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Investigating the Impact of Small-Scale Chemistry Experiments on Student Engagement and Concept Retention: Evidence from the Philippines

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Abstract- Small-scale chemistry experiments is a teaching approach often utilized in schools and institutions. It is carried out by means of little glassware for laboratories and drastically cuts back on the quantity of chemicals. It can also assist in overcoming increasing worries over issues with pollution in the environment and growing laboratory expenses. The purpose of this quasi-experimental study is to investigate the impact of small-scale experiments on students' engagement and retention of concepts in teaching chemistry lessons. A pretest and posttest were given to the purposely-selected grade 7 student participants prior and after the conduct of the lesson with the integration of small-scale experiment, respectively. The results were then compared and analyzed using the SPSS tool to get the mean, standard deviation, and the t-test of paired samples. The results revealed that when students in Grade 7 were taught Chemistry using microscale laboratory techniques, their test scores had increased both before and after. On average, learners' understanding and concept retention improved when introduced to hands-on experiences using microscale experiments.

Keywords: *Small-Scale Experiments, practical work, hands-on experience, student engagement, concept retention*

Introduction

Hands-on experimentation conducted by students is a crucial component of science education, despite the existence of differing opinions on its efficacy. A consensus among scientific educators and researchers in science education is that student engagement in practical work enhances science learning outcomes.An illustration of this phenomenon can be observed in Chemistry lectures through the implementation of small-scale experiments. These experiments have the potential to enhance students' active participation in the classroom and facilitate their comprehension and retention of key topics.Several researches have proved the immense contribution of classroom or lab-based experiments on the teaching-learning process. Experiments greatly help in developing the higher-order, critical, and analytical thinking skills of the students. However, a lot of schools faced several challenges in employing this method

due to the availability of materials, its cost, and the availability of science laboratories and facilities (Romeo et. al., 2023).

Moreover, De Borja and Marasigan (2020) noted that there is inadequate and mismatch of laboratory facilities and equipment in many schools in the Philippines. Moreover, handling large amounts of chemicals could also be dangerous when performed in an environment that is not suited for it. As conducting experiments plays a vital role in developing the student's scientific skills, it is imperative to consider these needs of the schools. However, it cannot be denied that the major concern of the schools that hinder them from taking concrete steps is primarily the lack of sufficient budget (Abojon et. al., 2023). Because of this, teachers continue to look for alternative means just to be able to provide suitable learning experiences for their students. Through the use of small-scale chemistry techniques, students can perform experiments by utilizing low-cost, synthetic materials and smaller amounts of chemicals than usual (Thompson, 1990).

Although the use of small-scale chemistry experiment techniques in science is slowly emerging in the field of science education, especially in Thailand, Indonesia, and Malaysia, there are only a small number of researches conducted on this in the Philippines. Urbano, De Jesus &Dimla (2022) have found that the microscale approach in conducting chemistry experiments on college students has significantly improved student chemistry academic performances. The results have shown that the strategy has increased the understanding of students in Chemistry.

With the aforementioned gaps and opportunities, the researchers saw the significance of investigating the impact of small-scale experiments on chemistry classes in high school. The results of this study will considerably contribute to developing innovative techniques that can be used in all chemistry classes, even in the absence of functional science laboratories. Science experiments can still be integrated into the lesson and ensure the safety of students while performing experiments even inside the classrooms.Moreover, as the researchers are teachers, they will look into the extent to which small-scale experiments can be employed and their effectiveness in helping students understand and remember concepts.

Methods and Materials

This research study employed a quasi-experimental method without a control group to investigate the impact of small-scale chemistry experiments on student engagement and concept retention. The study will involve thirty tow (32) Grade 7 students from Sinaloc National High School. They will be divided into pairs and one triad group. Group assignments will be determined through self-selection, allowing students to choose their partners or group mates.

A pretest and posttest will be administered to the students. The test will consist of items collected from various standardized tests, serving as both the pretest and post-test. These tests have been developed by the researchers and validated by subject specialists. The topics covered in the test align with the most essential learning competencies (MELCs) targeted in the lesson. Additionally, a

questionnaire on "Attitude Towards Chemistry Laboratory Work," originally developed and validated by Hofstein et al. (1997) and modified by Vermaak (2015), will be adapted to measure the respondents' attitudes regarding the use of small-scale chemistry techniques. Furthermore, the researchers will design a micro-scale laboratory procedure that is suitable for the students and aligned with the targeted MELCs. Subject experts in the field will validate the microscale laboratory experiment. In addition to tests and questionnaires, randomly selected respondents will be interviewed to further evaluate the impact of using small-scale chemistry techniques on understanding chemistry concepts and the level of student engagement in the activity.

The gathered data will undergo appropriate statistical treatment. Means and standard deviations will be computed to categorize the students' performance test scores and self-rating scores for attitude toward chemistry. The t-test for correlated means (paired samples) will also be employed as a statistical tool to determine whether the difference between the pretest and posttest scores is significant or not. Data collected from the research instruments will be presented in tabular forms and serve as the basis for result analysis. Statistical software will be utilized to process this data. Furthermore, data gathered from the interviews will be consolidated and analyzed by the researchers.

Results

The findings of our study on the effects of small-scale chemistry experiments on student engagement and concept retention offer compelling insights into the efficacy of hands-on learning in science education. This study analyzed the impact of small-scale experiments on students' academic performance and grasp of key concepts by analyzing pre-test and post-test data. The quantitative findings, which include mean scores, standard deviations, and correlation analyses, shed light on the changes found in a cohort of 32 students who were exposed to small-scale chemistry activities. By presenting these data, we hope to add to the current debate over the educational benefits of introducing practical, experienced elements into standard teaching approaches.

The following sections delve into the data's detailed presentation and analysis, displaying light on the significance of our research for both scientific educators and the broader field of science education.

Table 1. Pre- and Post-test Results

	Mean	**Standard Deviation**	**Standard Error Mean**
Pre-test	5.94	2.078	0.367
Post-test	9.75	2.328	0.412

The average pre-test score of the participants was 5.94 out of a possible total

of 10. On the other hand, the average post-test score is 9.75.

Table 2. Statistical Results of Pre- and Posttest

	Mean	Standard Deviation	t	P - Value	Decision	Interpretation
Pre-test and Post-test	-3.813	2.633	-8.192	.000	Reject the Null hypothesis	Significant Difference

With a P–Value of .000, the results indicate that there is an increase in the scores of the students before and after the use of micro-scale laboratory techniques in teaching Chemistry to Grade 7 students.

Discussion

The findings of the study shed light on the intriguing relationship between small-scale chemistry experiments and concept retention. In this discussion, we delve into the implications of the results, considering their significance in the context of science education and the broader discourse on effective teaching methodologies.

One of the most notable findings is the significant increase in post-test scores as compared to pre-test results. This significant improvement highlights the potential usefulness of hands-on learning experiences, which aligns with the theoretical frameworks of constructivist and experiential learning models. This result also agreed with Ezeano (2018) who found positive improvements in the students when small-scale experiments were conducted even if there is insufficient materials available. Moreover, It has been established that science lessons conducted with experiments even with basic equipment can foster positive attitudes and outcomes (Kirilmazkaya and Dal, 2022).

Moreover, the paired samples test confirms the significance of small-scale chemistry experiments.Collectively, these statistical metrics support the conclusion that the observed improvement in post-test scores is highly unlikely to be due to random chance.These findings have implications for educators and the design of scientific curricula that extend beyond statistical measurements. These findings suggest that participants' understanding significantly increased after engaging in small-scale chemistry experiments. This represents a notable change that demonstrates the effectiveness of practical experiences in enhancing students' understanding of concepts. Moreover, it illustrates the diversity in individuals' levels of progress, underscoring the significance of educators acknowledging and accommodating different educational needs.

Likewise, Shana and Abulibdeh (2020) emphasized the significance of school administrations ensuring the provision of sufficient science resources and supplies to facilitate the successful implementation of practical and hands-on activities for students (Canque et. al., 2021; Derasin et. al., 2021). It is also suggested that students should be provided with sufficient time to actively participate in

practical activities and instruction. Nevertheless, for educational institutions with extremely limited financial resources, this would be a significant difficulty. Therefore, employing small-scale experiments will effectively mitigate the issue and yet produce favorable outcomes in terms of the student's performance and retention of the lesson (Urbano et. al., 2022).

Conclusion

The findings provide persuasive evidence for the favorable influence of small-scale chemistry experiments on student learning outcomes. The hands-on nature of these experiments allows students to actively engage with the material, leading to a deeper understanding of key concepts. Additionally, the opportunity for trial and error in a controlled environment helps students develop critical thinking and problem-solving skills that are transferable to other areas of their education. Science educators are encouraged to incorporate small-scale experiments into their teaching practices, recognizing the potential for these experiences to not only enrich the learning environment but also foster a deeper and more lasting understanding of scientific concepts in students. Looking ahead, further research into hands-on learning approaches and their subtle influence on varied student populations is a viable area for educational research and innovation.

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