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Effects of Game-Based Activities on Student's Social Skills and Attitudes toward Learning Science

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Abstract

This study evaluated the effectiveness of four game-based activities (GBAs) in teaching ecosystems to Grade 7 Biology students. Involving 69 students (34 control, 35 experimental), the quasi-experimental study used a mixed-methods approach. The researcher utilized a static-group comparison design for the quantitative phase and a thematic analysis for the qualitative phase. Quantitative analysis revealed significant improvements in the experimental group's social skills ($p<0.05$; Cohen's $d = 0.63$) and conceptual understanding ($p<0.05$; Cohen's $d = 0.86$). Descriptive statistical analysis also suggests that GBAs can foster positive attitudes toward using GBAs and learning. Qualitative data from journal entries and teacher-observer interviews highlighted enhanced communication, collaboration, confidence, and participation among students using GBAs. The study also recognized the interconnection between conceptual understanding, social skills, and attitude toward learning, not just as pedagogical tools but also as practical tools in improving students' affective domain, creating a safe environment beneficial for the learning process in general.

Keywords

game-based activities, social skills, attitude inventory, pedagogical tool, ecosystem

INTRODUCTION

Sanchez (2022) and Lasala (2023) suggested that there is a need for innovative teaching strategies to improve not only academic performance but also students' positive cultural and social skills and attitudes to improve science education. Game-based activities (GBAs) are innovative strategies to enhance understanding and literacy in study areas, promote positive attitudes toward learning, and improve social skills. Li and Tsai (2013) observed that while most studies on game-based learning in science education (GBSL) primarily emphasize enhancing scientific knowledge and concepts, few studies have investigated GBSL outcomes from socio-contextual and affective learning perspectives. They suggested that using game-based activities in science learning has great potential to promote collaboration, especially among younger learners. The findings of the research of De Freitas (2018), Giannakas et al. (2018), and Romero et al. (2015) support this and emphasize the collaborative elements of game designs. Their studies suggest that serious games, made for educational purposes other than entertainment, can contribute to developing and improving 21st-century skills such as teamwork, collaboration, and other social

and cultural skills as they allow learners to interact and assist each other in completing learning tasks. Although their studies focused mainly on digital games, they also recognize the potential of non-digital games to bring out these effects on students' social skills as long as the collaborative element of the game is present.

Additionally, Hanghøj et al. (2018), in their study about the effects of cooperative video games on science and mathematics, also implied that cooperative games encourage and improve social inclusion and participation, even for at-risk students. Reinders and Wattana (2014) studied the effects of online role-playing games for English courses, and they found that the ability to project a character through games helps students feel at ease in the class, more confident, and more willing to participate. They further emphasized that games can improve students' communication skills.

Furthermore, some studies also show that the growth mindset, collaboration, and engagement that games often require and illicit create and improve students' attitudes towards the lessons and learning in general (Hui & Mahmud, 2023; Başkahya, 2021; White & McCoy, 2019). In a mixed-method study, Sanchal and Sharma (2017) noted that using the game increased students' positive attitudes toward math, which in turn affected the students' game performance and course achievement. Jääskä and Aaltonen (2022), and Hwang et al. (2016) found the same results about the effects of educational games on science learning, suggesting that game-based activities enhance students' attitudes, learning outcomes, and engagement in math and science content areas.

Liu and Chen (2013), in their study about the effect of the card game "Conveyance Go" on science learning, suggested that games can create and promote a positive attitude toward science learning as they invoke students' interests and understanding of how knowledge is acquired through playing games. Similarly, da Silva et al. (2021) also declared that using game-based activities is one of the most effective strategies in teaching and learning chemistry concepts, as this approach tends to engage students in the lesson physically, socially, and mentally. This engagement eventually brings about a positive attitude toward learning chemistry. Panganiban (2019) also tested the effect of educational games on conceptual understanding, social skills, and attitudes toward Grade 7 Physics in the form of "Laro ng Lahi to forty-four (44) students" and utilized pre-experimental one group –pre-test-post-test design and descriptive research using the qualitative and quantitative technique of collecting and analyzing data. He discovered that "Laro ng Lahi" enhanced students' conceptual understanding, social skills, and attitudes toward physics concepts.

Beyond mere engagement and collaboration, GBAs can catalyze deeper knowledge acquisition and conceptual understanding. Studies show that GBAs foster critical thinking, problem-solving skills, and active learning, which improve students' conceptual understanding (da Silva et al., 2021; Partovi & Razavi, 2019). Transforming regular classroom activities into games can help students understand concepts better as they can relate the scenarios depicted in the game-based activities to real-world scenarios (Lean et al., 2020; Udeozor et al., 2023). In this way, game-based activities can help students apply, refine, and solidify their understanding of even more complex concepts. Investigating the effects of GBAs on students' conceptual understanding alongside social skills and attitudes toward learning can provide a holistic and nuanced understanding of the GBAs' potential to improve the quality of science education and the students' learning experiences.

Nevertheless, despite these advantages, more research still needs to be done on the effects of games, particularly on challenging ecosystems such as the pyramid of biomass, communities, energy flow, interrelationships, and populations (Mambrey et al., 2022). In this context, the researcher believes that game-based activities will improve learners' social skills and attitudes.

This study utilized the game-based activities (GBAs) developed by the researcher to determine the effects of game-based activities in teaching ecosystem topics for Grade 7 Biology. The GBAs have already undergone the process of validation and tested positive in improving students' academic performance based on the initial study (Lasala, 2022); however, the researcher also recognizes the potential of GBAs in improving the affective domain of students' learning. Specifically, this study sought to (1) determine the effects of GBAs on students' social skills, (2) determine the effects of GBAs on students' attitudes, and (3) determine the effects of GBAs on students' conceptual understanding and the interplay of conceptual understanding, social skills, and attitude toward learning.

METHODS

Research Design

This study used mixed quantitative and qualitative data methods to answer research questions. For the quantitative phase, a static-group comparison design was used to determine the effect of GBA on the social skills of the students, in which a group exposed to treatment (GBAs) is compared with one that has not been exposed to such treatment and establishes the effect of the treatment (Rocchi et al., 2018). This design involves two groups—one experimental and one control group—and both are given post-tests only. The research design is as follows:

$$\begin{array}{ll} X & O1 \\ \hline & O2 \end{array}$$

Where: X- Game-based Activities; O1- Experimental Posttest; O2- Control Posttest

For the qualitative phase, the researcher gathered data through students' journal logs, teachers' observations, and informal interviews, which were analyzed thematically. The use of quantitative and qualitative data for this study provided a nuanced understanding of the effects of GBAs on the students' social skills and attitudes. For the qualitative phase, students' journal logs, teachers' observations, and informal interviews were also conducted to gather qualitative data, which were analyzed thematically. The use of quantitative and qualitative data for this study provided a nuanced understanding of the effects of GBAs on the students' social skills and attitudes.

Sampling Procedures and Respondents

This study employed sixty-nine (N = 69) Grade 7 students from Sorsogon, Philippines, taking ecosystem lessons during the study and for the academic year 2022-2023. These student-respondents were from two classes, which were randomly selected and assigned to experimental (n = 35) and control (n = 34) groups.

Three biology teachers acted as observers and helped facilitate the lessons during the implementation of the study. Their observations were essential in determining the effects of GBA integration on student's social skills and attitudes. Meanwhile, the science teacher assigned to the Grade 7 STE classes taught the experimental and control groups at different time slots.

Research Instruments

This study used several instruments to obtain data to determine the effects of GBA integration on students' social skills, attitudes towards using GBAs and learning, and conceptual understanding.

Developed GBAs. This study used the game-based activities developed by the researcher for selected ecosystem topics in Grade 7 Biology. These GBAs, namely: Eco-(1) The Conquest, (2) Eco-Dama, (3)

Eco-Challenge, and (4) Eco-Warrior, were developed adapting familiar games such as puzzles/quizzes, tangrams, treasure hunting, board games, and role-play while introducing, teaching, and clarifying ecosystem concepts. Teacher experts validated the GBAs before the implementation phase of this study. An initial study by the researcher discussed the development of GBAs and their validation through expert validation. Positive results from the initial study recommend using GBAs for science teaching (Lasala, 2022). The following table presents the selected lessons for this study and the GBAs integrated into the lessons for the experimental group and learning tasks or activities for the control group.

Table 1. *Integration of the learning activities in the different parts of the lessons*

Lessons/GBA	Learning Competencies	Experimental Group		Control Group	
		Learning Activity/GBA	Part of the Lesson	Learning Activity	Part of the Lesson
LESSON 1: Components of Ecosystem	Differentiate biotic from abiotic components of the ecosystem.	Game 1: THE CONQUEST: Saving SNHS Forest	Elaborate	Activity 2: Life Within a Small World (Activity Adapted from the Grade 7- Science Module of Students)	Elaborate
LESSON 2: Ecological Relationship	Describe the different ecological relationships found in an ecosystem.	Game 2: ECO-DAMA	Explore	Activity 1: Picture Analysis (Finding the Ecological Relationship in the Pictures)	Explore
LESSON 3: Transfer of Energy through trophic levels and the effect of changes in one population on another population in the ecosystem	Predict the effect of changes in one population on other populations in the ecosystem.	Game 3: The ECO-CHALLENGE	Elaborate	Activity 2: Exploring Ecosystem Interactions Through Simulation	Elaborate
LESSON 4: Effect of Changes in Abiotic Factors in the Ecosystem	Predict the effect of changes in abiotic factors on the ecosystem.	Game 4: ECO-WARRIOR: Saving the Animals from Extinction	Elaborate	Activity 2: Exploring Abiotic Factors and Ecosystem Dynamics	Elaborate

Teacher-made test. The researcher asked the facilitating teacher to conduct a post-intervention test for both groups of respondents to determine if there was a significant difference in the students' conceptual understandings between the experimental and control groups. The test questionnaire was validated prior to its utilization using experts' validation and item analysis. Experts comprising a science head teacher and three science teachers for grade 7 validated the test and approved its use in this study.

Self-Report on Social Skills. The researcher modified a four-point Likert scale adapted from the Fort La Bosse School Division Clinicians. The study only utilized the items of the scale on communication skills, problem-solving, understanding emotions, compliments, and flexibility. This tool was statistically validated; the test-retest reliability and internal consistency were 0.74 and 0.96 (Danielson & Phelps, 2003). This self-report on social skills was administered to both experimental and control groups.

Attitude Inventory Scale. This study adapted the attitude inventory scale from a study by Kasimu

and Nantomah (2019) to determine the students' attitudes toward learning science and using GBAs in the lessons. Items from the original inventory scale were modified to suit GBAs, and the scale's internal consistency was obtained using Cronbach's alpha to validate the tool. The calculated Cronbach coefficient alpha is 0.93, indicating the high reliability of the tool used. This five-point Likert scale with attitude inventory statements helps students express their thoughts and feelings using GBAs in learning the chosen ecosystem topics.

Journal Logs. In their journals, students wrote what they had learned and experienced at the end of each lesson. Students were allowed to use whatever language and form of writing they were comfortable with in their journal entries. The science teacher of each class checked the journal entries before proceeding to the following lessons to ensure that students were doing the task. Teachers used the qualitative data from journal entries to support the quantitative data.

Interviews. The researcher conducted informal interviews with the teacher-observers throughout the intervention period and at the end of the intervention to gather data for teachers' observations about the lessons integrating GBAs and the effects of GBAs. Data gathered from teacher-observers were thematically analyzed and used to support quantitative findings.

Data Collection

The researcher obtained the necessary permission from the school principal and parental consent to proceed with the study and have the Grade 7 students as the primary respondents. He then integrated game-based activities (GBAs) into the lessons about chosen ecosystem topics for the experimental group. The GBAs were usually part of the elaborate or explored phase of the lessons. They were also used to reinforce the previous topics taught—the implementation of GBAs incurred eight instructional hours as prescribed by the DepEd.

Students wrote in their journals at the end of every lesson, and researchers asked for teacher-observers' insights and observations through informal interviews. At the end of the implementation, students from the experimental and control groups answered a self-report social skills survey. In contrast, only students from the experimental group took the attitude inventory. Both groups of respondents took a summative test covering the topics discussed after the intervention period to determine the impact of GBAs on students' conceptual understanding. The facilitating teacher administered the test the day following the last ecosystem topic covered by this study. All of the data gathered were analyzed and interpreted accordingly.

Data Analysis

This study utilized descriptive statistics to treat the data. The researcher used parametric measures such as weighted mean, two-tailed t-test, and Cohen's d value to analyze the results of students' social skills and conceptual understanding and determine the statistical difference between data sets from both groups of respondents for these two components of learning. He also used a weighted mean and standard deviation to analyze the effects of GBAs on student's attitudes. In addition, he employed thematic analysis to analyze qualitative data and support findings from quantitative analysis. Such analysis determined the interrelationship of conceptual understanding, social skills, and attitude toward learning in promoting a meaningful and holistic learning experience for students.

RESULTS AND DISCUSSIONS

Effects of GBAs on Students' Social Skills

The researcher used a checklist on self-reporting social skills (SSS) and administered it to both groups of respondents to measure if there is a significant difference in social skills between students exposed to game-based activities and those taught using the usual way of teaching the said topics. The SSS is composed of five components, viz. (1) Communication Skills (Verbal and Non-Verbal), (2) Problem-

Solving, (3) Understanding Emotions, (4) Compliments, and (5) Flexibility with five indicators, each rated by the respondents using a four-point Likert scale-making four (4) as the highest possible rate and one (1) as the lowest possible rate. Then, the researcher tallied the responses, statistically treated them using a two-tailed t-test, and computed Cohen's d to measure its effect size for each social skill component.

Likewise, students' journal entries, informal interviews, and notes from teacher-observers were also used to support the result of the study. The table below summarizes the results of the self-report on social skills (SSS) for the control and experimental groups. It also presents the mean, standard deviation, p-value, and computed effect size along the five components of social skills.

Table 2. *Summary of the Effects of GBAs on Social Skills Based on Self-Report Social Skills*

Components of Social Skills	Control Group		Experimental Group		p-value (***significant at 0.05)	Cohen's d	Interpretation
	Mean	Sd	Mean	Sd			
Communication Skills	3.03	0.72	3.48	0.56	0.015	0.61	Medium
Problem- Solving	2.95	0.71	3.38	0.45	0.011	0.64	Medium
Understanding Emotions	3.04	0.84	3.60	0.40	0.014	0.62	Medium
Complements	3.10	0.92	3.71	0.44	0.002	0.77	Medium
Flexibility	3.02	0.76	3.49	0.64	0.012	0.63	Medium
Overall	**3.03**	**0.77**	**3.52**	**0.47**	**0.012**	**0.63**	**Medium**

Table 3. *Interpretation for Cohen's d Value adapted from Cohen (1998)*

Cohen's d Effect Size	Interpretation
0.2	Small effect size
0.5	Medium effect size
0.8	Large effect size

Table 2 shows a significant difference in the self-report on social skills (SSS) scores between the control and experimental groups, as the computed p-value is lower than the level of significance [N = 69, $p<0.05$]. The values of Standard deviation and Cohen's d also indicate greater consistency and extent of the effect of game-based activities on social skills. The group scored higher on every component of social skills, with an overall mean of 3.52, as compared to the control group, with a mean of 3.03 and an effect size equal to 0.63, which gathered a descriptive interpretation of medium effect, indicating that the integration of game-based activities on ecosystem concepts may have been notably effective in developing the social skills of the students.

Students exposed to GBAs ($\bar{x} = 3.48$) exhibited significantly better communication skills than those in the control group ($\bar{x} = 3.03$), as shown in their weighted mean, p-value, and Cohen's d values ($p=0.015$; $p<0.05$), Cohen's d favor of the intervention group. It is also evident from the results that the experimental ($d = 0.61$). This medium effect size denotes that it is not a coincidence that the experimental group obtained a higher average than the control group regarding improved communication skills. Integrating GBAs in the ecosystem lessons for Grade 7 made the lessons more collaborative and engaging, where students felt safe sharing their ideas, participating in open discussions, and expressing their opinions about the tasks or concepts. Existing studies also suggest that GBAs allow students to take turns in conversations, listen actively, and interact freely, thus improving students' social skills (Bodnar & Clark, 2017; Rahayu & Widayanti, 2019).

Based on statistical analysis ($p<0.05$; Cohen's $d = 0.64$), significant differences lie in problem-solving skills between the experimental and control groups in favor of the experimental group and the use of

GBAs in improving social skills. Cohen's d value indicates a medium effect size and affirms the potential of GBAs to improve students' problem-solving skills. The studies conducted by Emihovich et al. (2020) and Kühn et al. (2019) both attested that GBAs include tasks or learning activities that present challenges students need to resolve. This feature helps students develop strategies, foster critical and analytic thinking, and learn how to adapt to different circumstances.

Additionally, using GBA significantly improved the experimental group's ability to understand emotions compared to the control group ($p<0.05$; Cohen's $d = 0.62$). This medium effect size implies that GBAs can effectively enhance students' emotional comprehension and affective data processing skills. The engaging and collaborative nature of GBAs helps catch and maintain students' attention, social engagement, and dialogues, leading to an improved understanding of different emotions. This result resonates with the findings of earlier studies claiming that students can improve their emotional vocabulary, social-emotional skills, and understanding by using GBAs in lessons (Chen et al., 2020; Toh & Kirschner, 2023).

Remarkably, the complement has the most significant effect size among the measured components of social skills ($p<0.05$; Cohen's $d= 0.77$). This effect demonstrates the potential of GBAs to relate to other people's emotions by expressing empathy, showing support, and complimenting others. Earlier studies claim that using GBAs in teaching encourages students to express their emotions to their classmates and feel affection and empathy (Kleiber, 2021; Sohrabi, 2021). Being able to connect with others emotionally is essential to the social growth of students.

Furthermore, the experimental group showed a statistically significant improvement in flexibility compared to the control group ($p<0.05$; Cohen's $d = 0.63$), suggesting that GBAs can help improve the ability to adapt to different situations. The active and dynamic nature of GBAs requires versatility and willingness to embrace changes, which could be translated to real-life challenges and social interactions (Adipat et al., 2021; Chiotaki et al., 2023).

Qualitative analysis of data through thematic analysis also supports these quantitative findings. Two prominent themes emerged from students' journal entries and teachers' observations: enhanced communication and collaboration and improved confidence and active participation. Students themselves admitted that they became better at communicating with each other. Teachers' observations also emphasized how students consolidate their answers before coming up with the group's final answer and how they work together to answer questions raised during the games or discussions. Sentiments like "Let's do this" and "Let's find out" became common expressions of students, signaling increased collaboration and peer-to-peer learning. This improvement aligns with existing studies that argue that GBAs allow students to work together and have meaningful face-to-face communication, improving their social skills, particularly their collaborative and communication skills (Puga, 2022; Zhong, 2019).

Results of statistical and thematic analyses show that the unique features of GBAs enable them to become effective pedagogical tools. The use of GBAs enhances student social skills in general by providing opportunities to communicate, work together, and develop social-emotional understanding. These findings reiterated Alabbasi's (2018) conviction that game-based activities improve students' academic performance and give them opportunities for socialization. Funa et al. (2024) mentioned that the brain/mind is social. Thus, there are plenty of opportunities for socialization through integrating GBAs into ecosystem lessons. Students were allowed to work in teams as they accomplished the tasks by group, led others, and engaged in friendly discussions about the topics. They were also allowed to role-play and collaborate with their classmates on how to fulfill their tasks. These opportunities can improve students' social skills as they mingle with others and cooperate toward a common goal. Studies show that the interactive nature of game-based activities creates different social opportunities for students, offline or online, to improve their social and emotional skills (Laranjeiro, 2021; Wiederhold, 2021; Vlachopoulos & Makri, 2017). Hartanto et al. (2021) also added that game-based activities promote critical thinking and the development of social, communication, and problem-solving skills, mainly because games are often multiplayer. Overall, game-based activities give students opportunities to explore concepts with a more positive attitude. This study shows that the use of lessons integrating game-based activities has the

potential to improve the students' social skills more effectively as it provides a collaborative and engaging environment for learning.

Effects of GBAs on Students' Attitude toward Learning

This study adopted the Attitude Inventory from the study of Kasimu and Nantomah (2019). The table below shows the summary of the attitude inventory scale as rated by the students from the experimental group.

Table 4. *Summary of Attitude Inventory during GBAs Implementation*

Attitude Inventory Scale Statements	Mean	SD	Interpretation
A. ***Value of using GBAs for learning Ecosystem Concepts (VGBAEC)***			
1. I believe that GBAs help me understand the lesson well in the Ecosystem	4.53	0.50	Strongly Agree
2. GBAs help me incorporate new learning methods.	4.37	0.49	Strongly Agree
3. The GBAs features (such as interactive, collaborative and etc.) make it easier to explore and learn Ecosystem concepts.	4.60	0.23	Strongly Agree
4. GBAs enhance and make me more directed in learning and increase my motivation to study the topics.	4.92	0.49	Strongly Agree
Ave. Mean Score	*4.61*	*0.43*	*Strongly Agree*
B. ***Interest in using GBAs for learning Ecosystem concepts (IGBAEC)***			
5. I learn and understand ecosystem concepts when GBAs are used.	4.51	0.50	Strongly Agree
6. If I encounter difficulty in following the mechanics of GBAs, I do my best to discover it with my teammates in order for us to finish the tasks and study the lessons.	4.22	0.53	Strongly Agree
7. I can learn many concepts in ecosystem concepts when a GBA is used	4.49	0.47	Strongly Agree
8. I feel motivated to learn ecosystem concepts when GBAs are used.	4.65	0.50	Strongly Agree
Ave. Mean Score	*4.47*	*0.50*	*Strongly Agree*
C. ***Confidence with GBAs (CGBA)***			
9. I feel more confident in learning the lessons using GBAs	4.43	0.43	Strongly Agree
10. I am always very excited to learn using GBAs.	4.54	0.39	Strongly Agree
11. I have avoided GBAs because it is difficult for me*	4.1	0.41	Agree
12. Learning with GBAs is very frustrating*	4.43	0.49	Strongly Agree
Ave. Mean Score	*4.38*	*0.43*	*Strongly Agree*
D. ***Anxiety in using GBAs for learning Ecosystem Concepts (AGBAECS)***			
13. Studying ecosystem concepts with GBAs makes me feel tense and uncomfortable*	4.28	0.42	Strongly Agree
14. Using GBAs makes me feel tense and uncomfortable*	4.31	0.49	Strongly Agree
15. I know GBAs are important, but I don't feel I need to use them to learn Ecosystem concepts. *	4.43	0.42	Strongly Agree
16. I get a sinking feeling when I think of trying to play with GBAs to learn ecosystem concepts. *	4.21	0.43	Strongly Agree
Ave. Mean Score	*4.31*	*0.44*	*Strongly Agree*
E. ***GBAs Anxiety (GBAA)***			
17. I feel tense whenever learning the lesson with GBAs.*	4.23	0.50	Strongly Agree
18. I worry about making mistakes when navigating GBAs*	4.12	0.45	Strongly Agree
19. I have avoided GBAs because it is unfamiliar and somewhat intimidating to me.*	4.45	0.45	Strongly Agree
20. Working with GBAs makes me nervous. *	4.34	0.47	Strongly Agree
Ave. Mean Score	*4.29*	*0.47*	*Strongly Agree*
Overall Mean	4.41	0.45	Strongly Agree

Based on the table above, using GBAs in ecosystem lessons has a strong positive impact on students' attitudes toward learning the topics and the use of GBAs. Yildirim (2017) noted that students have a common positive notion that games are fun and challenging ways to learn, creating a positive attitude towards using games in educational settings and learning. Teacher-observers noted that students exhibited this positive attitude by showing confidence that the GBAs would help them learn the ecosystem concepts more clearly and effectively. This result also relates to the findings of Panganiban (2019) and Selvi and Cosan (2018) that game-based activities promote positive attitudes toward the subject and learning due to the fun and challenges embedded in the games.

Ratings from the students' attitude inventory scale about the effects of GBAs show that the positive attitude the GBAs bring out among the learners is mainly related to the perception that the students feel less anxious participating in a game-based activity compared to formal discussions of lessons. As the students feel more comfortable and familiar with the tasks and objectives of the GBAs, their perception of the game and the lessons also becomes more positive. Similar findings were discovered by White and McCoy (2019) in their study about the perspective of students on educational games, suggesting that students tend to have a more positive attitude toward the subject or lesson when they are in a more relaxed and cooperative environment, which is easily achievable in lessons integrating game-based activities. Additionally, throughout the implementation of GBAs in ecosystem lessons, the teacher explained the relation of the game-based activities to the expected competencies that students would obtain from the lessons that integrated GBAs. Having a clear understanding of the role of GBAs in the success of learning ecosystem concepts helped students value GBAs and see them as learning tools, not just for entertainment. Getie (2020) stressed that as students learn to recognize the role of games in their learning process and the value of concepts taught, they will have a positive attitude toward it. Using GBAs in the ecosystem lessons helps students relate the games to ecosystem topics and allows them to explore real-life situations wherein they can apply the concepts they are learning.

Interrelation of Conceptual Understanding, Social Skills, and Attitude to Learning

Studies suggest that a multifaceted and complex relationship exists between students' conceptual understanding, social skills, and attitude to learning. To determine the effects of GBAs on students' conceptual understanding, the researcher administered a post-intervention examination to both groups of respondents. The results of the post-intervention test are here in the table below.

Table 5. *Impact of GBAs on Students' Conceptual Understanding*

Respondents	Mean	Sd	Degrees of Freedom	Level of Significance	t-value	p-value	Cohen's d value	Interpretation
Experimental group	87.71	2.50	67	0.05	2.21	0.03	0.88	Large effect size
Control group	85.50							

The table shows that the experimental group has a higher average (87.71) than the control group (85.5). The figure implies that the students in the experimental group exhibited a higher performance or level of conceptual understanding. The result also aligns with the p-value (0.03)). Since the p-value<0.05, it implies that there is a significant difference between the conceptual understanding of the two groups of respondents based on their post-intervention exam results and Cohen's d value (0.88), which indicates a large significant difference in the conceptual understanding scores of the two groups, favoring the experimental group. Results suggest that using GBAs to teach ecosystem concepts could improve students' conceptual understanding. Studies assert that GBAs help create an environment more conducive to

learning and improve the learning experience, thus increasing conceptual understanding (Dalidig, 2020; Liu & Chen, 2013). The fun and explicit instruction elements for the GBAs made the learning activities more effective in teaching concepts. As the GBAs enable the students to think critically and actively participate in the learning process, they are more likely to understand the concepts being taught.

Table 6. *Correlation Table using Pearson Correlation Coefficients (r)*

Learning Outcome 1	Learning Outcome 2	Correlation Coefficient (r)	p-value
Conceptual Understanding	Social Skills	0.19	0.31
Conceptual Understanding	Attitude to Learning	0.45	0.01
Social Skills	Attitude to Learning	0.26	0.16

Using Pearson Correlation Coefficient (r), this study also explored the interrelationships between students' conceptual understanding, social skills, and attitude to learning based on data sets from the experimental group exposed to GBAs. The table below presents the correlation coefficients of the variables for correlational analysis.

Results from correlational analysis revealed that conceptual understanding has a weak positive correlation ($r = 0.19$) to social skills, but is not statistically significant ($p = 0.31$) and moderate positive correlation ($r = 0.45$) to attitude to learning, statistically significant ($p = 0.01$); while social skills have weak positive correlation ($r = 0.26$) to attitude to learning but is not statistically significant ($p = 0.16$). This shows that although, having high social skills may not be strongly associated with high conceptual understanding, the positive correlation still implies a positive relationship between these variables. This is also true between the relationship of social skills and attitude to learning. The results also emphasized that a positive attitude towards learning can be associated to higher conceptual understanding. This implies that fostering positive learning attitude among students, such as through integrating GBAs in the lessons, can potentially improve students' conceptual understanding. As an instructional strategy and tool, the use of GBAs can improve students' attitude and engagement with learning materials that could lead to better learning outcomes.

Qualitative analysis through thematic analysis highlighted two themes from students' journal entries and teacher observers' interviews: increased understanding due to collaboration and a positive learning environment. Students noted that they could discuss things they have learned with their groupmates and ask for help whenever they were confused. They also received strong support from their group, encouraging them to learn better. Students also shared that using GBAs also established a culture of open discussion, teamwork, and meaningful pursuit of learning. This positive learning environment helps them feel more eager to learn and engage in the learning process better, enhancing their conceptual understanding.

In connection with this, the study also recognizes the interrelationship of conceptual understanding, social skills, and attitude toward learning. Qualitative data analysis from respondents and teacher-observers revealed that these components have a reciprocal bidirectional connection. Students noted that because they can clearly understand the concepts they were taught, they feel more confident about connecting with their classmates and sharing their thoughts with their group or the class. Some students shared that knowing that they could contribute to the team because they understood the lesson motivated them to work with their group mates. Others specified that because they understood the lesson and concepts, their perspective regarding the subject and the learning process changed and motivated them to learn

better. These sentiments highlight the idea that increased conceptual understanding helps increase social skills and attitudes toward learning (Fulmer et al., 2019; Hussein & Csíkos, 2023).

The students' learning process using GBAs was iterative, with an increased conceptual understanding leading to improved social skills and a more positive attitude to learning, which in turn led to deeper comprehension (Adipat et al., 2021; Yadav & Oyelere, 2021). The positive impact of using GBAs on students' social skills is not an isolated incident. It creates a virtuous cycle of growth with students' conceptual understanding. As students learn to interact with their peers, improve their communication skills, and collaborate with their group through the GBAs, they can express their understanding better, co-construct knowledge with their peers, and seek answers to their questions. This flow and exchange of ideas among students leads to a deeper understanding of ecosystem concepts, individually and as a group. Most GBAs incorporate peer discussion, collaboration, and communication, leading to significantly higher comprehension (Chen & Law, 2016; Vlachopoulos & Makri, 2017).

Additionally, a more positive attitude towards learning fostered through the use of GBAs motivates students to persist in their learning efforts and fuels an active exploration of concepts. Using GBAs helps students be less apprehensive in asking questions or assistance, taking risks, and exploring more challenging topics related to the lessons. Students' positive attitude towards learning propels them to seek connections between the concepts they're learning and the game-based activities, fostering their critical thinking and enhancing their conceptual understanding. The positive approach of students toward learning, especially when it comes to knowing the purpose of activities, can help them learn concepts better, as studies suggest (Anwer, 2019; Díez-Palomar et al., 2020). As students persist in accomplishing their learning tasks and explore concepts, they are able to refine their understanding of ecosystem concepts and concretize abstract concepts

These findings strengthen the discussion on the effects of GBAs on students' social skills and attitudes to learning, as presented above. By improving students' social skills and nurturing positive attitudes to learning, GBAs can create a conducive and dynamic learning environment where understanding, engagement, and collaboration can foster and lead to better conceptual understanding. This positive feedback loop shows that conceptual understanding, social skills, and attitude toward learning can work together to provide holistic learning and create meaningful student learning experiences.

CONCLUSION

This study aimed to determine the effects of game-based activities (GBAs) on students' learning outcomes. The study's results revealed that GBAs can enhance students' social skills and attitudes towards using GBAs and learning earth science. Integrating GBAs in the lessons helped create an interactive, engaging, and meaningful learning environment where students can collaborate, explore, and discover concepts they need to learn while improving their social skills and attitudes. The study also supports the interrelationship of conceptual understanding, social skills, and attitude toward learning as components that could promote holistic and meaningful learning. GBAs connect these learning components to create a meaningful and effective learning experience. This study affirms the theories that suggest the potential of using games as an innovative and interactive instructional tool and strategy.

The study also recommends the integration of GBAs into the curriculum or lessons and continuous evaluation of GBAs based on specific learning objectives to optimize their effectiveness. Educational policies and the collaboration of game and curriculum developers can also improve the utilization of GBAs in educational settings. Future research could focus on mechanisms behind GBAs' impact on

social skills, such as the role of collaboration, social-emotional engagement, and cognitive challenges, or explore the interrelationship of GBAs and other academic outcomes. Future researchers can pursue longitudinal studies of the effects of GBAs using baseline data to determine their long-term effects for a deeper understanding of the impact of GBAs and address the limitations of the current study.

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