. Letters to the parents of student respondents were also issued, asking for the parent's consent to allow their children to become respondents to the study. After developing, validating, and revising the game-based activities for Ecosystem topics, the researcher administered the tool. The researcher got permission to administer a pre-test to the student-respondents to assess their prior knowledge and conceptual understanding of the topics chosen. After the pre-test, both groups received class instruction. In the control group, the teacher referred to the Teacher's Guide for Grade 7 Biology while the students used their learner's module. The teacher taught this group using the usual way of teaching the said topic, which involves the presentation of the lesson objectives for the day, asking for their prior knowledge, watching downloaded videos, group works, and presentations, and with other multimedia platforms, and answering analysis questions on the given activities. On the other hand, the teacher taught the experimental group by using the GBAs integrated into the Ecosystem lessons. The teacher-observers also recorded the students' engagement with the lessons using the student engagement walk-through checklist.

The teacher integrated GBAs either to elaborate or explore phases of the lessons, cover the previous topics, or reinforce students' learning of the previous concepts taught. Eight hours of instructional time was allocated to finish all topics per the DepEd prescribed instructional time indicated in the Teacher's Guide in Science for Grade 7. Moreover, students wrote in their journals after every lesson, and teacher-observers interviewed them informally.

At the end of the lessons, a posttest was administered to both experimental and control groups to measure the effects of GBAs on students' conceptual understanding. The data gathered were analyzed and interpreted accordingly.

Data Analysis and Statistical Treatment

Descriptive statistics were used and supported by qualitative data to analyze the effects of GBAs on the student's conceptual understanding and engagement. Specifically, to compare and analyze the pre-test and post-test results of the student-respondents, mean rating, performance level, unpaired T-test, normalized gain, and Cohen's d set at 0.05 level of significance were used. Mean ratings were used to analyze the effects of GBAs on student engagement. Qualitative data were also utilized to analyze and interpret quantitative data.

3.0. Results and Discussions

Effects of GBAs on Student's Conceptual Understanding

Integrating GBAs in Ecosystem lessons for Grade 7 Biology enhances the students' conceptual understanding of the topics. The chosen Ecosystem topics are listed in the table below. The difference between the pre-test and post-test mean scores of the control and experimental group, mean and normalized gain, and their performance level in each learning competency was also shown to determine the effects of GBAs on students' conceptual understanding. In addition, the standard deviation was utilized for the consistency of data, p-value, and significant level to determine the increase or decrease of data and effect size to know the extent of the effect of GBAs on the student's conceptual understanding.

Table 1. *Summary of Unpaired t-test results for the Pre-tests and Posttests of Students*

Learning Competencies	No. of Items	No. of Points	PRE-TEST						POST-TEST						Effect Size (Cohen's d)	Interpretation
			Control Group (N-34)			Experimental Group (N-35)			Control Group (N-34)			Experimental Group (N-35)				
			Weighted Mean	PL (%)	Interpretation	Weighted Mean	PL (%)	Interpretation	Weighted Mean	PL (%)	Interpretation	Weighted Mean	PL (%)	Interpretation		
LC1- Differentiate biotic from abiotic components of an Ecosystem (S7LT-IIh-9)	11	33	19.24	58.30	NM	18.90	55.12	LM	28.65	86.8	NFM	30.80	93.3	FM	3.43	L
LC2-Describe the different ecological relationship found in the Ecosystem (S7LT-IIh-10)	12	36	18.88	52.4	NM	17.73	49.3	LM	28.24	78.4	M	32.06	89.1	NFM	2.9	L
LC3- Predict the effect of changes in one population on other populations in the Ecosystem (S7LT-IIi-11)	14	42	19.18	45.7	LM	18.73	44.6	LM	30.06	71.54	NM	34.17	81.4	M	2.4	L
LC4-Predict the effects of changes in abiotic factors on the Ecosystem (S7LT-IIj—12)	13	39	17.12	43.9	LM	15.50	39.7	LM	29.38	75.3	M	31.77	81.5	M	2.9	L
Overall Mean	50	150	77.411	51.6	LM	75.77	50.5	LM	116.33	77.6	M	128.8	85.9	NFM	4.3	L
SD			**15.57**			**14.17**			**13.74**			**8.9**				
p-value			**0.324**						**0.00**							

*Note: ***Significant at 0.05 level --- PL= performance level; LM= low mastery; NM= Near Mastery; M=Mastery; NFM=Near Full; Mastery; FM=Full Mastery; Sd= Standard Deviation; L=Large*

The table displays the results of an unpaired t-test that compares the pre-test and post-test mean scores and performance levels (PL) of the control and experimental groups. Additionally, it displays the relevant interpretation, computed standard deviation, and p-value. Since the p-value is higher than the threshold of significance of 0.05 [t (67) =0.962, p>0.05], the pre-test scores of the two groups are not significantly different. Although there is a similar level of disparity in both groups, the standard deviations indicate that the scores of students in the experimental group are closer together than those in the control group. Both groups' pre-test results are similar, suggesting they may have shared similar ideas and learning experiences on the ecosystem topics explored in this study, indicating that students may have struggled with the topics before instructions. Results could also be attributed to factors such as teaching methods and instructional materials used in their previous lessons about the topic. Shahzadi and Nasreen (2020) suggested that teachers, regardless of the subject, should use teaching methods that help students become critical thinkers to improve their conceptual understanding. Additionally, a causal-comparative study by Palines and Cruz (2021) also suggested that addressing the gaps in teaching materials and strategies used in teaching science would help improve the conceptual understanding of Junior High School students. They recommended that teachers should use localized, contextualized materials that support differentiated instruction. These studies, along with the students' low-level mastery of ecosystem topics, give opportunities for game-based activities as these could be tailored to fit the students' needs and context and develop critical thinking.

As for the post-test results, the table also shows that there is a significant difference between the post-test results of the experimental and control groups because the computed p-value is lower than the level of significance [t (67) =0.073, p<0.05; d=4.3]. The standard deviations of the post-test scores suggest that scores of the experimental are closer together compared to that of the control group. These results imply that the experimental group has significantly higher posttest scores compared to the control group, although both groups performed well on the posttest after the instructions. These suggest that the teaching strategies indicated in the teaching guide provided by the DepEd are already effective; however, these could still be improved with the use of innovative strategies such as game-based activities. To support the t-test result and determine the magnitude of the significant difference, the study calculated Cohen's d. The table also reveals that the significant difference between the pretest and posttest results was remarkably large (d=1.08), indicating that the impact of incorporating GBAs in the lessons was substantial on the knowledge acquired by the students. This claim is further supported by the results of the comparison of the mean and normalized gain for the pre-test and post-test results of both groups, as shown in Table 2.

The table shows a significant difference between the experimental group and the control group, with the experimental group having a greater overall mean gain of 53.03 and the control group having a mean gain of 38.92. Additionally, the results of both groups' standard deviations demonstrate that the experimental group's performance in all learning competencies was more consistent than that of the control group, as shown by the experimental group's lower standard deviation. This means that the integration of GBAs in ecosystem lessons has a positive impact on the conceptual understanding of students. This finding is also supported by entries from the students' journals, as shown in the samples below.

Table 2. *Mean and Normalized Gain of Pre-test and Posttest results of the Experimental and Control Group*

Learning Competencies	Experimental Group (N=35)							Control Group (N=34)						
	PRE-TEST Weighted Mean Score	SD	POST-TEST Weighted Mean Score	SD	Mean Gain	Norm Gain	Interpretation	PRE-TEST Weighted Mean Score	SD	POST-TEST Weighted Mean Score	SD	Mean Gain	Norm Gain	Interpretation
LC1- Differentiate biotic from abiotic components of an Ecosystem (S7LT-IIh-9)	18.19	4.5	30.80	2.6	12.19	0.86	L	19.24	5.25	28.65	5.13	9.41	0.68	M
LC2-Describe the different ecological relationship found in the Ecosystem (S7LT-IIh-10)	17.73	6.42	32.06	3.0	14.33	0.78	L	18.88	7.25	28.24	6.1	9.36	0.6	M
LC3- Predict the effect of changes in one population on other populations in the Ecosystem (S7LT-IIi-11)	18.73	7.52	34.17	4.9	15.44	0.66	M	19.18	6.64	30.06	6.41	10.88	0.5	M
LC4-Predict the effects of changes in abiotic factors on the Ecosystem (S7LT-IIj—12)	15.50	6.9	31.77	3.9	16.27	0.69	M	17.12	5.31	29.38	5.12	12.26	0.6	M
Overall	**75.77**	**14.98**	**128.8**	**8.9**	**53.03**	**0.72**	**L**	**77.411**	**15.57**	**116.33**	**13.7**	**38.919**	**0.54**	**M**

Note: SD= Standard Deviation; L=Large; M= Medium;

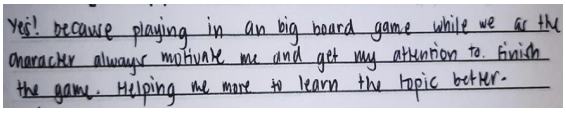


Figure 5. *Student #8 journal entry on the lesson about the effects of changes in the abiotic factors of ecosystem integrating GBA Eco-Warrior*

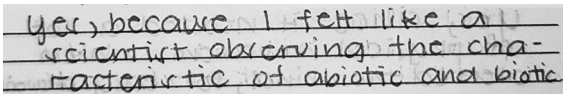


Figure 6. *Student #14 journal entry after the lesson about components of the ecosystem using GBA The Conquest*

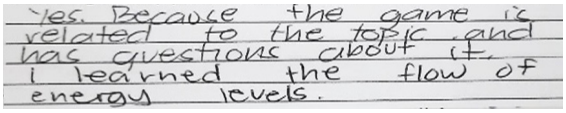


Figure 7. *Student #15 journal entry on the lesson about the transfer of energy integrating GBA Eco-Challenge*

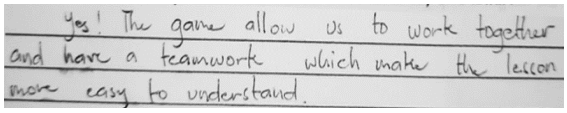


Figure 8. *Student #31 journal entry on the lesson about ecological relationships integrating GBA Eco-Dama*

These sample journal entries from the students indicate that the use of game-based activities on different ecosystem topics helped them understand the ecosystem concepts better and relate them to other settings, which suggests improvement in conceptual understanding. Students emphasized that the GBAs improved their conceptual understanding as it helped them learn from others, get motivated, immerse in a more contextualized learning environment, and feel a sense of familiarity with the games used. These are parallel to the findings of previous studies about the effects of

GBAs, noting that GBAs help motivate students to learn (Shena et al., 2019; Ubaidullah et al., 2019) and construct their learning through engaging, interactive, and informative, and fun elements of the games (Pan et al., 2021; Yazicioglu & Çavus Güngören, 2021). When students are exposed to different methods, materials, and activities through the integration of game-based, they are more likely to be satisfied with their learning experience, which is important in improving academic performance (Chaves, 2022). As the developed GBAs allow students to act on their learning and make decisions during the completion of the learning tasks, students become more immersed in the lessons and activities, thus learning more effectively and increasing their conceptual understanding.

Nature of Student Engagement during the Integration of GBAs for Ecosystem Topics

To determine the nature of student engagement during the conduct of the Game-based Activities, the teacher asked students to share their thoughts by answering the questionnaire in their journals. Additionally, the notes from teachers during the activities became a source for identifying the learning and level of engagement of the students using the adopted Student Engagement Walk-through Checklist (SECW) from the International Centre for Leadership in Education. There were also informal interviews or conversations with the teacher-observer to clarify the observations. Interview reports support the written notes and the observations done or conducted.

Table 3 below summarizes the nature of students' engagement during the conduct of GBAs as reflected in the student's journal entries, SECW, and informal interviews with the teacher. This summary reflects the six elements of a student's nature of engagement, as suggested by Charles et al. (2009).

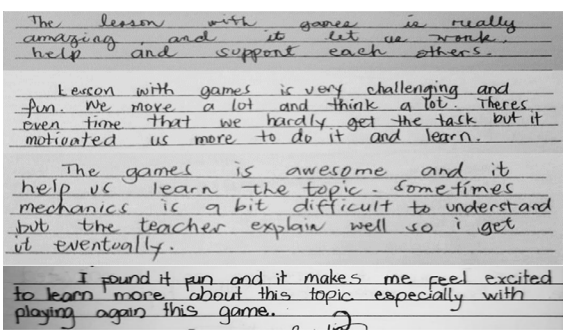
The table also shows that students had significant learning engagement during the integration of game-based activities. Central to the success of student's learning using GBAs is the meaningful learning experience the students engage in. These were further supported by the students' journal entries, as shown in Figure 9.

Table 3. *Summary of the Nature of Student Engagement during the Game-Based Activities*

Nature of Student's Engagement	Manifestation	Game-based Activity where Students' Engagement was observed
Excitement/ Enjoyment	*Students keep asking about the game they will play and its relevance to the topic. *Students were amazed; some even said "WOW" as the teacher started talking about the games. *Students responded promptly and listened attentively to the directions given. *Students actively participated in the game, tossing a dice, drawing a card from the deck, moving from place to place and answering questions and riddles. *Students were sweating and catching their breath as they performed the GBA, especially those outdoor games. *Students yelled out and even jumped as they get the correct answers and finished the task set in the games *Students' attendance improved and the numbers of late students in the afternoon were lessened.	True to All the Integrated Game-based Activities

Table 3. *Summary of the Nature of Student Engagement during the Game-Based Activities (cont.)*

Nature of Student's Engagement	Manifestation	Game-based Activity where Students' Engagement was observed
Social Support of Others:	*Students openly talked and communicated with their group mates for their strategies, ideas, and moves to complete the task given for every GBA. *Students ask for queries and assistance from their team members and teacher without hesitation. *Students cheer up their group mates as they play the game. *Students build teamwork and cooperation in doing the task. *Students accept defeat and comfort others saying "Ok lang yan, may susunod pa naman" (It's ok, there will be next time). *Members of the group speak kindly and respectfully to each other.	True to All the Integrated Game-based Activities
Visible role in the learning environment	*Students choose their leaders to guide the group in completing the task, secretary and reporters for the output presentation. *The group allocated the task to all the members, showing their teamwork and collaboration.	True to All the Integrated Game-based Activities
Challenge:	*Students had a hard time deciphering the mechanics of the games, so they constantly asked the teacher *Students were sweating hard while catching their breath as they ran from station to station in Game 1. *Some were distracted by the noise in the covered court where some outdoor games were held.	Mostly observed during the conduct of Game 1 (The Conquest) and Game 2 (Eco-Dama)
Structure:	*Students were aware of what they would do since the teacher properly explained the game objective. *Students openly asked for clarifications of instructions on some stations' challenges. *Students were observed doing the activity independently but with little assistance from the teacher.	True to All the Integrated Game-based Activities
Feedback/ Achievement:	*Students screamed as they answered correctly and passed each station. *Students were overly motivated to go through each station to get the points and win the game. *Winning teams were overjoyed as the teacher announced the winner of the game, while the losing teams were sad and frowned, yet still motivated to do better as they said, "Babawi kami sa susunod".	True to All the Integrated Game-based Activities


The lesson with games is really amazing, and it let us work, help and support each others.

Lesson with games is very challenging and fun. We move a lot and think a lot. Theres even time that we hardly get the task but it motivated us more to do it and learn.

The games is awesome and it help us learn the topic. Sometimes mechanics is a bit difficult to understand but the teacher explain well so i get it eventually.

I found it fun and it makes me feel excited to learn more about this topic especially with playing again this game.

Figure 9. *Sample students' journal entries about their engagement in GBAs integrated into ecosystem lessons*

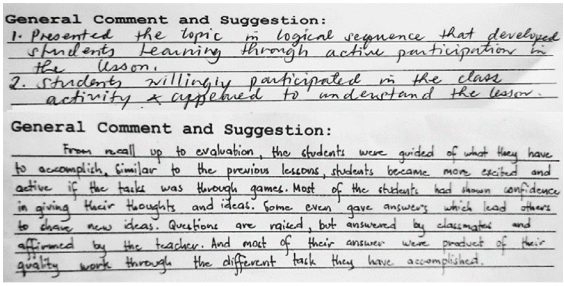
The summary of students' nature of engagement and students' journal entries shows that students are well-engaged in the lessons integrating GBAs. Features of GBAs such as active learning, collaborative learning, and inquiry-based learning are highly emphasized in the students' reports about their engagement in the lessons with GBAs. Students who are engaged in the lessons and learning process tend to act especially when they have a clear role in the completion of the learning tasks (Adipat et al., 2021), just like

how student respondents exposed to GBAs study in this study willingly participate, ask and answer questions. Complete challenges knowing their roles in the game could make a difference in the outcome and learning experience.

When the students felt excited and curious about the game, they were amazed, actively participated, asked questions, and engaged in all the activities and lessons. The experience of having a support system in a group allowed them to collaborate with the group, which also increased their performance. This coincides with the studies of Chen et al. (2020) and Sánchez-Mena and Martí-Parreño (2017), which emphasized that GBAs could engage students in meaningful learning experiences as these games allow students to work and learn with others than any other strategies. On the other hand, when the students had a visible role in the games, it increased their engagement as it defined their character as players and gave them a reason for what to contribute to complete the group task. Likewise, when the students are challenged, engagement can be expected as they tried their best to come up with various ways to complete it, which promotes socialization and respect. One advantage of using GBAs in teaching is that they recognize the role of mistakes and failures as part of the learning process, making students more comfortable engaging in the lesson or class (Partovi & Razavi, 2019). This is evident in students' continuous engagement or participation in the learning tasks and GBAs even after not gaining first place or failing to answer correctly, as students see these moments as learning opportunities.

In addition, the clear and acceptable objectives and constraints and display of students' achievement reinforced their engagement during the game. May (2021), in their study of the effects of game-based learning on student engagement, noted that game elements and constraints, such as the use of leaderboards and mechanics, contribute to an enjoyable learning environment students could quickly get engaged with. These also provided an opportunity to develop their social skills and motivation towards achieving their goals as they become more sensitive to the importance of rules which guide them to completion of the task and better on succeeding games.

These observations and claims are also supported by the teacher-observers' observations during the study. The sample notes of teacher-observers below show their observations on student engagement during the integration of GBAs in the ecosystem lessons.


General Comment and Suggestion:
1. Presented the topic in logical sequence that developed students learning through active participation in the lesson.
2. Students willingly participated in the class activity & applied to understand the lesson.

General Comment and Suggestion:
From recall up to evaluation, the students were guided of what they have to accomplish, similar to the previous lessons, students became more excited and active if the tasks was through games. Most of the students had shown confidence in giving their thoughts and ideas. Some even gave answers which lead others to share new ideas. Questions are raised, but answered by classmates and affirmed by the teacher. And most of their answers were product of their quality work through the different task they have accomplished.

Figure 10. *Teacher-observers' notes on student's enjoyment and participation during the GBA integration*

Teachers noted that students became more engaged in the lessons whenever the game-based activities were presented. Most of them willingly participated and confidently shared their thoughts and ideas. They even added that the answers given by the students were a product of quality work from the various tasks they have accomplished. Students learn better when given learning opportunities in a group setting and the chance to decide on their learning experience (Lasala, 2023; Erümit & Yilmaz, 2022; Friehs, 2016). It can be recalled that the lessons were fused with the features of active, collaborative, and inquiry-based learning, which made them student-centered and promoted teamwork and discussion among members because of the group tasks, including the GBA, that allowed the students to discover and learn the concepts on their own.

The data obtained through the Student Engagement Walk-through Checklist (SECW) support the claims. The table below summarizes the mean ratings for the SECW from the teacher observers.

Table 4. *Summary of Ratings by Teacher-Observers on Student Engagement Using GBAs*

Indicator	Mean	Interpretation
I. OBSERVATIONS		
1. POSITIVE BODY LANGUAGE: Students exhibit body postures that indicate they are paying attention to the teacher and or other students	4.2	High
2. CONSISTENT FOCUS: Students are focused on the learning activity, particularly in the Game-based Activity with minimum disruptions	4.43	High
3. VERBAL PARTICIPATION: Students express thoughtful ideas, reflective answers, and questions relevant or appropriate to learning.	4.6	Very High
4. STUDENT CONFIDENCE: Students exhibit confidence and can initiate and complete task with limited coaching and can work in group.	4.3	High
5. FUN AND EXCITEMENT: Students exhibit interest and enthusiasm towards the lesson and activities.	4.6	Very High
Average Mean Score and Interpretation	**4.43**	**High**
II. PERCEPTIONS		
1. INDIVIDUAL ATTENTION: Students feel comfortable seeking help and asking questions	4.13	High
2. CLARITY OF LEARNING: Students can describe the purpose of the lesson or unit.	4.53	Very High
3. MEANINGFULNESS OF WORK: Students find the work/activities/lesson interesting, challenging, and connected to learning.	4.6	Very High
4. RIGOROUS THINKING: Students work on complex problem, create original solutions, and reflect on the quality of their work.	4.6	Very High
5. PERFORMANCE ORIENTATION: Students understand what quality work is and it will assessed. They also can describe the criteria which their work will be evaluated.	4.7	Very High
Average Mean Score and Interpretation	**4.51**	**Very High**
Overall Level of Student Engagement	**4.47**	**High**

The teachers' observations reinforced the initial finding that GBAs encouraged students' engagement in the activities and towards the lessons. In general, integrating game-based activities in the lessons on Ecosystem Concepts significantly affected students' engagement. Likewise, it also contributed to developing students' conceptual understanding, motivation to learn, and social skills. Lastly, students' collaboration, teamwork, sportsmanship, and friendship formed during the conduct of games will forever linger as essential memories. Overall, there is a high level of student engagement with the integration of GBAs in ecosystem lessons (Serrano, 2019). As with the indicators in observation, the student's engagement is evident regarding their verbal participation and fun and excitement shown during the study. Students would usually express their excitement and enjoyment during the implementation of GBAs by responding "yes" and "yehey" whenever the activities were presented. These verbal participation and confirmation show positive student engagement (Tenglet, 2023). As students become more aware of the purpose of the activities and the roles they need to take to obtain the expected competencies in the lessons, they become more engaged and immersed in a meaningful learning experience. Although the extent of student engagement is not clarified in this study, the use of game-based activities for ecosystem lessons significantly improved students' engagement not

just in the lessons they were learning but in the learning process itself as they came to understand their role in the process and recognize their control for their learning experience.

4.0. Conclusion

This study sought to determine the effectiveness of the developed game-based activities (GBAs), namely Eco-(1) The Conquest, (2) Eco-Dama, (3) Eco-Challenge, and (4) Eco-Warrior, in terms of conceptual understanding and nature of student's engagement. The developed GBAs were already validated and recommended for use in ecosystem topics. Integrating developed GBAs in ecosystem topics allows students to immerse in more meaningful experiences and improve their academic performance. In conclusion, this study has provided evidence of the potential of GBAs to enhance conceptual understanding among Grade 7 students, as shown in the pre-test and post-test results. GBAs can elaborate, clarify, and reinforce understanding of ecosystem concepts in a more contextualized and constructive approach, mastery of competency, and therefore, conceptual understanding can be improved. This study supports previous studies claiming that GBAs could promote and improve student engagement. Elements of the nature of student engagement were evident throughout the intervention for this study, showing GBAs as practical tools for ensuring students are engaged in the lesson and learning process. Ratings and observations from the students and teacher-observers suggest that GBAs have the potential to continually engage students in meaningful learning experiences, especially since GBAs are often founded upon active learning, collaborative learning, and inquiry-based learning.

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