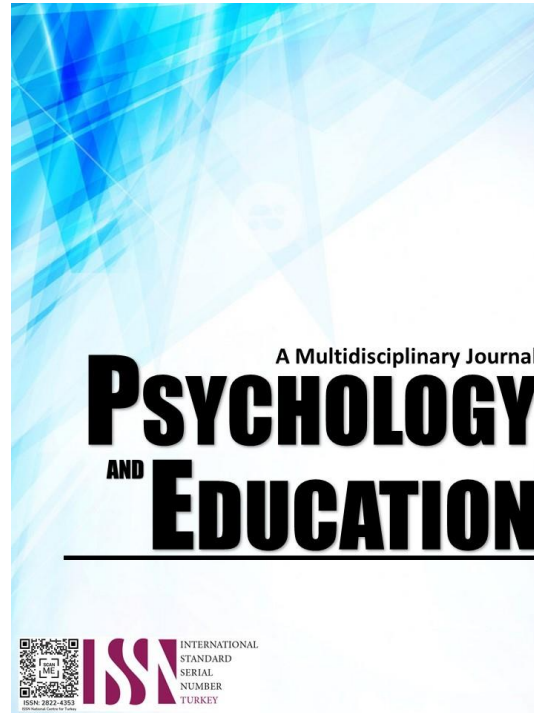


**GAME-BASED ACTIVITIES AS TEACHING  
STRATEGY IN CHEMISTRY FOR  
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## Game-Based Activities as Teaching Strategy in Chemistry for Grade 9 Students

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### Abstract

This study aimed to develop and evaluate the effectiveness of game-based activities as a teaching strategy in Chemistry for grade 9 students at Francisco P. Felix Memorial National High School, Cainta, Rizal during the school year 2022-2023. Sixty (60) students from two sections of grade 9 at F.P. Felix Memorial National High School served as respondents in using the developed game-based activities. The evaluation of the activities was based on a test composed of thirty multiple choice questions about the topic of Chemical Structures of Matter, Chemical formula, simple binary compound nomenclature, and chemical bonding for the second grading period. The statistical tools to treat the data were weighted mean, standard deviation, and t-test. Game-based activities were developed as teaching strategies for the Electronic Structure of Matter and Chemical Bonding. Overall, experts obtained a mean of 3.86 while teachers got 3.90 all are interpreted as Very Satisfactory. Also, there was no significant difference in the evaluation of the two-group respondents on the developed game-based activities. Based on the findings, it is recommended that game-based activities may be incorporated into teaching and learning processes, and further research could be conducted to investigate the effectiveness of this game-based activities in different grade levels in science in the Junior High School. Teachers and educators should receive adequate training and professional development on how to make, design and implement effective game-based activities in the classroom. Other teachers may develop, and design game-based activities as prescribed by the DepEd to improve learning outcomes of clientele.

**Keywords:** *game-based activities, chemistry, effectiveness*

### Introduction

Game-based activities have emerged as a popular teaching strategy across various subjects, including Chemistry. This approach involves the use of computers or traditional games that utilize different methods to teach Chemistry concepts. The goal is to make learning more interactive and engaging for students while improving their understanding and retention of Chemistry concepts.

The application of game-based activities as a teaching strategy for Chemistry is supported by the Philippine Constitution's provision for the state to promote and protect the right of all citizens to quality education at all levels. The Department of Education (DepEd) recognizes the importance of innovative approaches to teaching, including the use of technology and gamification, to enhance student learning outcomes as stated in the Presidential Decree No. 6 which states that, "One of the educational objectives is to design, utilize and improve instructional technology and to develop or produce textbook and other instructional materials leading to quality education." The use of game-based activities in teaching Chemistry has been found to be an effective way to promote student motivation and engagement.

Incorporating game-based activities a pedagogical approach in Chemistry classes holds promising advantages for students. One significant benefit is the

potential to boost their motivation and engagement, resulting in a greater fascination and appreciation of the subject. Another advantage is the opportunity for learners to implement their acquired knowledge and competencies in practical situations, consequently refining their analytical thinking and problem-solving capabilities. Lastly, integrating such activities can effectively tackle the recurring problem of disinterest and insufficient comprehension of Chemistry among students in numerous academic institutions.

According to The Philippine Star (2021), game-based learning has become increasingly popular in science education, including chemistry. The article discusses how games can help students develop critical thinking and problem-solving skills while making learning more enjoyable. Despite the potential benefits of using game-based activities as a teaching strategy for Chemistry, there is a limited amount of research conducted in the Philippines that specifically focuses on its effectiveness in enhancing students' understanding and retention of Chemistry concepts. Furthermore, there is a lack of studies that explore the different types of game-based activities that can be used for teaching Chemistry and their impact on student learning outcomes.

Given the potential benefits of using game-based activities as a teaching strategy for Chemistry and the legal support for innovative approaches to teaching, it is essential to conduct further research to explore its effectiveness in the Philippine context. This research

was conducted to provide game-based activities that are tailored to the needs of Filipino students which can help improve their understanding and retention of Chemistry concepts. It can also contribute to the advancement of teaching strategies in Chemistry and education in general.

### Research Questions

The focus of this study was to develop and evaluate the effectiveness of Game-based Activities as teaching strategy in Chemistry for Grade 9 Students at Francisco P. Felix Memorial National High School during the S.Y. 2022-2023. Specifically, this study sought answers to the following questions:

1. What game-based activities were developed as a teaching strategy for the topics Electronic Structure of Matter and Chemical Bonding?
2. How did the Science teachers and experts' respondents evaluate the researcher-made game-based activities in terms of the following criteria:
  - 2.1 Innovativeness;
  - 2.2 Significance;
  - 2.3 Potential Value to Teaching and Learning; and
  - 2.4 Alignment with the Curriculum?
3. Was there any significant difference in the evaluation of the respondents on the developed game-based activities?
4. How did the respondents perform in the pretest and posttest before and after using the researcher-made game-based activities?
5. Was there any significant difference between the pretest and posttest mean scores of the respondents?

### Literature Review

In 2019, ABS-CBN News reported that the Department of Science and Technology (DOST) developed a mobile game called "Fiesta of Chemistry" to help students learn chemistry concepts in an engaging and interactive way (ABS-CBN News, 2019). The game has different levels that cover topics such as the periodic table, chemical reactions, and laboratory equipment. Likewise, GMA News Online (2020) reported that a chemistry professor from Ateneo de Manila University created a mobile game called "Chemvasion" to help students understand chemistry concepts. The game features different characters that represent chemical elements and compounds, and players must use these characters to solve puzzles related to chemical reactions. In 2020, Manila Bulletin (2020) highlighted how game-based learning can make chemistry lessons more engaging

and effective. The article discussed different games and simulations that can be used to teach chemistry concepts, such as the "Minecraft: Education Edition" and "PhET Interactive Simulations."

A review by Zhao et al. (2020) focused on the use of virtual reality (VR) games in chemistry education. The authors analyzed 16 studies and found that VR games were effective in promoting student engagement, increasing motivation, and improving learning outcomes in chemistry. The authors noted that VR games allowed students to interact with chemistry concepts in a more immersive and realistic way, which led to deeper understanding and retention. Business World (2021) discussed how game-based learning can be used to promote science education in the Philippines, where the subject is not always a popular choice among students. The article highlighted different games and apps that can be used to teach chemistry and other science concepts in a more interactive way.

Lastly, a review by Al-Amri et al. (2021) focused on the use of game-based strategies in teaching chemistry to students with learning disabilities. The authors analyzed six studies and found that game-based strategies were effective in promoting student engagement, improving motivation, and enhancing learning outcomes in chemistry for students with learning disabilities. The authors noted that game-based strategies allowed for differentiated instruction that catered to individual student needs.

On the other hand, from the article of Fong et al., (2019) it examined 47 studies on game-based learning in science education, covering a wide range of topics such as physics, biology, and chemistry. The authors found that game-based learning can be an effective way to engage students, increase motivation, and enhance learning outcomes. They also identified several factors that can influence the effectiveness of game-based learning, such as the design of the game, the level of interactivity, and the alignment with the curriculum. The authors conclude that game-based learning has the potential to revolutionize science education, but more research is needed to fully understand its impact and effectiveness.

Furthermore, Liao et al., (2019) made a systematic review which analyzed 29 studies on game-based learning in science education, focusing on their effectiveness in improving students' cognitive and affective outcomes. The authors found that game-based learning can enhance students' content knowledge, problem-solving skills, and attitudes

towards science. They also identified several factors that can affect the effectiveness of game-based learning, such as the level of interactivity, the design of the game, and the feedback provided to students.

Czerniak et al., (2019) meta-analysis analyzed 24 studies on gamification in chemistry education, focusing on its impact on students' attitudes towards chemistry and their learning outcomes. The authors found that gamification can improve students' attitudes towards chemistry and their content knowledge, but the effect sizes were relatively small. They also identified several factors that can affect the effectiveness of gamification, such as the type of game elements used, the level of interactivity, and the feedback provided to students.

Moreover, Lin et al. (2020) aimed to investigate the effectiveness of digital game-based learning in improving students' academic achievement, attitude, and retention. The study included 113 participants and compared the learning outcomes of students who received digital game-based learning with those who received traditional instruction. The results of the study showed that the students who participated in the game-based learning had higher academic achievement, more positive attitudes towards learning, and better retention of knowledge than those who received traditional instruction.

Finally, Liu et.al (2021) found out that game-based learning can be effective in promoting student engagement, motivation, and learning outcomes in science education. They also found that game-based activities can be aligned with the curriculum by mapping game content to learning objectives and competencies. The authors suggest that game-based learning can be used as a complementary tool to traditional instruction and can be integrated into existing curricula across different subject areas. They note that game-based learning can be particularly effective in promoting 21st-century skills such as critical thinking, problem-solving, and collaboration. The authors also highlight the importance of teacher training and support in effectively integrating game-based learning into the curriculum.

## Methodology

This study utilized descriptive-evaluative research. Evaluative research in the sense that a product or output works as intended and uncovering areas for improvement within solution. It is descriptive because it seeks to describe the development and evaluation of

game-based activities as a teaching strategy in Chemistry for grade 9 students, specifically focusing on the topics of Electronic Structure of Matter and Chemical Bonding. The study aims to describe the effects of game-based activities that were developed to learners, how the Science teachers and experts evaluate them. With the reasons, the researcher considered this research design appropriate for the study because the concern of the paper was to develop a card-game as a teaching strategy tool in teaching Chemistry to Grade 9 and evaluate its effectiveness.

## Participants of the Study

The study collected primary data from 60 students from two sections, 30 males and 30 females of Francisco P. Felix Memorial National High School who participated in the game-based activities through convenience sampling. These students are heterogeneous in terms of intellectual capacity. The secondary source of data was the posttest, which was designed and validated which consisted of thirty multiple choice questions on the topics of Electronic Structure of Matter and Chemical Bonding. In addition to the primary source of data, 10 Science teachers composed of five Teacher I and five Teacher II; and 10 experts composed of one head teacher, five master teachers in science and four teacher III were involved as respondents to evaluate and validate the game-based activities. The selection of these respondents was based on their educational qualifications, subject matter expertise, and familiarity with game-based teaching strategies. Their evaluation provided insights into the potential of the game-based activities as a teaching strategy and helped in identifying areas for future improvements and modifications.

## Instruments of the Study

The evaluation checklist tool for the game-based activities adopted from DOST-SEI criteria for INNOBOX contest in 2019 was used and administered. It was distributed to 10 experts composed of 1 head teacher, 5 master teachers and 4 teacher III and 10 science teachers composed of teachers I and II to determine the acceptability of the Game-based activities with respect to its innovativeness, significance, potential value to teaching and learning, and alignment with the curriculum. The study also utilized pretest and posttest assessments to evaluate the effectiveness of the developed game-based activities. The pretest and posttest assessments were given to the sixty grade 9 students from 2 sections who participated in the game-based activities.

## Procedure

The Least Mastered Competencies (LCM) of Grade 9 students from S.Y. 2018-2019 was identified and revealed on the test result to be one of the lowest rank of skills (53.2%) during the second quarter. This served as a basis in selecting the topics for developing the game-based activities. Thirty item multiple questions were formulated and validated by master teachers and chemistry majors. Sixty selected grade 9 students using convenience sampling from 2 sections of grade 9 at Francisco P. Felix Memorial National High School students answered the pretest, then the developed game-based activities were introduced after it was validated by science teachers and experts. A letter of permission was given to parents before students were given pretests.

Instructions of the game were discussed before it was used as an activity material as strategy for three consecutive days, one game per day. During the first day, Atomopoly was introduced and played by the students during the discussion of the lesson on electronic structure of matter, on the second day was the Chem 'N Play for the topic types of chemical bond using electronegativity difference and on the third day was the Chemino game during the lesson on binary compounds. After using the game-based activities, posttest was administered to the same set of students during the pretest. The data collected was treated statistically and analyzed.

## Ethical Considerations

The researcher herself explained and gave the informed consent to each participant before the conduct of the study. She ensured them that the information would be used with utmost confidentiality and within the purpose of the study only.

## Results and Discussion

### Evaluation of Science Teachers and Expert Respondents on the Game Based Activities in terms of Innovativeness Significance, Potential Value to Teaching and Learning and Alignment with the Curriculum

Table 1. Respondents' Evaluation on the Game-based Activities in terms of the Innovativeness

A. INNOVATIVENESS	Respondents			
	Experts		Teachers	
	W	VI	W	VI
The proposed teaching and learning resource	M		M	
1. make economic use of available materials;	3.70	VS	3.90	VS
2. not duplicate any existing resource material;	3.90	VS	3.90	VS
3. introduce fresh ideas or novel methods in teaching science and math; and	3.90	VS	3.90	VS
4. build, extend, and/or integrate previous knowledge or materials to other situations.	3.90	VS	3.90	VS
Overall Mean	3.85	VS	3.90	VS

The ratings for innovativeness suggest that the proposed teaching and learning resources are perceived as highly innovative by both experts and teachers. The ratings are consistently high across all four dimensions based on Table 1 with an overall mean of 3.70 for experts and 3.90 for teachers. This indicates that the resource is likely to be perceived as novel, original, creative, and economical and that it offers a fresh perspective on teaching science.

Experts rated an average of 3.85 with a very satisfactory rating, the resource slightly lower than teachers in terms of innovativeness. Both groups agree that the resource is not a duplication of existing materials and that it introduces new ideas and methods in teaching science and math. Moreover, the resource is perceived as building, extending, and integrating previous knowledge and materials to other situations, which can facilitate deeper learning and transfer of knowledge.

The high ratings for innovativeness have important implications for the use of the proposed teaching and learning resource. Teachers can leverage the resource to enhance their teaching practices, engage students in new ways, and foster creativity and innovation in their classrooms. Overall, the high ratings for innovativeness suggest that the proposed resource has the potential to make a meaningful contribution to teaching and learning in science.



Table 2. Respondents' Evaluation on the Game-based Activities in terms of the Significance

B. SIGNIFICANCE	Respondents			
	Experts		Teachers	
	WM	VI	WM	VI
The proposed teaching and learning resource				
1. have versatile applications;	3.90	VS	3.90	VS
2. have the potential to stimulate students' and their teachers' curiosity, interest, and engagement;	3.90	VS	3.90	VS
3. provide opportunities for students to develop critical and inventive thinking, problem-solving/problem-finding, and informed decision-making skills;	3.70	VS	3.70	VS
4. enhance the teaching and learning of complex concepts by clarifying, concretizing, or allowing students to further investigate processes and concepts/ideas.	3.90	VS	3.90	VS
Overall Mean	3.85	VS	3.85	VS

The high mean scores for both experts and teachers (3.85) indicate that there is a strong consensus regarding the significance of the proposed teaching and learning resource. The average mean of 3.90 suggests that both groups view the resource as having versatile applications, meaning it can be used across different topics in chemistry as a teaching strategy. The resource is also seen as having the potential to stimulate students' and other teachers' curiosity, interest, and engagement which can help create a positive learning environment with an average mean of 3.90.

Furthermore, both groups, the experts and teachers agreed that the resource provides opportunities for students to develop critical and inventive thinking, problem-solving/problem-finding, and informed decision-making skills with an average mean of 3.70. This suggests that the resource has the potential to enhance students' overall academic growth and promote the development of important skills needed for success in higher education and the workforce.

Finally, the high mean average score of 3.90 for both the experts and teachers reveals that the game-based activity has the ability to enhance the teaching and learning of complex concepts by clarifying, concretizing, or allowing further investigation to indicate that the resource has the potential to improve learning outcomes for students. Overall, the high mean average score of 3.90 on enhancing the teaching and learning of complex concepts by clarifying, concretizing, or allowing students to further

investigate processes and concepts/ideas reveals that the proposed teaching and learning resource has significant implications for education, and has the potential to positively impact both students and teachers.

Table 3. Respondents' Evaluation on the Game-based Activities in terms of the Potential Value to Teaching and Learning

C. POTENTIAL VALUE TO TEACHING AND LEARNING	Respondents			
	Experts		Teachers	
	WM	VI	WM	VI
The proposed teaching and learning resource				
1. is user-friendly;	3.90	VS	3.90	VS
2. is cost-effective;	3.80	VS	3.90	VS
3. can be easily replicated and adopted/adapted	3.70	VS	3.70	VS
4. is sturdy, durable, portable, easily maintained and stored.	3.90	VS	3.90	VS
Overall Mean	3.83	VS	3.85	VS

The computed weighted mean of the respondents' evaluation on the researcher made GBA in terms of their potential value to teaching and learning is 3.83 for experts and 3.85 for teachers which are both categorized as very satisfactory (VS).

The respondents evaluated four aspects of the teaching and learning resource including user-friendliness, cost-effectiveness, ease of replication and adoption, and sturdiness, durability, portability, maintenance, and storage. The overall mean score for both groups is 3.83 for experts and 3.85 for teachers, indicating a positive evaluation of the potential value of the game-based activities in teaching and learning.

The evaluation suggests that the proposed teaching and learning resource has the potential to be user-friendly with an average mean of 3.90 which is very satisfactory. Moreso, its cost-effectiveness mean average of 3.85, easily replicated mean average of 3.70, its sturdiness, durability, portability cost-effective, easily maintained and stored with an average mean of 3.90 indicates that the game-based activities have the potential to be effective in enhancing the teaching and learning of science concepts and engaging students in the learning process.



Table 4. Respondents' Evaluation on the Game-based activities in terms of the Alignment to the Curriculum

D. ALIGNMENT WITH THE CURRICULUM	Respondents			
	Experts		Teachers	
	WM	VI	WM	VI
The proposed teaching and learning resource address the competency/ies of at least one topic each in the K to 12 Science Curriculum in the applicable category.	3.90	VS	4.00	VS
Overall Mean	3.90	VS	4.00	VS

Table 4 shows that the game-based activity is rated very satisfactory with an average mean of 3.95. This means that the proposed GBA is aligned with the competencies of the K-12 curriculum for grade 9 on Electronic Structure of Matter and Chemical Bonding as prescribed by the Department of Education.

Table 5. Summary on Respondents' Evaluation on the Game-based Activities in terms of the Different Variables

Variables	Respondents			
	Experts		Teachers	
	WM	VI	WM	VI
Innovativeness	3.85	VS	3.90	VS
Significance	3.85	VS	3.85	VS
Potential Value to Teaching and Learning	3.83	VS	3.85	VS
Alignment with the Curriculum	3.90	VS	4.00	VS
Overall Mean	3.86	VS	3.90	VS

The evaluation of game-based activities in terms of different variables was conducted among experts and teachers. The variable of innovativeness was assessed, and both groups, experts and teachers, provided positive ratings with an evaluation score of 3.90, reflecting a very satisfactory rating as well. These results suggest that both experts and teachers recognized the innovativeness of the game-based activities in the study.

From the overall results of tables 1,2,3, and 4, the

GBA rated very satisfactory in terms Respondents' Evaluation on the Game-based Activities in terms of the Innovativeness ( 3.85); Respondents' Evaluation on the Game-based Activities in terms of the Significance (3.85); Respondents' Evaluation on the Activities in Terms of the Potential Value to Teaching and Learning((3.78); and Respondents' Evaluation on the Researcher-made Game-based activities in terms of the Alignment to the Curriculum(3.95).

**Significant Difference on the Evaluation of the Respondents on the Developed Game-based Activities**

Table 6. Test on Significant Difference Between the Evaluation of the Respondents on the Developed Game-based Activities Based on the Criteria

Criteria	SD	t-score	df	p-values	HO	VI
Innovativeness	0.391	-0.873	38	0.389	FR	NS
Significance	0.245	0.000	38	1.000	FR	NS
Potential Value to Teaching and Learning	0.190	0.260	38	0.797	FR	NS
Alignment to the Curriculum	0.322	1.427	38	0.162	FR	NS

Based on Table 6, the p-values for all four categories of evaluation (innovativeness, significance, potential value to teaching and learning, and alignment to the curriculum) are greater than 0.05, indicating that there is no significant difference in the evaluation of the two groups of respondents on the developed game-based activities.

The t-scores for each category are also relatively low and, in some cases, negative, indicating that the differences between the mean scores of the two groups are not very large. Additionally, all categories have a VI (Valid Interpretation) of NS (No Significant Difference), suggesting that there is no meaningful difference between the mean scores of the two groups for any of the evaluation categories.

Therefore, we can conclude that there is no significant difference in the evaluation of the developed game-based activities between the two groups of respondents (experts and teachers).

These findings suggest that the game-based activities developed in the study were well-received by both the experts and teachers, and that they were perceived to have a significant, potential value to teaching and learning, and alignment to the curriculum. However, there may be a need to improve the innovativeness of the activities in order to make them stand out and be



more engaging to the target users. Overall, the results of the study highlight the potential of game-based activities as an effective teaching and learning tool and may serve as a basis for further research on the development and use of such activities in various educational contexts.

**Students’ Performance in the Pretest and Posttest Before and After Utilization of the Game-based Activities**

Table 7. Level of Performance of Learners Before and After the Utilization of the Game-based Activities

Pretest Mean	Pretest SD	Pretest Verbal Interpretation	Posttest Mean	Posttest SD	Posttest Verbal Interpretation
8.83	3.18	Low Average	18.20	4.61	Average

The findings of the study revealed that the developed game-based activities were effective in improving the level of performance of learners. The mean score on the pretest was 8.83, indicating a low average level of performance, while the mean score on the posttest was 18.20, indicating an average level of performance.

These findings suggest that educators may consider incorporating game-based activities in their instructional design, especially for learners who struggle with traditional teaching methods. The results of the study showed that the students who played the board game had significantly higher scores on a post-test than in the pretest. Additionally, the students exposed to the game reported higher levels of engagement and motivation. The study suggests that board games can be an effective tool for enhancing student learning in science classrooms.

**Significant Difference Between the Pretest and Posttest Mean Scores of the Students**

Table 8. Significant Difference Between the Pretest and Posttest Mean Score of the Experimental Group of Students

	Pretest	Posttest	Difference
Mean	8.83	18.20	9.37
Standard Deviation	3.18	4.61	1.43
Sample Size	30	30	
t-value			13.34
p-value (two-tailed)			<0.001

Table 8 shows the results of a paired t-test conducted to determine if there is a significant difference between the pretest and posttest mean scores of the experimental group of students. The results revealed that there is a significant difference between the pretest and posttest mean scores, as evidenced by the large t-value (13.34) and the very low p-value (<0.001). This suggests that the game-based activities had a positive impact on the students’ performance, as reflected in their posttest scores.

The findings of the study stated that the use of game-based activities can significantly improve the performance level of learners in the experimental group. The results of the paired t-test indicate a significant difference between the pretest and posttest mean scores of the experimental group of students, with a very large effect size ( $t = 13.34, p < 0.001$ ).

The implication of this study is that game-based activities can be an effective approach to teaching and learning, particularly in improving students’ academic performance. It also highlights the importance of developing and implementing innovative teaching methods to engage and motivate learners.

**Conclusion**

Based on the findings, the following conclusions were drawn : (1) Game-based activities could be an effective teaching strategy in teaching and selected topics for grade 9 chemistry. (2) The study provides evidence that game-based activities could make a difference in improving student’s performance as it could catch students interest in learning. (3) The study provides insight and avenue to future researchers to make and design game-based activities to increase student’s performance.



Based on the findings and conclusions drawn, the following recommendations are offered: (1) Game-based activities may be incorporated into teaching and learning processes, as they have been shown to produce a positive impact on students' performance. (2) Teachers and educators may consider integrating game-based activities into their lesson plans to enhance student engagement and promote active learning. (3) Further research may be conducted to investigate the effectiveness of game-based activities in different lessons in science at different grade levels. This would provide a more comprehensive understanding of the potential benefits of game-based learning across various contexts. (4) Teachers and educators may be sent to adequate training and professional development on how to design and implement effective game-based activities in the classroom. This may ensure that they are able to create engaging and meaningful learning experiences for their students. (5) Game developers and designers may work closely with educators to develop game-based activities aligned with educational objectives and learning outcomes as prescribed by the DepEd. This may ensure that the games are effective tools for learning and are able to support the achievement of desired learning outcomes.

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