Development of Balancing Equation Learning Packet: A Strategic Intervention Material for Grade 10 Learners

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ABSTRACT

This study aimed to assess the mastery of Grade 10 students in various chemistry topics aligned with the DepEd Most Essential Learning Competencies (MELCs) and identified areas where students demonstrated strengths and weaknesses. Utilizing a quantitative-descriptive research design, a 40-item Needs Assessment Questionnaire was developed, validated, and administered to 100 Grade 10 students in a public school in Iligan City. The results revealed a significant challenge in meeting the expected academic standards, with 92% of the participants failing to meet the minimum performance requirements. Topics such as Elements and Compounds were categorized as Nearly Mastered, while Solutions, Substances and Mixtures, The Particle Nature of Matter, Atomic Structure, Periodic Table of Elements, Electronic Structure of Matter, Chemical Bonding, Variety of Compounds, The Mole Concept, Gas Laws, and Biomolecules were identified as Least Mastered; Chemical Reactions was identified as Not Mastered. The findings highlighted the need for targeted interventions and more contextualized instruction, particularly in areas with high error frequencies, such as Chemical Reactions. This study underscored the importance of addressing learning gaps through enhanced instructional strategies, curriculum adaptation, and focused interventions to improve student mastery and ensure a deeper understanding of chemistry concepts among Grade 10 learners.

Keywords: Chemistry Learning Packet, Competencies, Grade 10, Intervention

INTRODUCTION

Students in the Philippine educational system continue to face significant challenges in interpreting the symbolic language of chemical reactions, often leading to errors in balancing equations. This issue is not unique to the Philippines; global research corroborates this, with a majority of high school students worldwide struggling with this fundamental skill (Hamerská, 2024). Rote memorization of procedures alone proves insufficient; a robust understanding of the relationship between subscripts and coefficients is crucial for mastery (Kern et al., 2010). Furthermore, Ndemo (2023) underscores the vital role of accessible and effectively utilized learning resources, such as learning packets, in fostering student academic success.

Research by Villar et al. (2022) demonstrated that the implementation of Supplementary Instructional Materials (SIMs) significantly improved learners' conceptual recall and problem-solving abilities. This research directly contributes to the Sustainable Development Goals (SDGs), particularly SDG 4 (Quality Education) and SDG 17 (Partnerships for the Goals). By developing and implementing effective learning materials like this packet, this research endeavors to substantially enhance the quality of education for Grade 10 learners. Although conceptual understanding is crucial for balancing equations, few instructional resources are specifically designed for the contextualized learning needs of Grade 10 Filipino students. Existing materials often focus on procedures rather than in-depth comprehension. This study addresses this gap by creating and validating a Strategic Intervention Material (SIM) tailored to the local curriculum and student difficulties, thus contributing to both local teaching methods and broader academic knowledge.

OBJECTIVES

1. To assess the level of mastery among Grade 10 learners in selected chemistry topics through a validated needs assessment tool.
2. Develop a learning packet on balancing equations for Grade 10 learners
3. Determine the effect of the developed learning packet for Grade 10 learners in terms of Conceptual understanding gain score.

LITERATURE REVIEW

Developing effective instructional materials hinges on their ability to bridge the gap between abstract concepts and real-world applications. Improvised instructional materials, for example, have been shown to foster a cognitive bond between learners and the content, making learning more relatable and easier to comprehend (Mushimiyimana, 2022). Instructional materials that are tailored to learners' needs and contexts can significantly enhance engagement and motivation, both of which are crucial for achieving successful learning outcomes (Aziz et al., 2023), and instructional materials that incorporate interactive elements or multimedia resources can effectively stimulate student interest and facilitate deeper understanding (Hardway et al., 2017). Strategic Intervention Materials (SIMs) can play a vital role in assisting learners in comprehending complex concepts such as chemical equations. The challenges learners encounter in balancing chemical equations and understanding the underlying chemical reactions have been extensively documented (Kern et al., 2010). These learning materials are designed to accommodate diverse learning styles, ensuring equitable benefits for both surface and deep learners (Espinosa, 2014).

Bruner's constructivist theory plays a pivotal role in the development of educational materials, such as learning packets for balancing chemical equations. This theory emphasizes that learners actively construct knowledge through their interactions with the environment, aligning with the principles of learner-centered education. According to Bruner, effective learning occurs when learners connect new information to their existing knowledge base, fostering deeper understanding and improved retention of concepts (Navaitienė et al., 2021). This principle is particularly relevant to balancing chemical equations, where learners must integrate prior knowledge of chemical symbols and reactions with new strategies to achieve balance. The constructivist approach emphasizes the importance of active student participation and collaboration. Research indicates that when learners engage in discovery learning—a cornerstone of constructivism—they are more likely to internalize complex concepts (Nutakor et al., 2023).

METHODOLOGY

This study employed a quantitative-descriptive research design to assess the level of mastery in selected chemistry topics among Grade 10 students. A researcher-made 50-item Needs Assessment Questionnaire was developed and validated by three experts before it was administered. A purposive sampling technique was implemented in determining the participants to be included in both the try-out and implementation procedures. The research instrument consisted of a 40-item validated Needs Assessment Questionnaire that was aligned with the DepEd Most Essential Learning Competencies (MELCs) in General Chemistry. The data collection procedures involved administering the Needs Assessment Questionnaire to the participants who fit the criteria. Descriptive Analysis was used to analyze the learners' performance and responses on the questionnaire to summarize their mastery.

The participants for this study were selected using a purposive sampling approach, a method that optimized resources by intentionally selecting individuals who were most aligned with the study's objectives. This approach ensured that the participants had nearly completed the Most Essential Learning Competencies (MELCs) in their Grade 10 chemistry curriculum. During the try-out phase of the Needs Assessment, three Grade 10 sections, totaling 150 students, participated. Following a thorough evaluation of the test items based on their difficulty and discrimination indices, some items were retained for the final version of the questionnaire. The final version of the Needs Assessment Questionnaire was then administered to two sections

of Grade 10 students, with a total of 100 participants. This approach ensured that the final data collection focused on students who met the necessary academic criteria.

The researcher-designed Needs Assessment Questionnaire comprised 50 items, all aligned with the DepEd Most Essential Learning Competencies (MELCs) in science. The questionnaire underwent rigorous face and content validation by the thesis adviser and three external experts in both content and methodology. Based on the feedback and suggestions from the experts, a try-out phase was conducted to further evaluate the instrument. Following this, an item analysis was performed, calculating the difficulty and discrimination indices of each question. As a result of this analysis, the original 50-item questionnaire was refined and reduced to a 40-item version, which was then prepared for the implementation phase of the study.

To establish the reliability of the test, the original 50-item questionnaire was administered to 150 participants who were enrolled in the 2024-2025 school year at a public school in Iligan City. The calculated Cronbach alpha of 0.7356 indicated that the scale demonstrated an acceptable level of internal consistency and reliability. Additionally, the Difficulty Index was determined to be 0.4789, suggesting that the test items were of average difficulty. The Discrimination Index, with a value of 0.2120, indicated that the test items had an average ability to differentiate between higher and lower-performing students. These reliability metrics confirmed that the test was suitable for measuring the participants' mastery of the assessed chemistry topics.

In adherence to research ethics, a letter of intent was submitted to the school principal for approval, and a consent form was provided to the learners. Participation in the study was entirely voluntary, ensuring that students could choose to participate without any coercion. To maintain confidentiality, coding was implemented to protect the identities of the participants. The collected questionnaires were carefully reviewed, and the data obtained were tabulated and analyzed using descriptive statistics, including mean scores and percentages. The performance of the respondents was then interpreted according to the criteria outlined in Table 1, with the interpretations following the DepEd K to 12 Grading System as specified in DepEd Order No. 8, s. 2015.

Table 1. Interpretation on Learners Performance on the Needs Assessment

Score Ramge	**Descriptors**	**Range**	**Interpretation**
39-40	Outstanding	100	PASSED
37-38		95	PASSED
35-36	Very Satisfactory	90	PASSED
33-34		85	PASSED
31-32	Satisfactory	80	PASSED
29-30	Fairly Satisfactory	75	PASSED
28 and below	Did Not Meet the Expectations	70 and below	FAILED

Reference: DepEd Order No.8 s. 2015

RESULTS AND DISCUSSION

The Needs Assessment of the student's mastery in chemistry revealed significant challenges in meeting the expected academic standards.

Research Objective 1: To assess the level of mastery among Grade 10 learners in selected chemistry topics through a validated needs assessment tool.

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Table 2. Summary of the Assessment

Index	Frequency (n)	Percentage	Descriptors	Interpretation
39-40	0	0	Outstanding	PASSED
37-38	0	0		
35-36	1	1%	Very Satisfactory	PASSED
33-34	4	4%		
31-32	3	3%	Satisfactory	PASSED
30	0	0	Fairly Satisfactory	PASSED
0-29	92	92%	Did Not Meet Expectations	FAILED
TOTAL	**100**	**100%**		
	Mean 20.12	**Std. Dev. 5.226737786**	**Did Not Meet Expectations**	**FAILED**

Table 2 presented a summary of an assessment involving 100 respondents. The results showed that a vast majority, 92%, scored within the 0–29 index range, which fell under the descriptor "Did Not Meet Expectations" and was interpreted as FAILED. Only a small fraction of the respondents achieved higher performance levels: 4% scored between 33–34 (Satisfactory), 1% scored between 35–36 (Very Satisfactory), and 3% scored between 31–32 (Satisfactory). Notably, no respondents scored within the higher ranges of 37–40, which were classified as "Outstanding" or "Very Outstanding." The computed mean score of 20.12 and a standard deviation of 5.23 further confirmed that the overall performance did not meet expectations, as reflected in the general interpretation of FAILED. This indicated a significant need for instructional improvement or intervention to address learners' understanding and performance.

Table 3. Needs Assessment Analysis

CHEMISTRY TOPICS	No. of Items	No. of Correct (55)	Percentage	Rank
Elements and Compounds	3	235	78%	1
Substances and Mixtures	2	142	59%	2
Solutions	2	71	59%	3
The Particle Nature of Matter	3	175	62%	4
Atomic Structure	3	122	64%	5
Periodic Table of Elements	4	224	64%	6
Electronic Structure of Matter	2	87	70%	7
Chemical Bonding	2	87	69%	8
Variety of Compounds	5	240	62%	9
The Mole Concept	2	147	68%	10
Gas Laws	3	161	62%	11
Biomolecules	4	155	51%	12
Chemical Reactions	5	177	40%	13

Table 3 showed the topics were ordered based on their rank, with "Elements and Compounds" having the highest percentage of correct answers (78%) and thus ranked 1st, indicating it was the best understood topic. Conversely, "Chemical Reactions" had the lowest percentage of correct answers (40%) and was ranked 13th, suggesting it was the least understood topic among those assessed. There was a considerable range in

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understanding across the different chemistry topics, highlighting specific areas where students may have needed more support and instruction. For instance, while basic concepts like "Elements and Compounds" and "Substances and Mixtures" showed relatively high comprehension, more complex topics such as "Biomolecules" and "Chemical Reactions" indicated significant learning gaps. This analysis provided valuable insights for educators to tailor their teaching strategies and focus on areas where students were struggling the most in chemistry.

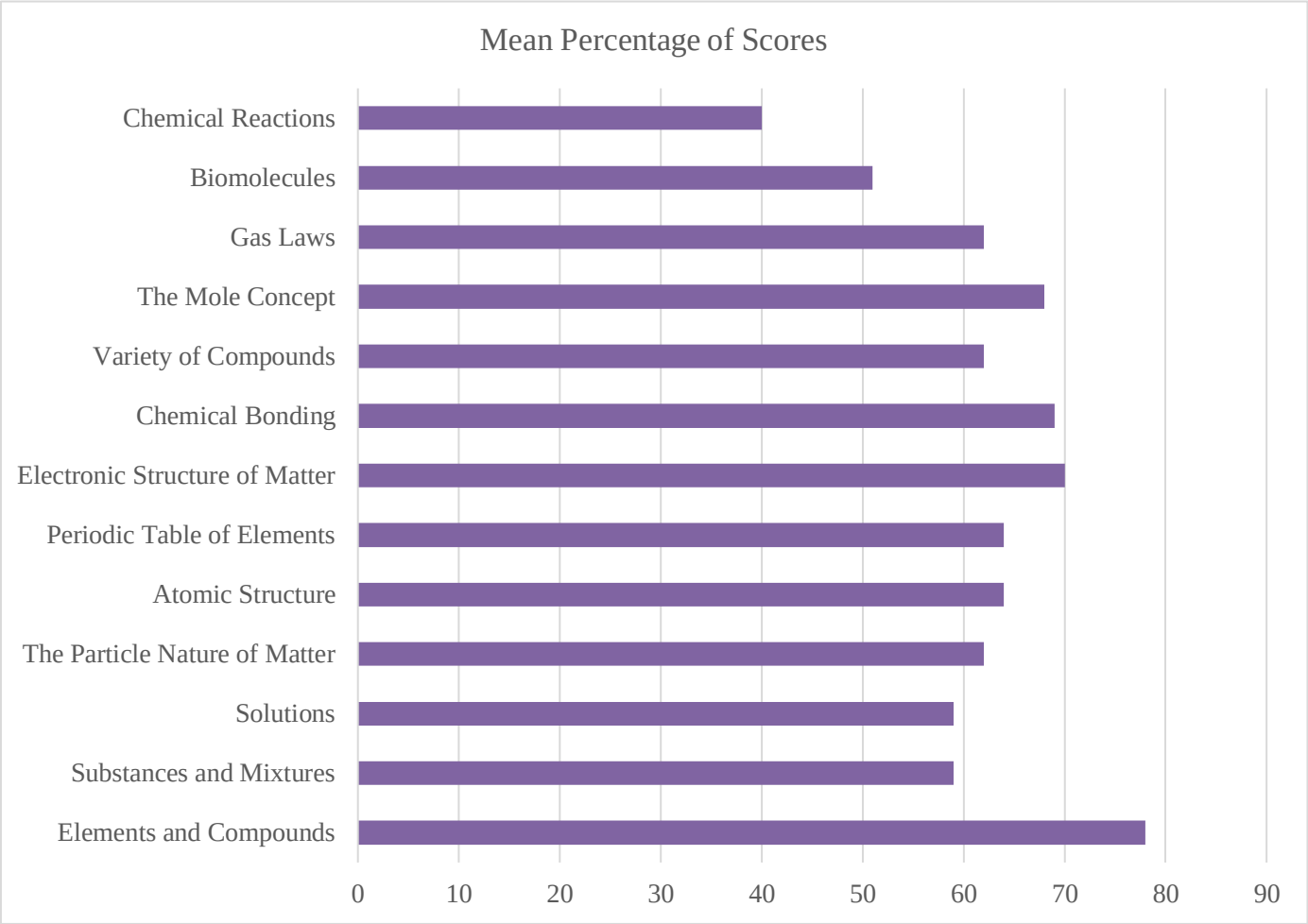

Figure 1. Grade 10 Learners Learning Competencies

Figure 1. Presented the average performance of learners across various chemistry topics. Among the topics, Elements and Compounds had the highest mean percentage score, reaching close to 80%, indicating strong student understanding in this area. In contrast, Chemical Reactions had the lowest score, just around 40%, suggesting that learners found this topic more challenging.

Several topics such as Electronic Structure of Matter, Chemical Bonding, The Mole Concept, and Variety of Compounds showed relatively high mean percentages, ranging from 65% to 70%, reflecting a fair grasp of these concepts. Topics like Gas Laws, Biomolecules, and Solutions were situated in the mid-range, hovering around 55% to 60%. The rest of the topics, including Substances and Mixtures, The Particle Nature of Matter, and Atomic Structure, also fell within this moderate range.

Overall, the data implied varying levels of conceptual understanding among learners, with foundational topics such as Elements and Compounds being well understood, while more complex or abstract topics like Chemical Reactions may have required further instructional support. This variation highlighted areas where targeted intervention could have been beneficial to improve learning outcomes.

Research Objective 2: Develop a learning packet on balancing equations for Grade 10 learners

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Table 4. Validation Result of the Learning Packet

	TEACHER A	TEACHER B	TEACHER C	MEAN	INTERPRETATION
A. CONTENT	4	4	4	4	VERY ACCEPTABLE
B. TECHNICAL QUALITY B1. PRINT B2. ILLUSTRATIONS B3. DESIGN AND LAYOUTS	4	4	4	4	VERY ACCEPTABLE
C. PRESENTATION AND ORGANIZATION	4	4	4	4	VERY ACCEPLTABLE
D. ACCURACY AND UP-TO-DATE INOFRMATION	4	4	4	4	VERY ACCEPTABLE
MEAN	**4**	**4**	**4**	**4**	**VERY ACCEPTABLE**

Legend 4= Very acceptable, 3=Acceptable, 2=Partially Acceptable, 1=Not Acceptable

Table 4 presented the validation results of a learning packet based on the evaluation of three teachers (A, B, and C). The learning packet was assessed across four main categories: Content, Technical Quality (further broken down into Print, Illustrations, and Design and Layouts), Presentation and Organization, and Accuracy and Up-to-date Information. Each teacher rated each category with a score of 4, which, according to the legend, corresponded to “Very Acceptable”. Consequently, the mean score for each individual category, as well as the overall mean, was 4, with an interpretation of “Very Acceptable”. This indicated a strong consensus among the teachers that the learning packet was highly satisfactory in all the evaluated aspects.

Research Objective 3: Determine the effect of the developed learning packet for Grade 10 learners in terms of Conceptual understanding gain score.

Table 5. Conceptual Understanding of Learners in Balancing Equation

		PRE-TEST		POST-TEST		DESCRIPTION
SCORES RANGE	**EQUIVALENT PERCENTAGE OF SCORE**	**FREQUENCY**	**%**	**FREQUENCY**	**%**	
29-30	90-100	0	0	0	0	Outstanding
26-28	85-89	0	0	0	0	Very Satisfactory
23-25	80-84	8	16%	18	36%	Satisfactory
20-22	75-79	6	12%	8	16%	Fairly Satisfactory
Below 20	Below 75	36	72%	24	48%	Did Not Meet Expectations

Legend: Outstanding =90-100, Very Satisfactory=85-89, Satisfactory=75-79, Did not meet the Expectations = Below 75

Table 5 presented a comparative analysis of learners' conceptual understanding of balancing equations before (pre-test) and after (post-test) an intervention.

Prior to the intervention (pre-test), a significant majority of the learners, specifically 36 out of the total (72%), scored below 20, which translated to below 75% and was described as "Did Not Meet Expectations." A smaller proportion of learners demonstrated some level of understanding, with 6 learners (12%) scoring in the 20-22 range ("Fairly Satisfactory") and 8 learners (16%) scoring in the 23-25 range ("Satisfactory"). Notably, no

learners achieved scores in the "Very Satisfactory" (26-28) or "Outstanding" (29-30) ranges before the intervention.

The post-test results revealed a positive shift in the learners' conceptual understanding. The number of learners who Did Not Meet Expectations decreased substantially from 36 (72%) to 24 (48%). Conversely, there was an increase in the number of learners in the higher performance categories. The "Satisfactory" group (23-25) more than doubled from 8 (16%) to 18 (36%). The "Fairly Satisfactory" group (20-22) also saw a slight increase in the percentage, from 12% to 16%, although the frequency remained relatively stable (6 to 8). Importantly, no learners still reached the "Very Satisfactory" or "Outstanding" levels after the intervention, indicating that while there was improvement, the intervention might have needed further refinement to push more learners towards these higher levels of conceptual understanding.

Table 6. Paired Sample Test of Pre-test and Post-test

Group	Mean	t-statistics	P value	Remark
Pre-Test	17.28	-5.92667	<0.001	Significant
Post-Test	21.3			

Table 6 presented the results of a paired-samples t-test that compared pre-test and post-test scores. The analysis assessed whether there was a statistically significant difference in performance before and after a given intervention or treatment. According to the data, the mean score for the pre-test was 17.28, while the post-test mean increased to 21.3, indicating an improvement in performance. The t-statistic value was -5.92667, which signified a substantial difference between the two sets of scores. The negative sign simply reflected the direction of the difference (i.e., post-test scores were higher than pre-test scores).

Importantly, the p-value was reported as less than 0.001, which was well below the common significance threshold of 0.05. This strongly suggested that the observed difference in means was not due to random chance. Consequently, the result was marked as "Significant" in the table. This implied that the intervention or condition introduced between the pre-test and post-test had a meaningful and statistically significant effect on the participants' performance.

CONCLUSION

The chemical reactions and balancing equations emerged as the least mastered during the Needs Assessment Phase, where 92% of learners had not reached the expected level of mastery. To respond to this need, a Strategic Intervention Material (SIM) titled "Balancing Equation Learning Packet" was developed. The development phase involved a rigorous validation process to ensure the quality and effectiveness of the material. Three expert educators evaluated the learning packet. The results of the validation showed that the material was “Very Acceptable” in all criteria, affirming that the learning packet was comprehensive, well-organized, and suitable for its intended purpose.

The results showed a positive increase in learners' scores, with the mean rising from 17.28 in the pre-test to 21.3 in the post-test after utilizing the learning packet. A paired sample t-test indicated a statistically significant improvement ($p<0.001$), demonstrating that the learning packet had helped enhance students’ understanding of the topic, even within a small-scale test. While no student reached the “Outstanding” level, there was a visible shift in performance, with more learners achieving “Satisfactory” and “Fairly Satisfactory” results. This suggested that the SIM, when fully implemented and continuously refined, held great promise as an instructional tool to support students’ learning in Chemistry, particularly in mastering complex processes like balancing chemical equations.

Overall, the Balancing Equation Learning Packet had demonstrated strong potential as a helpful resource, and its wider application contributed significantly to improving science education outcomes.

RECOMMENDATIONS

In light of the findings, the study strongly recommended the broader implementation of the Balancing Equation Learning Packet as a supplemental instructional tool in Grade 10 Science classes, particularly in Chemistry. Since the pilot test showed promising results in improving learners' conceptual understanding of chemical reactions and equation balancing, it was advised that science teachers utilized the learning packet during their classroom instruction to reinforce the topic in a more focused and student-friendly manner. Moreover, continued collaboration with subject matter experts was recommended to further enhance the content and ensure its alignment with the K to 12 curriculum standards. Future studies also considered conducting a full-scale implementation involving a larger group of students to gather more robust data on its effectiveness.

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