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VALIDATION OF GAME-BASED ACTIVITIES IN TEACHING GRADE 7-BIOLOGY

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ABSTRACT

The use of game-based activities in education has been recognized as an innovative alternative instructional material. As any sort of instructional material is essential to the teaching and learning process, it is imperative to check its quality before widespread utilization to ensure effectiveness. This study aims to evaluate the validity of the developed lessons in Ecosystem integrating game-based activities (GBAs) namely (1) THE CONQUEST, (2) ECO-DAMA, (3) ECO-CHALLENGE, and (4) ECO-WARRIOR for Grade 7 Biology. This research employed descriptive developmental research design involving 8 experts and 66 students chosen through purposive sampling. Experts used the DepEd standards for non-print resources while students were given the evaluation checklist and asked to write journals for the validation. Results show that the GBAs met all of the LRMDS DepEd's standards for non-print resources and were deemed "very satisfactory" by both the students and the experts implying high validity. Additionally, the students' pre-test and post-test results revealed that integrating GBAs improved their academic performance. The experts and students acknowledged the potential for GBAs to make classes engaging, instructive, and fun, supporting the validity of the developed GBAs. This study concludes that the use of GBAs is a valid and effective approach in Science education and the developed GBAs can be used as supplemental and cutting-edge instructional materials for teaching Ecosystem. This study adds to the body of knowledge exploring the potentials of GBAs for educational purposes and promotes the use of GBAs in similar fields of study.

Keywords: descriptive-development research; ecosystem; game-based activities; instructional material; validation

INTRODUCTION

The current setting of Philippine education, particularly in Science, English, and Mathematics, and the performance test results show a decline in students' academic performance and quality of basic education. This matter is felt throughout the country and needs immediate action if the government wants to prepare students for the world's challenges and improve the country's status. With the expansion of science and technology, the value of Science education rises; however, the Philippines' educational system is struggling in this area. The 2012 National Achievement Test (NAT) showed a national average of 48.9% and a mean percentage score (MPS) of 40.5% for Science compared to the 75% performance target set by the Department of Education (DepEd) to ensure good quality of Basic Education in the country for high school students (De Dios, 2013). This poor performance of Filipino students in Science is also shown in the 2018 Program for International Student Assessment (PISA) test results sponsored by the Organization for Economic Cooperation and Development (OECD) where they scored 357 and placed second to last in ranking (OECD, 2019). Rogayan & Albino (2019) in their study about Filipino students' common misconceptions in Biology also noted that the Philippines lags behind when it comes to quality of Science education, specifically in Biology. Their study also revealed

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that students have a moderate level of misconception about basic concepts in ecology that could be remediated using fun and innovative strategies, implying the role of learning materials and strategies in the quality of learning. The declining trend in the performance of Filipino students in Science can be attributed to a number of variables, one of which is the quality of learning materials.

Rabino (2014) found that "the key variables that account for Filipino students' low Science performance are the lack of support for a scientific culture represented in the school curriculum, the inadequate teaching-learning process, insufficient instructional materials, and lack of teacher training." The paucity and quality of learning materials in Science is a long standing challenge in the country which should not be taken for granted as learning materials influence the learning-teaching process and students' performance. Dagget (2014) emphasized in his study that the learning material and strategy used by the teachers in the classroom has a huge impact in the teaching and learning process and that students are more likely to fail when the instructional strategy is lecturing so there's a need for teachers to shift the role from disseminators of knowledge to facilitators of the learning process. One way to make that transition is the integration of game-based activities in the learning process.

Game-based learning is generally built upon a constructivist type of learning. With this type of learning approach, students are encouraged to actively participate in solving the problem presented to them by interacting with their surroundings. Game-based activities help students to take control of their own learning and make decisions aligned with their goals making learning more effective. Part of the nature of game-based learning is its close relationship to active learning. Game-based activities are generally known to excite and engage learners when they actively participate in tasks and work on attaining the learning goals (Huotari & Hamari, 2017; Koivisto & Hamari, 2019; Dabbous et al., 2022). In addition to allowing students to experience and apply knowledge, game-based learning activities offer a stimulating, individualized, interactive, and enjoyable learning environment (Chen et al., 2018). Game-based activities in education can enhance learner performance in a number of cognitive domains, such as memory, comprehension, and concept application. (Von Wangenheim, et al., as cited in Dabbous, et al., 2022). The efficacy of game-based methods has been the subject of much research over the past decades with teachers and students favoring the use of game-based activities in their teaching and learning process.

The use of games to encourage student learning has reportedly been done in the past to pique students' attention, boost motivation, improve social skills, increase students' engagement through the learning materials, and integrate fun and collaboration in the learning process (Franklin et al., 2003; Bergin & Reilly, 2005; Plass et al., 2009; Liu & Chen, 2013; Luna, 2019). Game-based activities help students be more hands-on with their learning individually or in a group. The use of game-based activities in learning and teaching provides a unique framework to support a variety of teaching strategies and infuse them with fun, spark, creativity, and innovative thinking while still focusing on their academic contents to help students understand better rather than the competition and task difficulty (Boyle, 2011; Dicheva, et al., 2015; Manzano-Leon et al., 2021). As a pedagogical device, game-based activities are especially effective for dealing with problem solving and key concepts of the subjects; hence, it can also be integrated into subjects like Science.

The use of game-based activities in science education has been proven to increase students' motivation, engagement, and mental grasp of the subject matter. Previous studies stated that game-based activities can help students develop their cognitive, affective, and psychomotor skills in teaching Science subjects like Physics and General Science (Panganiban, 2019; Yazicioglu & Çavus Güngören, 2021). The use of game-based activities in Science also helps learning and teaching experience become informative, entertaining, collaborative, and interesting (Miller et al., 2011; Yien et al., 2011; Guido, 2013; Selvi & Cosan, 2018). Different studies about the efficiency of game-based activities in teaching Science also suggested that the use of game-based activities improves students' conceptual understanding based on the increase in their post test results compared to pretest results, increased retention and reinforcement of key concepts in Science, and that game-based activities could also promote positive attitude toward science games (Liu & Chen, 2013; Karadag, 2015; Pinder, 2016).

Moreover, according to Bayat et al. (2014), one main reason for the effective use of game-based activities in Science lessons is that it makes abstract Science concepts become more tangible and understandable to the students. Murat et al. (2013) also argued that having the opportunity to give immediate feedback through game-based activities also made this method more effective for both learners and teachers. Based on these studies, it can be said that the use of game-based activities in education, and more specifically in Science, can improve students' cognitive, social, behavior, and psychomotor skills. This teaching strategy and tool could contribute to a more meaningful, flexible, creative, engaging, and innovative learning and teaching process. These advantages are why it is important to assess the validity of game-based activities integrated in the lessons for Science. Li & Tsai (2013) suggested that researchers thoroughly assess the efficacy of game-based activities and establish a stronger connection to learning. Funa & Ricafort (2019) also emphasized that it is crucial that instructional materials, such as game-based activities, go through validation to guarantee quality and help improve education quality. For this reason, this present study focuses on validating game-based activities for Grade 7-Biology as a solution in Science learning.

Although the previous studies presented help in establishing the basis and importance of this study, some aspects differentiate this research from the previous ones. In this study, the game-based activities will be integrated in selected topics for Grade-7 Biology class, specifically for the topics in ecosystem. This study focuses on the implementation and evaluation of the Game-based activities developed by the researcher that are integrated in Ecosystem lessons as part of the validation process. This study aims to validate the game-based activities developed by the researcher for selected Ecosystem topics for Grade-7 Biology class based on experts' and students' evaluations. Determining the validity of any instructional materials is essential to ensure its readiness for utilization and in response to the DepEd's goal of creating research-based and the need for responsive and innovative instructional materials. The integration of game-based activities to the ecosystem lessons are expected to enhance students' performance in the subject.

METHODS

This study utilized the descriptive developmental research design, a mixture of descriptive and developmental methods. This design is chosen as it is most appropriate for studies that involve examination, documentation, and assessment of developed product or process (Richey, 1994). To suit the purpose of this research, the researcher also employed the Analysis, Design, Develop, Implement, Evaluate (ADDIE) model as it is a widely recognized and efficient model for educational studies and has strong association with high-quality design, clear learning objectives and content, and assessment closely tied to desired learning outcomes (Dick & Carey, 2005; Morrison, 2010). This paper focused on the discussion of the latter part of the ADDIE model, which involves the implementation and evaluation phases.

This study used purposive sampling in choosing the respondents consisting of eight experts and 66 student-participants. The experts consisted of a University Professor in Biology, a Science Supervisor in DepEd Sorsogon City Division, and six Biology teachers. Whereas, the sixty-six (66) Grade 7 students came from the two Science, Technology, and Engineering (STE) classes comprising 33 students for control group and 33 students for experimental group). The student-respondents officially enrolled in a public high school in Sorsogon City for 2019-2020.s

In order the collect relevant data to the study, the researcher utilized the following instruments:

Developed GBAs. The researcher developed four GBAs integrated into 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 anchored in different topics and learning competencies in Ecosystem while adapting popular games for the purpose of the study.

LRMDS Assessment and Evaluation Tool of DepEd. The experts used this to evaluate the validity of the GBAs adapted from the guidelines provided by DepEd for manipulative comprising three parts: (1) Content (2) Accuracy of Information, and (3) Instructional and Technical Designs as a reference in validating the developed game-based activities with the help of experts. This can be found on the DepEd Website for learning resources (Evaluation Rating Sheet for Charts, Posters, Drill / Flash Cards and Manipulative) through https://lrmds.deped.gov.ph/docs/LRMDSGuidelines.pdf.

Student Evaluation Checklist (SEC). The experimental group students used this to evaluate the validity of the GBAs adapted from the study of Funa and Ricafort (2019) focusing on the format and content of the lessons integrating GBAs.

Pretest and Posttest. The constructed multiple choice type of pre-test and posttest on identified topics in Ecosystem used review materials and item banks. The test consisted of 50 items that covered the competencies in Grade 7 Biology particularly in Ecosystem topics and validated by the experts. The tests were administered to both groups of student-respondents at the beginning and end of the implementation phase.

Journal logs. Students were asked to record their impressions and learning experience in a journal after each discussion or lesson. The journal logs were treated with confidentiality that the students only shared the entries with the researcher for the purpose of the study.

This study uses the ADDIE model in the development and validation of the GBAs integrated in the Ecosystem lessons for Grade-7 Biology class, however, it only focuses on the latter part of the ADDIE model which is the implementation and evaluation phases. Analysis, Design, and Develop phases were already done and discussed in a separate study conducted by the researcher. The data collection procedures are explained as follows:

Implementation phase. During this stage, the materials created during development are introduced to the target audience and the learning process starts (Morrison, 2010). For this study, the implementation phase began after obtaining an approval from the principal to conduct the study in the institution. Once approved, the researcher was able to administer a pretest to the respondents. For the lessons implementation, the control group were taught using the suggested teaching method for the selected topics based on the Teacher's guide and learner's modules in Grade 7- Biology. They were taught from 10:30AM to 11:30AM. On the other hand, the experimental group were taught using the developed lessons integrating GBAs from 1:00PM to 2:00PM. Games masters were chosen to introduce the mechanics of the game-based activities for each lesson. Students were also asked to keep a journal to write their experiences and learning during the implementation of each lesson integrating GBAs. The implementation was conducted from the third week of September 2019 up to the first week of October following the timeline presented by the researcher to the teacher facilitating the lessons.

Evaluation Phase. The evaluation stage includes formative and summative evaluations of the effectiveness of the instructional design or material and gathering feedback to improve the material or design (Dick et al., 2001). The experts validated the GBAs using the LRMDS Assessment and Evaluation Tool of DepEd during the implementation by observing the actual lesson delivery for each lesson integrating GBAs. They evaluated the validity of the instructional materials based on three indicators:(1) Content (2) Information contained in the developed materials, and (3) Instructional and Technical Designs. After all the lessons had been carried out, the students took the posttest and evaluated the validity of GBAs using the SEC based on two indicators: (1) format and (2) content. The researcher then compared and analyzed the result of pretest and posttest and the responses from the experts and students evaluation of the instructional materials. Finally, improvement and revisions on the GBAs were done based on the feedback from the experts and students who evaluated the materials.

Data Analysis Procedure. The researcher used descriptive statistics in order to analyze the experts and students evaluation of the developed GBAs. The interpretation of the mean rating from the experts' validation using LRMDS Assessment and Evaluation Tool was used to know the validity of developed GBAs integrated in Ecosystem lessons based on experts' perspective. Mean or average of the data was used in analysis to summarize the responses of the experts and provide understanding of the characteristics of GBAs observed. The mean or average is one of the key metrics for interpreting the outcomes of the validation of analytical methods (Belouafa et al., 2017). The SEC were determined as follows: 4= Very Satisfactory, 3= Satisfactory, 2= Poor, and 1= Unsatisfactory. The mean or average of the responses in SEC were also analyzed and interpreted to get an understanding of the validity of the developed GBAs integrated in the Ecosystem lessons based on students' perspective. Qualitative data were also used using adjectival description to support the statistical analysis. Whereas, to compare and analyze the pretest and posttest results, mean rating, unpaired T-test, and Cohen's d set at 0.05 level of significance were used. Analysis of the students' validation was done following the pattern of validation employed by Funa and Ricafort (2019) on their study where the SEC form was adapted.

RESULTS AND DISCUSSION

This study utilized DepEd LRMDS guidelines for non-printed materials in order to evaluate the validity of the GBAs in terms of content, information, and instructional and technical designs. The researcher gathered, analyzed, and interpreted the experts' responses based on frequency distribution, weighted mean, and brief verbal statements in each given item or criteria in the evaluation instrument for each GBA. These were done to limit "expert bias" in the validation process and ensure consistency and reliability on the data and findings.

Table 1 shows the summary of mean rating given by the eight experts. The experts' validation of GBAs focused on (1) Content such as objectives, students' age group and the appropriateness of the game to their level, (2) Information contained in the developed materials which can lead to the mastery of learning competence for the level and subject it was intended, and (3) Instructional and Technical Designs such as the size and composition of manipulative, materials used and supports innovative pedagogy.

Table 1. Experts' Validation of the Game-basedcActivities

Components	Mean Evaluation of the Developed GAME-BASED ACTIVITIES				Average	Interpretation
	G1	G2	G3	G4		
Content	3.85	3.80	3.75	3.53	3.73	VS
Information	4.0	3.88	3.55	3.65	3.77	VS
Instructional and Technical Design	4.0	3.87	3.85	3.60	3.83	VS
Average	3.95	3.85	3.72	3.59	3.78	VS

Note: G1- THE CONQUEST: Saving SNHS Forest; G2- Eco-DAMA; G3- Eco-Challenge; G4- Eco-Warrior
VS-Very Satisfactory

The overall mean rating is 3.78, implying a "very satisfactory" or excellent validity of the GBAs. Likewise, its different aspects obtained mean ratings indicating a "very satisfactory" or excellent validity rating of 3.73 (content), 3.77 (information), and 3.83 (instructional and technical designs) for the materials. In detail, the part for instructional and technical design gained the highest rating from the experts. This is especially true for the first GBA which is named as *The Conquest.* This could be attributed to the fact that the GBAs integrated in the lesson required physical participation especially with the first GBA which consisted of different games adapted for educational purposes based on the goal for each station. This follows the concept of having customizable tasks when using GBAs in lessons, making it more effective for students' learning. The researcher made sure to add some unique touch or modifications to the developed game-based activities. All these games promote student active involvement, thus, challenging their motor skills and understanding. Regarding the GBAs' instructional and technical design, one of the experts also noted, "The games developed are very creative and are highly recommended for innovative teaching". All the experts' agreed that the instructional and technical design are "very satisfactory" thus, the overall validation on this criterion is "Very Satisfactory" with a mean rating of 3.83. The flexibility of tasks requirements involved in GBAs make it easier for students to make their own decisions throughout the game and take steps beneficial to their learning as shared by Rapini (2012) suggesting the GBAs allow teacher and students to construct their own learning experience during the integration of GBAs in the lesson.

In addition, experts also found the GBAs "very satisfactory" with a mean average of 3.77 for information. Experts found minor errors in the games especially in grammar and had them corrected before the pilot testing or implementation in class. Sources of pictures and information related to the GBAs were also added based on the experts' suggestions. Overall, the experts still found them informative and acceptable, supporting their validity. This could be attributed to the fact that the developed GBAs were aligned with the specifications and competencies suggested by the Department of Education for teaching the said topics in Biology 7. Candido (2000) mentioned that having the table of specifications and standardized content in developed game-based activities would help in maintaining the integrity of information included in the game-based activities and gamified lessons. This shows that integrating GBAs in the lesson also requires acceptable and legitimate standards in order for it to be effective.

For the content validity of developed GBAs integrated in the lessons, experts' overall mean rating for this criterion is 3.73 and interpreted as "Very Satisfactory" which can be interpreted as having high content validity. This means that experts believe that the developed GBAs could reinforce, enrich, and / or lead to the mastery of certain learning competencies for the level and subject they were intended, the information and facts used are updated, and the visuals used have the potential to arouse the students' interest, convey the message of the topic and are fitted for use in school. A similar study by She (2004) also supports this finding as the study claims that having more accurate facts integrated in games could make it more reliable when using them as tools for instructions. This finding may also be associated with the unique framework GBAs have that allows teaching to be creative, innovative, and fun while focusing on the learning goal. GBAs also often include a lot of visuals such as pictures, game cards, and props which are proven to increase students' interest and motivation to learn. Having these features on the content make the scientific concepts introduced and taught through the GBAs more tangible rather than abstract.

The experts' validation of the developed GBAs implies high validity. Findings on this study suggests that the integration of GBAs in the lessons is an excellent strategy in conveying scientific knowledge according to experts and providing a creative space for the students to learn given that the GBAs are customizable, flexible, and based on sound learning goals. This also suggests that using GBAs in teaching and learning Ecosystem topics is an effective strategy especially when it is designed around the key concepts of the topics and learning outcomes.

The developed game-based activities were pilot tested on thirty-three (33) grade 7 students (experimental group) enrolled in Science, Technology, and Engineering (STE) class in one of the public high schools in Sorsogon City as part of the validation process. They were tasked to evaluate the games using the Student Evaluation. This is a 5-point likert scale adapted from the study of Funa and Ricafort (2019) and modified to suit the purpose of the study, focusing on Format and Content only.

Below is the summary of the result of Student's Validation on developed Game-based Activities in terms of format and content:

Table 2. Students' Validation of the Game-based Activities

Components	Mean Evaluation of the Developed GAME-BASED ACTIVITIES				Average	Interpretation
	G1	G2	G3	G4		
Format	3.85	3.70	3.80	3.65	3.75	VS
Content	3.63	3.55	3.56	3.65	3.60	VS
Average	3.64	3.63	3.68	3.65	3.68	VS

Note: G1- THE CONQUEST: Saving SNHS Forest; G2- Eco-DAMA; G3- Eco-Challenge; G4- Eco-Warrior

For the students' validation, only students from the experimental group provided the evaluation as they were the only group exposed to the developed GBAs integrated into the lessons. Students looked at the format and content of the developed GBAs for the validation using the Student Evaluation checklist. Specifically, the format of the developed GBAs got an overall rating of 3.75 interpreted as "strongly agree" and denoting a high validity of the format. This means that the students find the instructions for the GBAs clear, the text font and styles readable, and the pictures and illustrations clear and appropriate for the topics. Govender and Jaffer (2021) emphasized that using the correct font size style, and simplifying text reduces cognitive loads and makes the instructions more relatable to the learners or listeners. The tone of the instruction, whether written or verbal could also affect the clarity of the instruction. Game-based activities often adopt a motivating language by making the instructions straightforward and clear which is advantageous when used as instructions. This is also a good rating as most of the students tend to be visual so having high validity on this aspect could increase the effectiveness of the GBAs for its intended users. The use of GBAs in lessons for Ecosystem greatly minimized cognitive load for the students especially for lessons with concepts that need a lot of narrative definitions as they come to understand these key concepts through game-based activities rather than just reading about it.

Further, the students also strongly agreed that the content of the developed GBAs help and keep them motivated to learn, have fun, and enjoy the lessons with an average mean of 3.6. This also implies that students find the objectives being emphasized in the GBAs and the mechanics understandable. Plass et al. (2015) stated that game mechanics or rules are often presented within the context of the lesson thus, students find it clearer and more engaging as they could see the aesthetic and cognitive value of the mechanics or instructions. This suggests that with the use of GBAs in the lessons, confusion and misconceptions could be avoided as instructions are clear and concepts become more concrete to the students.

For students, the developed GBAs have high validity both in terms of format and content. The developed GBAs got a total average of mean rating from the students of 3.68 which indicates high validity in general. This implies that even for the intended users, the developed GBAs have a potential of aiding students' learning based on its format and content. The advantage of using GBAs in Ecosystem lessons lies in how GBAs help students relate key concepts to their prior knowledge and experience as games integrated in the lessons are often simulated situations.

One of the main objectives of instructional materials, including GBAs, is to help students in their learning; thus, increasing the students' level of performance. In this study, the level of performance is determined based on the results of students' pretest and posttest results. A statistical comparison between the control and experimental groups were done in order to pinpoint the effect of the integration of GBAs to the students' level of performance. The table 3 below shows the result of pretest and posttest for the experimental and control groups through the unpaired t-test results, mean and performance level and the adjectival description using Mastery Level Descriptive Equivalent (MLDE).

Table 3. Unpaired t-test Results for Pre-test and Post-test of Students

Learning Competencies	No. of Items	No. of Points	PRE-TEST						POST-TEST						Effect Size
			Control Group (N-33)			Experimental Group (N-33)			Control Group (N-33)			Experimental Group (N-33)			
			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	16.55	50.00	LM	16.36	49.59	LM	26.85	81.36	M	31.03	94.03	FM	1.07
LC2-Describe the different ecological relationship found in the Ecosystem (S7LT-IIh-10)	12	36	14.33	39.81	LM	14.00	38.00	LM	29.39	81.65	M	30.88	85.77	NFM	0.40
LC3- Predict the effect of changes in one population on other populations in the Ecosystem (S7LT-IIi-11)	14	42	16.12	38.38	LM	14.50	34.42	LM	28.72	68.00	NM	32.53	77.00	M	0.63
LC4-Predict the effects of changes in abiotic factors on the Ecosystem (S7LT-IIj—12)	13	39	14.00	35.51	LM	14.24	36.52	LM	26.00	66.67	NM	27.79	71.25	NM	0.38
Overall Mean	50	150	61	40.57	LM	59.1	39.11	LM	110.90	73.98	NM	122.2	81.33	M	1.25
SD			13.81				11			9.43			8.44		
p-value					0.48							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

For the pretest results, as shown in the table, there is no significant difference between the pretest scores of both groups of respondents since the p-value is equal to 0.48, greater than 0.05 level of significance [t (64) =0.711, p>0.05]. Looking at the standard deviations of the two groups, it can be inferred that the scores of students in the experimental group are closer than the control group yet they show similar disparity. Statistical data showed that the control and experimental groups' pre-test scores are similar. From the table, it can be said that the two groups of respondents on the study may have the similar learning experiences and ideas about the topics presented in Biology 7, particularly in Ecosystem topics prior to the instruction. The result can be partially attributed to the spiral progression approach in the present curriculum. According to Gatdula (2016), in spiral progression, core principles are introduced in first grade and revisited in later grades; however, Samala (2018) stressed that in spiral progression, students had a hard time remembering the concepts and skills they learned in the previous grade level. Thus, there are some learners who cannot relate to the present lesson, since the previous lesson is necessary to understand the new lessons.

For the posttest results, as reflected in the table, there is a significant difference between the post-test results of experimental and control groups since the computed p-value is lower than the level of significant [t (64) =5.01, p<0.05; d=1.25]. Looking at the standard deviations of the post-test of the two groups, it can be inferred that the scores of the experimental group are closer compared to the control group. Focusing in value of standard deviation of the experimental group (SD=8.84), which is lower than the control group, also implies that the scores of the students in the experimental group conforms with the t-test result that there is a significance difference in the post-test scores of both groups. In addition, both groups performed well in the post-test after the instruction. For the control group, the overall mean is 110.97 with a PL of 73.98%, compared to their pre-test general mean of 60.85 and a PL of 40.57%. This indicates that the control group nearly mastered all the learning competencies after the instruction which implies the effectiveness of teaching strategies suggested in the teaching guide provided by the Department of Education. However, the result of the post-test of the experimental group outperformed the control group post-test result.

Considering the average mean and performance level on the post-test results stated in Table 3, the experimental group students were still significantly higher than that of their counterparts in the control group. These data suggest that the Game-based Activities integrated in each lesson for the experimental group enabled them to understand the Ecosystem concepts better. This claim was further supported by comparing mean gain and normalized gain between the pre-test and post-test of control and experimental groups and the standard deviation shown in table 4 below.

Table 4. Mean and Normalized Gain of Pre-test and Post-test of Experimental Group and Control Group

Learning Competencies	Experimental Group (N=33)									Control Group (N=33)								
	PRE-TEST Weighted Mean Score	Sd	POST-TEST Weighted Mean Score	Sd	Mean Gain	Norm Gain	Interpretation	Effect Size	Interpretation	PRE-TEST Weighted Mean Score	Standard Deviation	POST-TEST Weighted Mean Score	Standard Deviation	Mean Gain	Norm Gain	Interpretation	Effect Size	Interpretation
LC1- Differentiate biotic from abiotic components of an Ecosystem (S7LT-IIh-9)	16.36	4.6	31.03	2.0	14.67	0.88	L	1.48	H	16.55	4.9	26.85	5.8	10.30	0.6	M	0.89	VL
LC2-Describe the different ecological relationship found in the Ecosystem (S7LT-IIh-10)	14.00	5.9	30.88	3.9	16.88	0.8	L	1.74	H	14.33	4.7	29.39	3.7	15.06	0.7	M	1.3	H
LC3- Predict the effect of changes in one population on other populations in the Ecosystem (S7LT-IIi-11)	14.50	5.8	32.53	4.8	18.03	0.65	M	1.82	H	16.12	7.2	28.72	6.6	12.60	0.5	M	1.08	VL
LC4-Predict the effects of changes in abiotic factors on the Ecosystem (S7LT-IIj—12)	14.24	3.7	27.79	4.7	13.46	0.48	M	1.36	H	14.00	4.2	26.00	4.6	12.15	0.5	M	1.05	VL
Overall	59.1	11	122.2	8.4	63.04	0.70	L	1.6	H	61	13.8	110.9	9.4	50.12	0.6	M	1.08	VL

Note: Sd= Standard Deviation; L=Large; M= Medium; VL=Very Large; H= Huge

As presented in the table, the experimental group differed significantly by obtaining an overall mean gain of 63.23, surpassing the control group with a mean gain of 50.12. It can be recalled that the game-based activities were integrated in teaching ecosystem topics in the experimental group, while the control group was taught using the more common ways of teaching Biology including multimedia presentation, lectures, worksheet activities, and question and answers. The standard deviations of both control and experimental groups also implies that there is more consistency in the scores of the experimental group in all of the learning competencies compared to the control group as shown by the lower value of standard deviation for experimental group. This means that the integration of GBAs in the lesson had positive effects on the students' performance. This result is parallel to previous studies where game-based activities in teaching yielded an increase in the students' level of performance due to the engaging, interactive, informative, and fun elements of games and constructive approach in its implementation (Tham & Tham, 2012; Boyraz & Serin, 2017; Karamustafaoğlu & Coşgun, 2021). Moreover, to support the t-test result and measure how much the significant difference was, the study computed the Cohen's d. In the same table, it was revealed that the significant difference between the pretest and posttest results was very large (d=1.08), showing that the effect size of the integration of GBAs in the lessons is notable on the student knowledge gained. The students' impressions also supported this finding and learnings manifested in their daily journal. Below are some sample journal logs from the students on how the GBAs helped them learn the lessons and improve their level of performance:

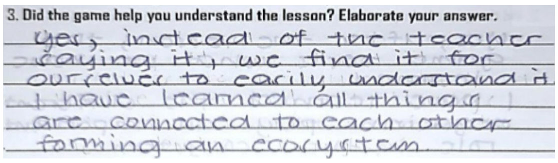
3. Did the game help you understand the lesson? Elaborate your answer.
Yes, instead of the teacher saying it, we find it for ourselves to easily understand it. I have learned all things are connected to each other forming an ecosystem.

Figure 1. Student # 4 Journal Log on the GBA Integration for LC1

In the first figure for journal logs, student # 4 emphasized that through the GBAs, he/she was able to learn and understand the lesson easily rather than just being told by the teacher about it. This reflects the ability of the game to engage students in the process and encourage active participation in a way that elevates learning. The game-based activities integrated in Ecosystem topics were able to help students have a personalized understanding of the topic and express it in their own way.

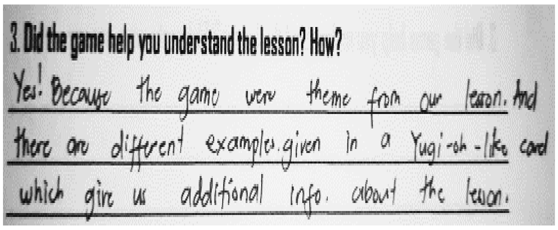
3. Did the game help you understand the lesson? How?
Yes! Because the game were theme from our lesson. And there are different examples given in a Yugi-oh-like card which give us additional info. about the lesson.

Figure 2. Student # 30 Journal log on the GBA Integration for LC2

Another student shared that the GBA for the second lesson helped him/her understand the lesson better because the game itself was patterned after the lesson. This shows that GBAs could effectively represent scientific and abstract concepts making it more understandable for students as they have familiarity with the games being used to represent the concepts similar to the findings of Karamustafaoğlu & Kaya (2013) regarding the effect of GBAs in learning.

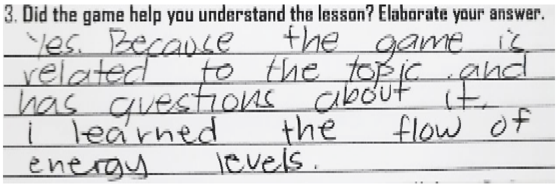
3. Did the game help you understand the lesson? Elaborate your answer.
Yes. Because the game is related to the topic and has questions about it. I learned the flow of energy levels.

Figure 3. Student # 15 Journal log on the GBA Integration for LC3

Looking at the student's journal entry shown in figure 3, it could also be inferred that the embedded questions relating to the topic in GBA for lesson 3 is helpful in promoting learning on energy levels. This shows that one could include different teaching strategies through the use of GBAs, like discussion and use of questions to support learning. As Science subjects have a variety of topics, using GBAs in the lessons could help teachers use different teaching techniques that would be most appropriate to the topic without losing its fun component.

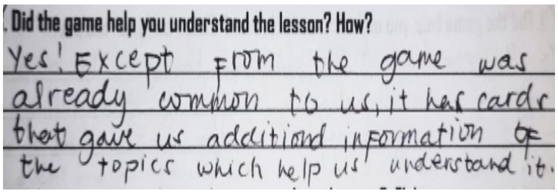
Did the game help you understand the lesson? How?
Yes! Except from the game was already common to us, it has cards that gave us additional information of the topics which help us understand it.

Figure 4. Student # 11 Journal log on the GBA Integration for LC4

Student 11, as shown in the journal entry in figure 4, also suggested that one reason why the GBA integrated in lesson four was effective in helping them learn the topic is because they're already familiar with the game adapted for the purpose of the lesson. As students were already familiar with the game, this could increase their eagerness and confidence to participate in the activity and make the setting more comfortable for them to learn. Victoria (2017) also shared the same thought regarding the effects of GBAs stating the GBA helps students feel less stressed about learning thus, making them more receptive to new information or knowledge. Lessons in Science, like Ecosystem topics, could be stressful, boring, or complicated for students but with the use of GBAs. Students could find a familiar ground where they could start understanding the topic.

CONCLUSION

This study sought to validate the developed GBAs for ecosystem lessons in Grade 7-Biology enrolled in the STE class, SY 2019-2020. The integration of GBAs in lessons has high validity based on the evaluation of experts and students. The experts recognized that the integration of GBAs in lessons may require adjustments on the teachers' role as facilitators of learning process and designing games focusing on learning goals to maximize its potential as a pedagogical tool and as a strategy has great potential and is effective in motivating and helping students learn scientific concepts. The students who evaluated the GBAs also noted that GBAs format and content are valid as it aligns with the learning goals required for the topic and use instructions and materials that are clear and easy to understand. Analysis of the pretest and posttest results and students' journal logs also confirm that integrating GBAs in the lesson could improve students' level of performance and understanding of scientific concepts. The use of GBAs allow students to immerse in Ecosystem topics more fully, relate them to their experiences, and make choices throughout the lessons making their learning experience more meaningful. This adds to the body of knowledge that claims that the use of game-based activities is a fun and innovative approach to improve teaching and learning experience. The use of game-based activities in Science, especially in teaching Ecosystem topics is recommended as one innovative learning and teaching strategy and material based on cognitivism, constructivism, experiential and active learning to improve students' learning experience and performance. The study results are also beneficial for teachers as an alternative to innovative learning and research-based learning material and strategy. They are also helpful to other researchers regarding game-based activities, concept understanding, and instructional materials. Beyond the academic research contribution, this research could increase awareness of students on their role in resolving ecological concerns and maintaining ecological balance. The use of game-based activities also allowed students to be more responsible for their own learning which could be extended to improve their accountability as individuals and members of the society for its improvement. Additionally, positive elements of game-based activities may be considered when developing learning resources or instructional materials. The researcher also recommends replicating this study and using GBAs in different topics and subject matter to further discover and explain its impact on the students and other variables that may come into play; likewise, addressing the content and approach's shortcomings and limitations of this study. Meanwhile, the use of game-based activities as a pedagogical tool also comes with the risk of falling into the pitfalls of games such as increased competition and focus on the reward instead of the learning goals associated with it, along with the time constraint for each lesson as suggested in the curriculum. Game-based activities are likely to affect the students and the teaching-learning process positively; however, finding the balance between focusing on learning goals and entertaining them is important in pursuing this kind of study. Furthermore, this study only focuses on the experts' validation based on the standard guidelines provided by DepEd for instructional materials thus, it is suggested that this validation can also be improved with the use of another source of data like an interview with the experts to clarify and confirm the statistical findings. Other variables and aspects of GBAs or examples of GBAs could also be considered as points of interest for future research to profoundly describe and explain the effects of GBAs to the students and the learning process. This study also has limitations in the implementation as the game-based activities involved in the study require physical interaction which may not be feasible in other set up like on digital or online set up. It also requires individuals to act as facilitators other than the teacher to help with setting up the materials and stations for the activities which could be improved by having experts or observers, other than students, to act as facilitators.

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