

Chemistry Learning and Inquiry through Real-World Exploration (CLAIRE) Approach and Grade 9 Critical Thinking Skills and Knowledge Retention

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Date received: May 2, 2025

Date revised: June 7, 2025

Date accepted: July 2, 2025

Originality: 93%

Grammarly Score: 99%

Similarity: 7%

Recommended citation:

Barotas, C.C. & Daza, S. (2025). Chemistry learning and inquiry through real-world exploration (CLAIRE) approach and grade 9 critical thinking skills and knowledge retention. *Journal of Interdisciplinary Perspectives*, 3(8), 97-104. <https://doi.org/10.69569/jip.2025.351>

Abstract. Despite the growing emphasis on developing students' critical thinking skills and positive attitudes in science education, a lack of contextualized and learner-centered instructional materials remains for junior high school chemistry. This study addressed this gap by examining the acceptability and effectiveness of the Chemistry Learning and Inquiry Through Real-World Exploration (CLAIRE) module in enhancing the critical thinking, knowledge retention, and attitudes of Grade 9 students toward chemistry. Conducted at New Pangasinan National High School, the study employed a quasi-experimental design with 84 participants, comprising 42 in the control group and 42 in the experimental group. Data were collected through adapted survey questionnaires and researcher-made tests. The CLAIRE module was rated highly acceptable in terms of content quality, logical organization, clarity, and design. Pretest results showed comparable critical thinking skills between groups, while the experimental group had slightly higher baseline scores in knowledge retention and attitude. Following the intervention, the experimental group showed a statistically significant improvement in critical thinking ($t = 3.45$, $p < 0.01$). It outperformed the control group in knowledge retention ($M = 87.6$ vs. $M = 79.3$) and attitude scores ($M = 4.32$ vs. $M = 3.85$ on a 5-point scale). These findings highlight the effectiveness of CLAIRE in promoting higher-order thinking and fostering more meaningful learning experiences. Although the initial advantage in retention warrants cautious interpretation, results support the integration of learner-centered materials into the curriculum. It is recommended that the CLAIRE module be adopted in classroom instruction and that teachers receive training in learner-centered and blended teaching approaches.

Keywords: Chemistry education; Critical thinking skills; Inquiry-based learning; Knowledge retention; Real-world applications.

1.0 Introduction

The Chemistry Learning and Inquiry through Real-World Exploration (CLAIRE) approach was designed to enhance student engagement and learning outcomes by connecting abstract chemistry concepts to real-life contexts. Inquiry-based learning (IBL) is globally recognized for fostering critical thinking and knowledge retention, particularly in science education. According to Slaven et al. (2020), real-world exploration promotes better retention by making learning more relevant and engaging. Similarly, Hofstein and Kind (2018) emphasize that inquiry learning enhances higher-order thinking skills. While both studies highlight the benefits of IBL, they

differ in their focus: the former emphasizes contextual relevance, while the latter emphasizes cognitive development. Despite these positive findings, IBL remains underutilized in many educational settings due to practical barriers. In the Philippines, the K-12 curriculum promotes inquiry-driven instruction, yet classroom practice often defaults to traditional, teacher-centered methods (Villanueva et al., 2019). Teachers face barriers such as limited resources, insufficient professional development, and varying levels of student readiness (Estacio, 2021), hindering effective implementation. This issue is further reflected in the 2018 Program for International Student Assessment (PISA), where Filipino students ranked among the lowest globally in reading, mathematics, and science, highlighting widespread challenges in critical thinking and problem-solving (OECD, 2018).

Research by Bernardo and Garcia (2021) and Santiago (2020) suggests that a continued reliance on rote memorization over analytical thinking contributes to these low outcomes. While inquiry-based methods have been studied in urban schools, few empirical studies have examined their effectiveness in rural, resource-constrained environments, such as South-Central Mindanao (Santos & Marquez, 2022). This gap underscores the need for contextually responsive pedagogical interventions. Guided by constructivist and experiential learning theories, this study aims to evaluate the effectiveness of the CLAIRE approach in enhancing critical thinking skills and knowledge retention among Grade 9 students in a rural public school. By examining the impact of an inquiry-based module in a low-resource setting, this research contributes to a more nuanced understanding of how real-world applications can foster higher-order thinking and enhance learning outcomes in chemistry. Ultimately, it offers empirical evidence to support the integration of learner-centered, inquiry-based strategies in Philippine science education.

2.0 Methodology

2.1 Research Design

The study employed a quasi-experimental design featuring non-randomized control and experimental groups to evaluate the effectiveness of the CLAIRE approach in enhancing the critical thinking and knowledge retention of Grade 9 students in chemistry. Two intact classes from New Pangasinan National High School were selected based on comparable academic performance in previous science subjects and scheduling availability. One class was assigned as the experimental group and received instruction through the CLAIRE module, which utilized inquiry-based strategies and real-world applications. The other class, designated as the control group, received instruction using the traditional lecture-based approach. Group assignment was based on existing class sections, a common practice in quasi-experimental research where randomization is not feasible. This approach helped maintain the natural classroom setting and operational flow of the school while minimizing potential selection bias. Baseline equivalence between the two groups was assessed through pretest scores in critical thinking and knowledge retention. The impact of the intervention was measured using pretest and posttest assessments, allowing for a comparison of learning gains between the two instructional methods.

2.2 Research Locale

The study was conducted at New Pangasinan National High School, located in Isulan, Sultan Kudarat, during the 2024-2025 school year. The school utilized a heterogeneous sectioning approach, per DepEd Order No. 21, Series of 2006, which provided guidelines for class organization.

2.3 Research Participants

The respondents of this study consisted of Grade 9 students from New Pangasinan National High School for the academic year 2024-2025. The total number of students in this grade level was 87, all of whom were included in the study through complete enumeration. For this experimental study, one pre-existing section, consisting of 43 students, served as the control group, while the other section, with 44 students, was designated as the experimental group.

2.4 Research Instrument

This study employed multiple evaluation tools to comprehensively assess the effectiveness of the Chemistry Learning and Inquiry through Real-World Exploration (CLAIRE) approach, focusing on content accuracy, organization, mechanics, and overall instructional quality. The module evaluation instrument was adapted from the Southern Philippines Agri-Business and Marine and Aquatic School of Technology (SKSUIMPC). It employed a five-point Likert scale questionnaire based on the framework by Mosquera (2019). To establish content validity, the instrument underwent rigorous expert review and was evaluated using the Item-Level Content Validity Index (I-CVI) and Scale-Level Content Validity Index (S-CVI). Both indices yielded a perfect score of 1.00, confirming

excellent content validity and indicating that the module met the validity criteria.

Critical thinking skills were measured using criteria adapted from the Catalina Foothills School District's Deep Learning Proficiencies (CFSD DLPs), specifically targeting relevant variables associated with critical thinking. Student progress was interpreted according to guidelines outlined in the Department of Education (DepEd) Order No. 009, s. 2024. Reliability analysis using the Kuder-Richardson Formula 20 (KR-20) yielded a coefficient of 0.82, indicating high internal consistency and confirming the instrument's reliability. Knowledge retention was evaluated through a Likert-type survey questionnaire adapted from Brown (2018), with interpretative categories for retention levels derived from Brown (2010). Retention levels ranged from "Very Low" to "Very High" based on computed mean scores. Collectively, these instruments provided a robust and validated framework for evaluating the instructional quality and learning outcomes associated with the CLAIRE approach.

2.5 Data Gathering Procedure

The study followed a systematic seven-step process to ensure the accuracy, validity, and reliability of the findings. First, formal approval was secured from the Dean of the Graduate School at Sultan Kudarat State University and the Department of Education (DepEd) authorities. Second, the CLAIRE materials were developed and produced by the study framework. Third, the CLAIRE module, researcher-made tests, and questionnaires were evaluated and validated by a panel of experts to establish content validity. Fourth, pilot testing of the validated instruments was conducted to assess their effectiveness and clarity further. Fifth, a pretest was administered to the participating students to determine their baseline critical thinking skills and knowledge retention levels. Sixth, the experimentation phase was conducted, during which the CLAIRE approach was implemented with the experimental group, while the control group followed the standard curriculum. Lastly, following the intervention, a posttest was administered, and all data were collected for subsequent analysis.

2.6 Ethical Considerations

This study adhered to strict ethical guidelines to protect the rights and welfare of all participants. Informed consent was obtained from each participant or their legal guardian through written consent forms detailing the study's purpose, procedures, potential risks, and benefits. Participation was entirely voluntary, and participants were informed of their right to withdraw at any time without consequence. Measures were taken to minimize any physical, psychological, social, or other harm, prioritizing the safety and well-being of all involved. Participant dignity, privacy, and confidentiality were rigorously maintained throughout the study. Data confidentiality and anonymity were ensured by assigning identification codes to participants and securely storing all information in password-protected files accessible only to the research team. Results were reported in aggregate to prevent identification of individuals. The study also upheld academic integrity by strictly avoiding misconduct such as plagiarism or data fabrication. The CLAIRE instructional intervention was implemented and evaluated with transparency to guarantee the reliability and validity of the findings.

3.0 Results and Discussion

Table 1 presents the content acceptability of the CLAIRE module, with a grand mean of 4.47, indicating a very high level of acceptability.

Table 1. Level of Acceptability of Chemistry Learning and Inquiry Through Real-World Exploration (CLAIRE) in terms of Content		
Indicators	Mean	Verbal Description
1. Coverage of the lesson	4.75	Very High
2. Appropriateness of the activities/exercises	4.25	Very High
3. Appropriateness of the language used	4.25	Very High
4. Content is appropriate to the target age level	4.50	Very High
5. Content is culture-sensitive	4.50	Very High
6. Content is gender sensitive	4.50	Very High
7. Exercises are in accordance with the Filipino Values	4.50	Very High
8. Illustration and content are in accordance with ethical standards	4.50	Very High
9. Explanations are self-explanatory	4.50	Very High
Grand Mean	4.47	Very High

The highest-rated item was Coverage of the lesson ($M = 4.75$), while the lowest was Appropriateness of the activities/exercises and Language used ($M = 4.25$). This suggests that while the module effectively presents comprehensive content, refinement in task design and linguistic simplicity could further enhance clarity. The

consistently high ratings affirm the module's relevance, aligning with prior research (Olipas, 2023; Portana et al., 2021) that emphasizes the importance of structured and relatable content in enhancing student engagement.

Table 2 shows that the CLAIRE module is also highly acceptable in terms of organization (grand mean = 4.50). Items such as Sequence of topics, technical descriptions, and concepts of every lesson received the highest mean (M = 4.75), suggesting a strong logical structure. Meanwhile, items such as order of presentation, Arrangement of parts, and Layout uniformity were rated slightly lower (M = 4.25). This highlights potential areas for enhancing visual and instructional flow. The results support Mahanan et al. (2021), who emphasize the importance of coherence and sequencing in instructional design.

Table 2. *Level of Acceptability of Chemistry Learning and Inquiry Through Real-World Exploration (CLAIRE) in terms of Organization*

Indicators	Mean	Verbal Description
1. Sequence of Topics (simple to complex)	4.75	Very High
2. Order of presentation of the lesson	4.25	Very High
3. Arrangement of basic parts	4.25	Very High
4. Illustrations Used	4.50	Very High
5. Spacing of every part	4.25	Very High
6. Harmony of font styles	4.50	Very High
7. Uniformity of layout	4.25	Very High
8. Technical Description (Objective per lesson)	4.75	Very High
9. Technical term used	4.75	Very High
10. Concepts of every lesson	4.75	Very High
Grand Mean	4.50	Very High

Table 3 reveals that the module scored highest in mechanics (grand mean = 4.55), with top marks in User-friendliness, Creativity development, and Clarity of instruction (M = 4.75). Conversely, Clarity of images and Consideration of weaknesses (M = 4.25) were rated lowest, indicating a need for improved visual quality and differentiated instruction. These results underscore the module's accessibility and practical usability, aligning with Amos et al. (2022) and Blessing and Ikoku (2011), who highlight clarity and structure as core instructional strengths.

Table 3. *Level of Acceptability of Chemistry Learning and Inquiry Through Real-World Exploration (CLAIRE) in terms of Mechanics*

Indicators	Mean	Verbal Description
1. General Instruction is user-friendly	4.75	Very High
2. Examples are coherent	4.50	Very High
3. Font size is readable	4.50	Very High
4. Step-by-step procedure is in order	4.50	Very High
5. Arrangement of parts	4.50	Very High
6. Clarity of images/pictures/graphs	4.25	Very High
7. Individual differences are considered	4.75	Very High
8. Weaknesses of target users are considered	4.25	Very High
9. Development of one's creativity and critical thinking is emphasized	4.75	Very High
10. Clear instructions per activity	4.75	Very High
Grand Mean	4.55	Very High

Table 4. *Level of Acceptability of Chemistry Learning and Inquiry Through Real-World Exploration (CLAIRE) in terms of the Overall Package*

Indicators	Mean	Verbal Description
1. Styles of letter fonts	4.75	Very High
2. Appropriateness of binding techniques used	4.75	Very High
3. Paper size used	4.75	Very High
4. Paper quality used	4.75	Very High
5. Color combinations	4.75	Very High
6. Durability	4.50	Very High
7. Handiness	4.75	Very High
8. Appropriateness of cover design	4.75	Very High
9. Usability	4.75	Very High
10. Labels and captions	4.50	Very High
Grand Mean	4.70	Very High

Table 4 summarizes the module's overall package, which received the highest grand mean across all domains (M = 4.70). Nearly all indicators scored 4.75, except Durability and Captions (M = 4.50). This suggests an exceptional physical design and usability, with minor opportunities for improvement in materials and labeling. Findings

support Damanik et al. (2020), who assert that tangible features, such as design and material quality, have a significant influence on instructional effectiveness.

Table 5 consolidates these findings. Among the four areas, Overall Package scored the highest ($M = 4.70$), while Content had the lowest ($M = 4.47$). The grand mean of 4.56 confirms Very High Acceptability. These findings collectively demonstrate that CLAIRE is well-rounded; however, future revisions may focus on enhancing the appropriateness of activities and visual quality to improve the content and mechanics further. These results affirm CLAIRE's strong design and usability, although improvements in content activities and visuals may further enhance its effectiveness (Cerbo, 2025).

Table 5. *Summary of the Grand Mean Ratings on the Content, Organization, Mechanics, and Overall Package of the Developed CLAIRE Module*

Indicators	Mean	Verbal Description
Content	4.47	Very High
Organization	4.50	Very High
Mechanics	4.55	Very High
Overall Package	4.70	Very High
Grand Mean	4.56	Very High

Table 6 shows that both groups demonstrated comparable critical thinking skills prior to the intervention (Experimental MPS = 58.33; Control MPS = 54.37), categorized as Average Mastery. This baseline similarity supports internal validity, as suggested by the principle that equivalent starting points minimize bias in experimental studies (Fraenkel & Wallen, 2009; Creswell, 2014). The observed variation across critical thinking subdomains also aligns with Halpern's (2014) findings, which emphasize that critical thinking is domain-specific and sensitive to instructional context.

Table 6. *Onset Level of Students' Critical Thinking Skills of the Control and Experimental Groups*

Variables	Control			Experimental		
	MPS	SD	Description	MPS	SD	Description
Inquiry	67.80	15.22	Moving Towards Mastery	59.09	14.44	Average Mastery
Interpretation	58.14	14.84	Average Mastery	70.45	17.78	Moving Towards Mastery
Analysis	51.42	13.83	Average Mastery	55.05	17.96	Average Mastery
Reasoning	40.31	17.82	Average Mastery	48.74	21.19	Average Mastery
Overall	54.37	1.70	Average Mastery	58.33	2.76	Average Mastery

Table 7, however, shows that the experimental group exhibited High Retention ($M = 3.66$), while the control group showed Moderate Retention ($M = 3.38$). This difference may suggest early benefits of exposure to interactive, inquiry-based strategies even before formal implementation. According to Mayer (2002) and LaDage et al. (2018), prior exposure to meaningful learning tasks and retrieval practices can enhance baseline retention. These findings may also reflect early cognitive engagement triggered by pre-intervention exposure to exploratory learning, aligning with the principles of constructivist learning theory (Bruner, 1996).

Table 7. *Onset Level of Students' Knowledge Retention of the Control and Experimental Group*

Variables	Control			Experimental		
	MPS	SD	Description	MPS	SD	Description
Conceptual Understanding	3.31	0.28	Moderate Retention	3.73	0.17	High Retention
Application of Knowledge	3.36	0.31	Moderate Retention	3.65	0.22	High Retention
Retention Over Time	3.36	0.22	Moderate Retention	3.60	0.24	High Retention
Attitudes Toward Chemistry Learning	3.48	0.32	High Retention	3.65	0.27	High Retention
Overall	3.38	0.22	Moderate Retention	3.66	0.16	High Retention

Table 8 shows a significant increase in critical thinking skills among the experimental group ($MPS = 86.72$) compared to the control group ($MPS = 72.41$). This shift from Moving Towards Mastery to Closely Approaching Mastery suggests that the CLAIRE intervention successfully activated higher-order thinking. These results are consistent with studies by Paul and Elder (2019) and Facione (2015), which highlight the impact of structured instruction in critical thinking. The dramatic difference in scores may also be attributed to the use of inquiry-based and problem-solving activities, which are known to improve metacognitive awareness (Abrami et al., 2015; Silva et al., 2016).

Table 8. *Outset Level of Students' Critical Thinking Skills (in MPS) of the Control and Experimental Groups*

Variables	Control			Experimental		
	MPS	SD	Description	MPS	SD	Description
Inquiry	71.56	14.30	Moving Towards Mastery	89.51	7.44	Closely Approaching
Interpretation	76.74	12.86	Moving Towards Mastery	89.32	5.87	Closely Approaching
Analysis	69.77	13.13	Moving Towards Mastery	89.52	9.90	Closely Approaching
Reasoning	71.58	19.74	Moving Towards Mastery	78.54	1.40	Moving Towards Mastery
Overall	72.41	3.22	Moving Towards Mastery	86.72	3.57	Closely Approaching

Table 9 showed that both groups achieved high retention, yet the experimental group consistently outperformed the control across all subdomains ($M = 4.61$ vs. 4.26). The smaller standard deviations in the experimental group indicate more consistent performance, which is often associated with scaffolded instruction and active engagement (Brame, 2016; LaDage et al., 2018). According to Viswanathan and Krishnamurthy (2023), active learning strategies increase long-term retention by encouraging deeper cognitive processing. The experimental group's superior performance in Attitudes Toward Chemistry ($M = 4.68$) also reflects increased motivation, a key predictor of learning persistence (Schunk et al., 2014).

Table 9. *Outset Level of Students' Knowledge Retention of the Control and Experimental Groups*

Variables	Control			Experimental		
	MPS	SD	Description	MPS	SD	Description
Conceptual Understanding	4.27	0.33	High Retention	4.55	0.19	High Retention
Application of Knowledge	4.27	0.31	High Retention	4.55	0.21	High Retention
Retention Over Time	4.23	0.26	High Retention	4.63	0.18	High Retention
Attitudes Toward Chemistry Learning	4.27	0.33	High Retention	4.68	0.17	High Retention
Overall	4.26	0.28	Very High Retention	4.61	0.13	Very High Retention

Table 10 reveals no significant pre-intervention difference in critical thinking ($p = .123$), but a significant difference in knowledge retention ($p < .001$), favoring the experimental group. This raises a limitation: the observed gains in retention might not be solely attributed to the intervention, possibly reflecting prior familiarity with retrieval-based strategies (Yang & Shanks, 2018).

Table 10. *T-Test Result on Onset Level of Control and Experimental Groups*

Variables	Control Group		Experimental Group		t (df)	p	Cohen's d
	M	SD	M	SD			
A. Critical Thinking	43.50	8.43	46.67	10.46	$t(82) = -1.56$	.123	-0.33
B. Knowledge Retention	3.38	0.22	3.66	0.16	$t(78) = -6.74$	.001*	-1.45

Note: $n = 47$; M = Mean; SD = Standard Deviation; * $p < 0.05$

Table 11 showed reports of significant post-intervention gains in both critical thinking ($d = -1.72$) and retention ($d = -1.60$) in the experimental group. These suggest that the CLAIRE approach effectively enhanced both critical thinking and long-term knowledge retention. This aligns with prior research (e.g., Buchman, 2024; Al Najjar et al., 2021), which supports active, student-centered learning strategies as a means to foster deeper understanding and cognitive engagement.

Table 11. *T-Test Result on the Outset Level of Control and Experimental Groups*

Variables	Control Group ^a		Experimental Group ^b		t (df)	p	Cohen's d
	M	SD	M	SD			
A. Critical Thinking	57.93	6.65	69.38	6.65	$t(85) = -8.03$	<.001*	-1.72
B. Knowledge Retention	4.26	0.28	4.61	0.13	$t(60) = -7.41$	<.001*	-1.60

Note: $N = 87$; ^a $n = 43$; ^b $n = 44$; M = Mean; SD = Standard Deviation; * $p < 0.05$

Table 12 indicates that while critical thinking gains were significant ($p < .001$), retention gains were not ($p = .225$), despite high post-test scores. This apparent inconsistency suggests that while CLAIRE fosters critical analysis, it may be less effective in enhancing long-term memory retention. One possible explanation is that retention requires repeated spaced retrieval, which may not have been emphasized during the intervention. These findings align with prior research (Chen et al., 2024; Wei et al., 2024), which supports the impact of Problem-Based Learning on critical thinking but indicates limited effects on knowledge retention. This suggests that while the intervention fostered higher-order thinking, it may be less effective in promoting factual recall.

Table 12. T-Test Result on the Mean Gain Scores of Control and Experimental Groups

Variables	Control Group ^a		Experimental Group ^b		<i>t</i> (df)	<i>p</i>	Cohen's <i>d</i>
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>			
A. Critical Thinking	14.43	9.87	22.71	12.47	<i>t</i> (82) = -3.44	<.001*	-0.74
B. Knowledge Retention	0.88	0.27	0.95	0.21	<i>t</i> (79) = -1.22	.225	-0.26

Note: *N* = 87; ^a*n* = 43; ^b*n* = 44; *M* = Mean; *SD* = Standard Deviation; **p* < 0.05

The findings affirmatively answer the research questions: the CLAIRE module is highly acceptable in terms of content, organization, mechanics, and design. It effectively enhances critical thinking, with evidence of strong post-intervention improvements. However, despite high retention scores, gains were not statistically significant, suggesting that critical thinking was the area most influenced by the module. This highlights the need to integrate reinforcement and retrieval practices to boost retention. Overall, this study contributes to the growing body of evidence supporting learner-centered instructional tools, such as CLAIRE. Its strengths lie in promoting analytical thinking and providing structured, engaging content. Future iterations might include spaced practice techniques to sustain knowledge retention over time.

4.0 Conclusion

The CLAIRE module is a highly effective and thoughtfully designed instructional tool for enhancing chemistry education. It fosters deeper conceptual understanding, better application of knowledge, and more positive student attitudes toward learning. The experimental group consistently outperformed the control group in key areas; however, their initially higher baseline scores in critical thinking and knowledge retention should be taken into account when interpreting the results. The intervention significantly improved students' critical thinking skills, although it did not show a clear advantage in knowledge retention compared to traditional instruction. Variations in specific critical thinking domains suggest the need for more targeted pedagogical strategies.

This study makes a unique contribution to the growing body of research on inquiry-based learning by demonstrating the successful implementation of a real-world exploration module in chemistry instruction, particularly in rural and resource-limited educational settings. It addresses a critical gap in the literature by showing how structured, student-centered learning can be adapted and effectively employed in such contexts. Future research should explore the long-term impacts of the CLAIRE module on knowledge retention through longitudinal studies, investigate its applicability across a broader range of educational environments, and refine interventions to strengthen specific critical thinking domains. These steps will help further optimize inquiry-based strategies and promote equitable access to quality science education.

5.0 Contributions of Authors

The authors conceptualized the study, designed the methodology, and wrote the manuscript. Also, the authors collected and analyzed the data, reviewed and provided critical revisions, and finalized the manuscript.

6.0 Funding

This endeavor was conducted without backing from any specific grant provider.

7.0 Conflict of Interests

The authors report no competing interests concerning the publication of this work.

8.0 Acknowledgement

The researcher extends heartfelt gratitude to the Almighty God for the divine guidance, wisdom, and strength he gave throughout this study. To her adviser, Ma'am Susie D. Daza, for her invaluable guidance and unwavering support, to her panel members, Dr. Jeannie A. Romano, and Dr. Christine P. Abo, for their expert insights and constructive feedback, to her MAT Science Program chairperson Dr. Anamarie G. Valdez, for her meaningful recommendations, to Dr. Mildred F. Accad, Dean of the SKSU Graduate School, for her encouragement and support, and to Dr. Samson L. Molao, the University President, for fostering a research-driven academic environment. Sincere appreciation is also extended to her family and everyone who, in their way, contributed to the successful completion of this research.

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