Fenhancing Learning Outcome of Junior High School Learners through Small-Scale Chemistry

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ABSTRACT

This study investigated the effectiveness of Small-Scale Chemistry (SSC) in enhancing the learning outcomes of junior high school students, focusing on their conceptual understanding of chemical reactions. Utilizing the ADDIE model (Analysis, Design, Development, Implementation, Evaluation), the research addressed critical gaps identified through a needs assessment involving 150 participants, which revealed significant deficiencies in abstract topics like biomolecules and the mole concept (82% scored below passing, mean = 13.86). The implementation on needs assessment with 96 learners further confirmed SSC's impact, as evidenced by a 22% increase in high achievers and reduced low-scoring students (38% to 22%). A pilot test with 45 learners demonstrated the efficacy of Small-Scale Chemistry interventions, with post-test results showing a statistically significant improvement in conceptual scores *(mean increase: 10.64 to 15.93, $p < 0.001$)*. The study highlights SSC's potential as a cost-effective, engaging, and sustainable teaching strategy, aligning with SDG 4 (Quality Education) by making abstract concepts accessible through hands-on, miniaturized experiments. Recommendations include integrating Small-Scale Chemistry into curricula and providing teacher training to maximize its benefits. These findings advocate for Small-Scale Chemistry as a transformative approach to overcoming systemic challenges in chemistry education.

Keyword: Addie Model, Most Essential Learning Competencies (MELCs), Small-Scale Chemistry

INTRODUCTION

In recent years, there has been an increased emphasis on the value of practical science education, notably in the discipline of chemistry. Hands-on experiments are generally recognized for improving Learners' grasp of chemical principles (Derasin et. al, 2019). The introduction of context-oriented chemistry has increased the importance of practical work in chemistry education (Bradley, 2021). Junior high Learners are introduced to fundamental chemistry ideas, which serve as the foundation for more advanced courses in high school and beyond. However, traditional methods of teaching chemistry frequently fail to engage Learners effectively, resulting in a lack of enthusiasm and comprehension of the subject (Hoffstein & Lunetta, 2024).

The goal of this study is to look into the effects of small-scale chemistry (SSC) on junior high school learners learning outcomes, specifically their ability to interpret the types of chemical reactions. Traditional chemistry laboratory procedures frequently encounter obstacles such as high prices, safety concerns, and environmental issues as a result of the usage of huge amounts of chemicals. This study directly supports the Sustainable Development Goals (SDGs), particularly SDGs 4 (Quality Education) and 17 (Partnership for the Goals). The research intends to greatly improve the educational quality of Grade 10 learners by developing and implementing effective learning resources such as this manual. Small-Scale Chemistry tackles these difficulties by using minimum chemicals and simpler techniques, making laboratory experiences more accessible and sustainable (Syaadah et. al, 2021).

METHODOLOGY

This study used a mixed-method experimental design to analyzed the influence of small-scale chemistry experiments on learning outcomes, with a focus on least mastered competencies identified through needs

assessment. The study used purposive sampling to choose participants who satisfied particular criteria, ensuring that the sample reflected the target demographic of junior high school learners. This study employed the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation) to develop and validate small-scale chemistry (SSC) interventions aimed at enhancing junior high school learners' conceptual understanding.

In the analysis phase - needs assessment approach of 150 participant to identify the least mastered competencies, revealing critical gaps in abstract topics. Needs Assessment began with the researcher-made of a 50-item conceptual understanding questionnaire based on the DepEd Most Essential Learning Competencies (MELCs), which was reviewed by three content experts to verify it met curriculum standards and was scientifically accurate. The validation method evaluated the instrument's clarity, relevance, and suitability for assessing learners understanding of essential chemistry concepts. Cronbach's alpha was used to determine internal consistency in the obtained data, and item difficulty and discrimination indices revealed questions that needed to be revised. The 40-item questionnaire used in the main implementation phase was finalized after considering feedback from both learners and experts.

Score Range	**Frequency (n)**	**Percentage**	**Descriptors**	**Interpretation**
39-40	0	**0**	Outstanding	PASSED
37-38	0	**0**	Outstanding	PASSED
35-36	1	**1%**	Very Satisfactory	PASSED
33-34	0	**0**	Very Satisfactory	PASSED
31-32	2	**2%**	Satisfactory	PASSED
29-30	6	**15%**	Fairly Satisfactory	PASSED
28 and below	88	**82%**	Did Not Meet the Expectations	FAILED
Mean	**13.85714**	**Std. Dev 0.303464**	**Did Not Meet the Expectation**	**FAILED**

In the design phase, Small-Scale Chemistry Manual which consists of several activities and Small-Scale Chemistry Kit were tailored to address the gaps, emphasizing hands-on and low-cost experiments to demystify complex concepts. In the development 45 students from Kiwalan National High School underwent a pre-test to establish baseline conceptual understanding and followed by three days intervention – having class using the Small-Scale Chemistry Manual and Small-Scale Chemistry KIT on the types of chemical reaction. The small-scale chemistry manual emphasized step-by-step visual guides and real-world application while the small-scale chemistry kit included miniaturized laboratory tools and contextualized materials for experiment. Post-test was administered after the intervention with qualitative feedback highlighting increased engagement and clarity in chemical reaction topic.

In line with research ethics an informed consent letter was given to each learner. Participation is voluntary and learners can withdraw anytime they want. The data were collected and evaluated using the mean and percentage to identify the least mastered competencies, and paired t-test for the pre-test and post-test to know the significant difference of the learners. This organized strategy guaranteed the validity and dependability of the requirements assessment, laying a solid foundation for the study's succeeding phases. Interpretation was guided by the DepEd K to 12 Grading System (DepEd Order No. 8, s. 2015) presented in the table 1 below.

Table 1: Summary of the Assessment

Score Range	**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

Table 2: Summary of Needs Assessment

Score Range	**Frequency (n)**	**Percentage**	**Descriptors**	**Interpretation**
39-40	0	**0**	Outstanding	PASSED
37-38	0	**0**	Outstanding	PASSED
35-36	1	**1%**	Very Satisfactory	PASSED
33-34	0	**0**	Very Satisfactory	PASSED
31-32	2	**2%**	Satisfactory	PASSED
29-30	6	**15%**	Fairly Satisfactory	PASSED
28 and below	88	**82%**	Did Not Meet the Expectations	FAILED
Mean	**13.85714**	**Std. Dev 0.303464**	**Did Not Meet the Expectation**	**FAILED**

The table provides a complete examination of the learners pre-test performance, indicating major gaps in conceptual comprehension prior to instruction. The data shows a strong concentration of scores in the lowest performance area, with 82% of learners (88 learners) scoring 28 or lower and falling into the "Did Not Meet Expectations" category. This overwhelming majority of failing scores is highlighted by the exceptionally low mean score of 13.86 (SD=0.30), which is significantly below the passing level and demonstrates pervasive underperformance across the group.

Only 9 learners (18%) received passing grades in all satisfactory areas, with 1 learner (1%) at the "Very Satisfactory" level (35-36 score range) and 2 learners (2%) in the "Satisfactory" range (31-32). The entire lack of scores in both the "Outstanding" categories (37-40) and the upper "Very Satisfactory" range (33-34) demonstrates the severity of the knowledge gaps. The standard deviation of 0.30 indicates highly constant low performance across the cohort, with little fluctuation in results.

This distribution plainly shows that the vast majority of learners entered the study with insufficient subject knowledge, as indicated by the cluster of scores below 30. The extremely low mean score, along with the high frequency of failing grades, establishes a solid baseline that emphasizes the critical need for specialized training. These findings support the importance of using the small-scale chemistry strategy to address these fundamental learning gaps, and they imply that traditional teaching approaches may have been inappropriate for this student

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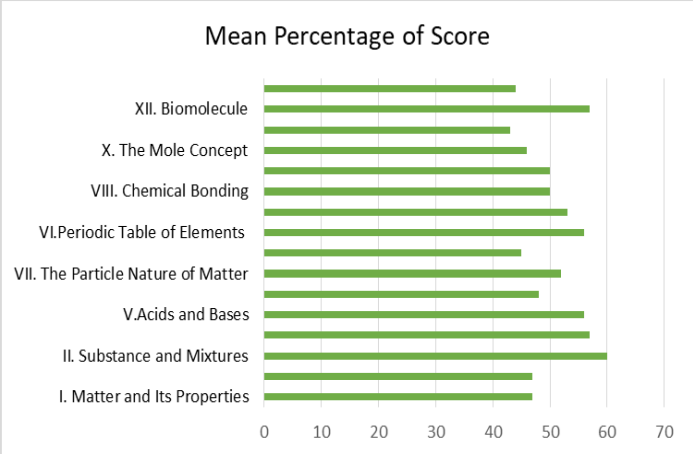
population. The data is an important reference point for determining the effectiveness of the subsequent action in achieving these aims.

Table 3: Ranking of Least Mastered Competencies.

CHEMISTRY TOPICS	No. of Items	No. of Correct Items	Percentage	Rank
Substance and Mixtures	2	86	60%	1
Elements and Compound	3	167	57%	2
Acids and Bases	3	160	56%	3
Periodic Table of Elements	2	149	56%	3
Electronic Structure of Matter	3	136	53%	5
The Particle Nature of Matter	3	134	52%	6
Chemical Bonding	3	105	51%	7
Variety of Compounds	3	159	50%	8
Metals and Nonmetals	2	98	48%	9
Matter and Its Properties	3	160	47%	10
Solutions	3	166	47%	10
The Mole Concept	3	136	46%	12
Atomic Structure	2	106	45%	13
Chemical Reactions	3	144	44%	14
Biomolecule	1	43	43%	15
Gas Laws	2	98	42%	16

Significant differences in learners comprehension of various topics are revealed by this ranking of the least learned chemical competencies; performance percentages range from a high of 60% (Substance and Mixtures) to a worrisome low of 42% (Gas Laws). Foundational subjects like Substance and Mixtures (60%) Elements and Compounds (57%) and Acids and Bases (56%) rank in the top three and are comparatively better comprehended, according to the research. These results, however, nevertheless indicate just partial comprehension and fall short of mastery. The subjects with the lowest rankings—Gas Laws (42%), Biomolecules (43%), and Chemical Reactions (44%), are more concerning since they exhibit serious shortcomings, most likely as a result of their abstract nature or dependence on cumulative knowledge. While the low score in Atomic Structure (45%) and The Mole Concept (46%) identifies particular conceptual barriers, the middle-ranked topics (Particle Nature of Matter at 52% and Electronic Structure of Matter at 53%) demonstrate moderate but inconsistent understanding.

Figure 1: Needs Assessment Analysis



The graph depicts the average percentage results for eight fundamental chemistry topics, indicating considerable differences in student mastery levels. The findings show that "Biomolecule" did the worst, ranking far to the left with the lowest score (precise percentage not stated but in the 0-10% range), demonstrating severe gaps in student grasp of the biological chemistry concept. "The Mole Concept" and "Chemical Bonding" have slightly higher but still concerningly low scores (possibly in the 10-30% range), indicating that these abstract quantitative and theoretical ideas pose significant learning obstacles. Mid-range performance is seen in "Periodic Table of Elements", "Particle Nature of Matter", and "Acids and Bases" (about 30-50% range), indicating partial but inconsistent comprehension. The significantly higher score in "Substance and Mixtures" and "Matter and Its Properties" (closer to 50-60%) indicates that these foundational topics are better understood, albeit still below mastery level.

The descending order from right (strongest) to left (weakest) reveals a clear pattern: concrete, tangible notions (e.g., matter qualities) are more easily understood than abstract or math-intensive concepts. This is consistent with recurrent pedagogical issues in chemistry education, in which visual/conceptual concepts frequently outperform those requiring symbolic reasoning. The uniformly low sub-70% ratings across all areas highlight systemic issues, underlining the importance of focused interventions—particularly for the leftmost topics with near-zero mastery. The absence of any topic approaching 70% reveals broad knowledge gaps, supporting the study's emphasis on new teaching approaches, such as small-scale chemistry experiments, to address these deficits.

Conceptual Understanding of Learners on Chemical Reaction

Table 4: Pre-test and Post-test Conceptual Score of Learners in Chemical Reaction

		Pretest		Posttest		
Score Range	Rating	N	%	N	%	Description
20	90-100	0	0	5	11	Very High conceptual understanding
19-17	85-95	2	5	10	22	High conceptual understanding
16-15	80-75	5	11	20	44	Average
Below 14	Below 75	18	38	10	22	Low conceptual understanding

Table 4 shows the pre-test and post-test conceptual scores of junior high school learners on the topic of chemical reactions, indicating how small-scale chemistry affects their learning outcomes. Initially, the majority of learners (38%) scored less than 14, suggesting poor conceptual understanding, with only 5% and 11% scoring high and very high, respectively. Significant increases were found following the intervention: the number of learners with

very high conceptual knowledge (90-100 score range) grew to 11%, while those with high comprehension (85-95 score range) improved to 22%. Furthermore, 44% of learners had an average level of comprehension (80-75 score range), whereas the proportion of learners with poor understanding reduced to 22%. These findings imply that small-scale chemistry significantly improved learners conceptual understanding of chemical reactions, moving their performance from mostly low to higher levels of comprehension.

Table 5: Paired Sample T-test of Pre-test and Post-Test Conceptual Understanding in Chemical Reaction

PAIRED SAMPLE TEST					
	Mean	Std. Deviation	T-Statistics	P-Value	Remarks
Pre-Test	10.64	3.657	-8.496	<0.001	Significant
Post-Test	15.93	1.947			

Table 5 shows the results of a paired sample t-test comparing junior high school Learner's pre-test and post-test conceptual comprehension scores in chemical reactions following the adoption of small-scale chemistry. The mean pre-test score was *10.64 (SD = 3.657),* showing a rather low initial knowledge; however, the post-test mean climbed dramatically to *15.93* (*SD = 1.947*), indicating greater conceptual mastery. The negative t-statistic *(-8.496)* and p-value *(<0.001)* indicate a significant difference between pre-test and post-test scores. This implies that small-scale chemistry had a significant positive impact on learners' conceptual knowledge of chemical reactions, demonstrating its efficacy as a teaching method. The low standard deviation in post-test results shows that learners performed more consistently following the intervention.

CONCLUSION

The needs assessment results revealed substantial inadequacies in learners conceptual grasp of general chemistry, with 82% of Learners scoring below the passing level *(mean = 13.86, SD = 0.30)* and only 9 learners (18%) performing satisfactorily. The total lack of excellent scores and small score variance revealed systemic knowledge deficits, notably in abstract concepts such as biomolecules (0-10%), the mole idea (10-30%), and chemical bonding (10-30%), which demonstrated the least mastery. While core topics (such as matter characteristics and combinations) performed rather well (50-60%), no area achieved 70% competency, highlighting general learning obstacles. Meanwhile based on the findings on the Small-Scale Chemistry Manual and Small-Scale Chemistry Kit on learners understanding in chemical reaction, this clearly shows that small-scale chemistry improved junior high school learners conceptual grasp of chemical reactions. Table 4 shows a remarkable shift in learner's performance, with a significant decrease in low-scoring Learners (from 38% to 22%) and a significant increase in high (from 5% to 22%) and very high (from 0% to 11%) achievers. The paired sample t-test in Table 5 supported the improvement by showing a statistically significant rise in mean scores *(from 10.64 to 15.93, $p < 0.001$)*, with post-test results indicating improved consistency. These findings highlight the effectiveness of small-scale chemistry as an instructional strategy for improving the depth and consistency of learners conceptual grasp of chemistry. Thus, incorporating small-scale chemistry into teaching methodologies is strongly advised to improve learning results in junior high science education.

RECOMMENDATION

Given the obvious gaps in learners conceptual comprehension of general chemistry, particularly in abstract issues, incorporating small-scale chemistry into junior high school science instruction is strongly advised. This strategy has been helpful in improving conceptual understanding, as evidenced by better learning outcomes and increased consistency in student performance. To enhance its impact, educators can use small-scale chemistry kits and instructions as additional teaching resources, especially for complicated concepts like biomolecules, the mole idea, and chemical bonding. In addition, professional development programs should be created to train teachers on how to properly use these hands-on, cost-effective ways. Schools and curriculum makers could also consider introducing small-scale experiments into normal lesson plans to increase student engagement and

comprehension. By instituting this technique, scientific education can become more accessible, engaging, and effective at closing learning gaps among learners.

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