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GAMIFIED SIMULATION IN TEACHING AND LEARNING CHEMICAL REACTION FOR GRADE 11 SENIOR HIGH SCHOOL

ROSCELA MAE A. REGIL
roscelamae.arizo@deped.gov.ph
Department of Education - Cebu Province

Abstract

This study explored how online gamified simulation activities can enhance students' learning of chemical reactions in Physical Science. Before the intervention, students showed limited understanding and struggled with key competencies such as identifying limiting reactants, distinguishing between limiting and excess reactants, and calculating product amounts. After engaging with the simulations, their performance improved noticeably, with the strongest gains in conceptual understanding. While computational skills also advanced, the progress was more modest. Student feedback reflected positive experiences, highlighting feelings of autonomy, competence, engagement, and appreciation for the functionality of the activities. Overall, the gamified simulations helped reduce misconceptions and strengthened conceptual grasp, though many learners still fell short of the expected proficiency benchmark. These findings suggest that gamified simulations are a powerful complement to traditional instruction, particularly for building deeper conceptual understanding, but they should be paired with scaffolded practice and guided problem-solving to fully support mastery of more complex quantitative tasks.

Keywords: *Autonomy, Liki National High School, Chemical Reaction, Competencies in Physical Science, Competency, Engagement, Excess Reactant, Functionality, Gamification, Limiting Reactant, Physical Science, Post-test scores, Pre-test scores, Significant Difference, Simulation, Simulated Gamification Activities, Student's Feedback, Student's experiences*

INTRODUCTION

Rationale of the Study

Science education is a critical tool for preparing learners to meet the demands of the 21st century, especially in a world shaped by rapid technological advancement and globalization. The Department of Education (DepEd) of the Philippines emphasizes inclusivity, innovation, and future-readiness, yet the country faces an alarming education crisis. Results from the 2022 PISA reveal that Filipino students continue to struggle in mathematics, science, and reading, with only 23% meeting basic science standards. These figures highlight systemic issues in teaching strategies and student engagement, requiring urgent, evidence-based solutions.

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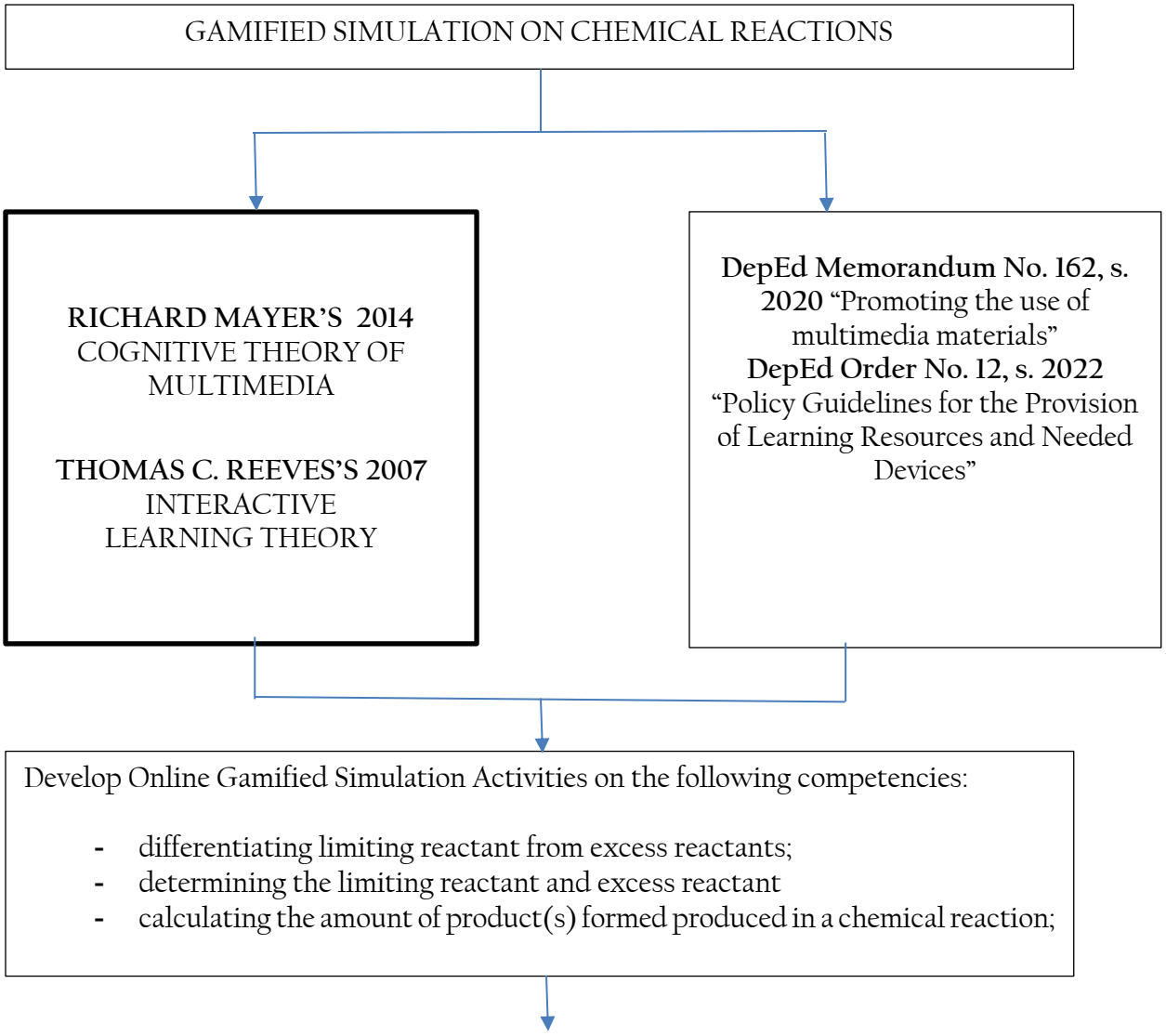
One promising approach is gamification, which transforms learning into interactive, game-like experiences that sustain curiosity, foster collaboration, and build competence. Research supports its effectiveness: Batamuliza et al. (2024) found that students using interactive simulations scored higher and retained knowledge longer than those taught through traditional methods. Tools such as PhET simulations, Kahoot, Canva, and Quizizz provid nam visualizations and virtual experimentation environments, making abstract concepts like chemical reactions and equilibrium more accessible.



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SIMULATED GAMIFICATION ACTIVITIES IN CHEMICAL REACTION

RESEARCH METHODOLOGY

This section discussed the effectiveness of Gamification Simulation in Chemical Reaction in Physical Science Grade 11.

Research Design

This study used a mixed-method, one-group pretest-posttest design with 7 11 students, who completed a 30-item pretest.

Flow of the Study

Figure 2 illustrates the study's flow using the input-process-output format: s ts took pre- and post-tests on chemical reaction competencies, then participated in gam... simulation.

INPUT

Pre-test and Post-test scores of the students to the following first quarter of the second semester competencies Physical Science:

- differentiating limiting reactant from excess reactants;
- determining the limiting reactant and excess reactant;
- calculating the amount of product formed produced in a chemical reaction;

Student's feedback about the use of online gamified simulation activities in terms of:

- autonomy
- competence
- engagement
- functionality

Students' experiences with the use of online gamified simulation activities.

PROCESS

-Transmittal Letter
-Implementation of the Gamified Simulation Activities in Chemical Reaction
-Data Gathering
-Data Analysis and Statistical Treatment
-Interpretation of the Data Gathered

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Simulated Gamified Simulation Activities in Chemical Reaction

Figure 2. Flow of the Study

The Research Environment

The study was conducted at Liki National High School, located in Barangay Liki, Sogod, Cebu (Figure 3). The school comprises two main departments: Junior and senior high school students from different barangays in Sogod, equipped with classrooms, a library, and computer laboratories.

Respondents of the Study

The respondents of the study were two Grade 11 sections at Liki National High School during the school year 2025–2026. Section A had 36 students (20 male and 16 female), while Section B also had 36 students (24 male and 12 female), making a total of 72 participants.

Table 1
Frequency Distribution of Respondents

Respondents	Male		Female		Total
	f	%	f	%	
Grade 11 – Section A	20	56	16	44	36
Grade 11 – Section B	24	67	12	33	36
Total	44		28		72

As shown in Table 1, the respondents were from Grade 11 Section A and Section B. There were 36 respondents respectively from every section to totally compose of 72 students.

Research Instrument

The study used a modified questionnaire from Gan (2022) to measure students' skills in chemical reactions, their academic performance, and gather feedback on online gamified simulations focusing on autonomy, competence, engagement, and functionality.

Data-gathering Procedure

The study was conducted with proper approval from school authorities. Questionnaires were administered by the researcher with teacher support, and only fully completed responses were accepted, all within scheduled class times and finished in about an hour.

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Statistical Treatment of Data

After collecting the questionnaires being accomplished by the respondents, the responses being processed was analyzed and interpreted by the researcher.

Scoring Procedure

Below was the scoring procedure to determine the pretest and post-test scores in the study which is adapted from DepEd Order No. 8 series of 2015.

Raw Score	Equivalent Percentage	Category	Verbal Description
9 – 10	90%-100%	Outstanding	The respondents have an outstanding performance on the identified learning competencies.
7 – 8	85%-89%	Very Satisfactory	The respondents have a very satisfactory performance on the identified learning competencies.
5 – 6	80%-84%	Satisfactory	The respondents have a satisfactory performance on the identified learning competencies.
3 – 4	75%-79%	Fairly Satisfactory	The respondents have a fairly satisfactory performance on the identified learning competencies.
1 – 2	0%-74%	Did Not Meet Expectation	The respondents did not meet the expectations of the identified learning competencies.

To determine the student's feedback level of agreement on Online Gamification Activities, the researcher used the four-point Likert scale identified below.

Scale	Mean	Category	Verbal Description
4	3.26 – 4.00	Strongly Agree	If the impact of gamification affects extremely to the students' motivation and performance.
3	2.51 – 3.25	Agree	If the impact of gamification affects very much to the students' motivation and performance.

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2	1.76 – 2.50	Disagree	If the impact of gamification affects moderately to the students' motivation and performance.
1	1.00 – 1.75	Strongly Disagree	If the impact of gamification affects slightly to the students' motivation and performance.

DATA PRESENTATION, ANALYSIS, AND INTERPRETATION OF DATA

STUDENT'S PRE TEST SCORES ON THE FIRST QUARTER COMPETENCY IN PHYSICAL SCIENCE

The assessment of the students' performance was systematically carried out through the administration of pretests.

Table 2
Pre-Test Scores of the students on the first quarter second semester competency in Physical Science

Competencies	Score Range	f	%	$\bar{x}$	(SD)	%	VD
differentiating limiting reactant from excess reactants	9-10	0	0.00				
	7-8	0	0.00				
	5-6	6	8.33				
	3-4	24	33.33				
	0-2	42	58.33				
				2.13	1.48	21.30	Did not meet expectations
determining the limiting reactant and excess reactant	9-10	0	0.00				
	7-8	2	2.78				
	5-6	8	11.11				
	3-4	25	34.72				
	0-2	37	51.39				
				2.69	1.65	26.90	Did not meet expectations
calculating the amount of product(s) formed produced in a chemical reaction	9-10	0	0.00				
	7-8	0	0.00				
	5-6	9	12.50				
	3-4	25	34.72				
	0-2	38	52.78				
				2.53	1.40	25.30	Did not meet expectations
		Overall		2.45	1.51	24.50	Did not meet expectations

Legend:
90 and above (Outstanding); 85-89 (Very Satisfactory); 80-84 (Satisfactory); 75-79 (Fairly Satisfactory); Below 75 (Did not meet expectation)

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The pre-test revealed that Grade 11 students had very low mastery of stoichiometry, scoring only 21–27% across key competencies

STUDENT'S POST TEST SCORES ON THE FIRST QUARTER COMPETENCY IN PHYSICAL SCIENCE

The post-test scores in Physical Science showed how students applied their learning from gamified simulation activities.

Table 3
Post-Test Scores of the students on the first quarter competency in Physical Science

Competencies	Score Range	*f*	%	$\bar{x}$	SD	%	VD
differentiating limiting reactant from excess reactants	9-10	4	5.56	4.65	2.02	46.50	Did not meet expectations
	7-8	8	11.11				
	5-6	23	31.94				
	3-4	32	44.44				
	0-2	5	6.94				
determining the limiting reactant and excess reactant	9-10	4	5.56	4.46	1.93	44.60	Did not meet expectations
	7-8	4	5.56				
	5-6	23	31.94				
	3-4	31	43.06				
	0-2	10	13.89				
calculating the amount of product(s) formed produced in a chemical reaction	9-10	3	4.17	3.86	1.88	38.60	Did not meet expectations
	7-8	0	0.00				
	5-6	22	30.56				
	3-4	27	37.50				
	0-2	20	27.78				
Overall				4.32	1.94	43.23	Did not meet expectations

Legend: ***significant when p-value* <.05**

Table 3 showed that students improved after using gamified simulations, especially in understanding limiting and excess reactants.

SIGNIFICANT MEAN DIFFERENCE BETWEEN THE PRE-TEST AND POST-TEST SCORES OF THE STUDENTS IN IDENTIFIED LEARNING COMPETENCY

Table 4 showed a significant mean difference between pre-test and post-test scores, providing clear evidence that the gamified simulation activities positively impacted student achievement.

Significant Mean Difference between the Pre-Test and Post-Test scores of the Students in Identified Learning Competency

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Learning Competencies	Pretest Mean (SD)	Post Test Mean (SD)	Mean Difference	Test Statistic	Effect Size	p-value
differentiating limiting reactant from excess reactants	2.13 (1.48)	4.65 (2.02)	2.53	9.58	1.13	‹0.001*
determining the limiting reactant and excess reactant	2.69 (1.65)	4.46 (1.93)	1.76	5.98	0.71	‹0.001*
calculating the amount of product(s) formed produced in a chemical reaction	2.53 (1.40)	3.86 (1.88)	1.33	5.15	0.64	‹0.001*

Table 4 shows that students made statistically significant gains after using gamified simulations, with all three competencies improving at $p < 0.001$. The strongest effect was seen in differentiating limiting and excess reactants (Cohen's d = 1.13, very large), while determining reactants (d = 0.71) and calculating product amounts (d = 0.64) showed medium-to-large effects. These results confirm that the intervention had a genuine impact, not just chance improvement, and helped students grasp difficult chemistry concepts more effectively.

STUDENTS' FEEDBACK LEVEL OF AGREEMENT ABOUT THE USE OF ONLINE GAMIFIED SIMULATION ACTIVITIES

The feedback from Grade 11 students showed strong agreement that online gamified simulation activities were valuable in their learning. For many, these tools turned Physical Science from a difficult and abstract subject into something more engaging and enjoyable. The game-like features sparked excitement, encouraged collaboration, and motivated students to participate more actively. Learners appreciated the immediate feedback, which helped them correct mistakes and deepen their understanding of chemical reactions. Overall, the simulations created a dynamic, student-centered environment where students felt more confident, motivated, and capable of succeeding in Physical Science.

Table 5

Students' feedback level of agreement about the use of online gamified simulation activities

Statements	$\bar{x}$	SD	Category
Autonomy			

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The simulation allows me to...			
1. learn at my own pace.	3.66	0.48	Strongly Agree
2. choose how I wanted to explore the lesson.	3.61	0.52	Strongly Agree
3. make decisions during the activity without constant teacher guidance.	3.72	0.57	Strongly Agree
4. repeat parts of the simulation when I needed more practice.	3.67	0.53	Strongly Agree
5. control the speed and flow of my learning.	3.72	0.49	Strongly Agree
6. explore different outcomes based on my choices.	3.78	0.42	Strongly Agree
7.feel responsible for my own learning progress.	3.82	0.39	Strongly Agree
8. set my own goals while using the simulation.	3.82	0.39	Strongly Agree
9. discover concepts on my own through trial and error.	3.78	0.52	Strongly Agree
10. feel more independent in understanding chemical reactions.	3.78	0.49	Strongly Agree
Overall	**3.74**	**0.48**	**Strongly Agree**

Legend: (3.25-4.00 Strongly Agree; 2.50-3.24 Agree; 1.75-2.49 Disagree; 1.00-1.74- Strongly Disagree)

Statements	$\bar{x}$	SD	Category
Competency			
The simulation helped me...			
1. understands limiting and excess reactants better.	3.67	0.53	Strongly Agree
2. differentiate between limiting and excess reactants clearly.	3.54	0.56	Strongly Agree
3. calculate the amount of product(s) formed more accurately.	3.60	0.52	Strongly Agree
4. improve my problem-solving skills in chemical reactions.	3.75	0.47	Strongly Agree
5. feel more confident in answering science questions.	3.63	0.57	Strongly Agree
6. apply what I learned in real-life situations.	3.76	0.43	Strongly Agree
7. remember key concepts more effectively.	3.75	0.47	Strongly Agree
8. perform better in assessments related to chemical reactions.	3.76	0.43	Strongly Agree
9. develop a deeper understanding of Physical Science.	3.70	0.46	Strongly Agree
10. feel more prepared for future science lessons.	3.84	0.37	Strongly Agree
Overall	**3.70**	**0.48**	**Strongly Agree**

Legend: (3.25-4.00 Strongly Agree; 2.50-3.24 Agree; 1.75-2.49 Disagree; 1.00-1.74- Strongly Disagree)

Statements	$\bar{x}$	SD	Category
Engagement			
While using the simulation, I ...			
1. feel excited to learn about chemical reactions.	3.63	0.52	Strongly Agree
2. am more focus than in traditional lessons.	3.78	0.45	Strongly Agree
3. enjoy the interactive features of the activity.	3.60	0.58	Strongly Agree
4. find the experience fun and motivating.	3.81	0.47	Strongly Agree
5. look forward to using the simulation again.	3.73	0.51	Strongly Agree
6. participate more actively in class discussions.	3.73	0.48	Strongly Agree

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7. feel curious to explore more science topics.	3.84	0.37	Strongly Agree
8. am less distracted during the lesson.	3.78	0.42	Strongly Agree
9. feel emotionally connected to the learning experience.	3.76	0.43	Strongly Agree
10. stay engage throughout the activity.	3.79	0.41	Strongly Agree
Overall	**3.75**	**0.46**	**Strongly Agree**

Legend: (3.25-4.00 Strongly Agree; 2.50-3.24 Agree; 1.75-2.49 Disagree; 1.00-1.74- Strongly Disagree)

Statements	$\bar{x}$	SD	Category
Functionality of online gamification activities			
1. The simulation was easy to navigate.	3.52	0.59	Strongly Agree
2. The design and usability of the simulation instructions were clear and easy to follow.	3.57	0.56	Strongly Agree
3. The design and usability of the simulation graphics and visuals were helpful in understanding the topic.	3.75	0.47	Strongly Agree
4. The simulation works smoothly without technical issues.	3.67	0.56	Strongly Agree
5. The design and usability of the simulation feedback helps me correct my mistakes.	3.82	0.42	Strongly Agree
6. The design and usability of the simulation layout is well-organize and user-friendly.	3.81	0.43	Strongly Agree
7. The simulation loaded quickly and responded well.	3.78	0.45	Strongly Agree
8. I can access the simulation easily on my device.	3.81	0.40	Strongly Agree
9. The buttons and controls were easy to understand and use.	3.82	0.39	Strongly Agree
10. The overall design supports my learning experience.	3.79	0.41	Strongly Agree
Overall	**3.73**	**0.47**	**Strongly Agree**

Legend: (3.25-4.00 Strongly Agree; 2.50-3.24 Agree; 1.75-2.49 Disagree; 1.00-1.74- Strongly Disagree)

The feedback from Grade 11 students showed that online gamified simulations were highly valued and made learning chemistry more engaging and approachable. Across four dimensions autonomy, competence, engagement, and functionality ratings were consistently strong, averaging 93% of the maximum score.

STUDENTS' EXPERIENCES WITH THE USE OF ONLINE GAMIFIED SIMULATION ACTIVITIES

The thematic analysis of Grade 11 Physical Science learners shows that online gamified simulation activities were not simply novel tools, but deeply meaningful learning experiences.

CONCLUSION

The findings of this study demonstrate that online gamified simulations activities significantly improved students' performance in chemical reaction. The positive student feedback further highlights the motivational benefits of gamification as learners reported feeling more autonomous, competent and engaged while using the simulations. Hence, the online gamified simulation activities were effective.

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