Advanced Journal of STEM Education, Vol. 2 No. 2 (2024) https://doi.org/10.31098/ajosed.v2i2.2653

Research Paper

Effectiveness of Quantom Kit as a Supplementary Learning Material in Enhancing the Academic Performance

Manilyn M. Galarosa[1*], Ofelia Maningas[1], Karen A. Manaig[1]
Rolando Maningas[1], Alberto D. Yazon[1]

[1]Laguna State Polytechnic University, Philippines

Received : August 6, 2024	Revised : October 14, 2024	Accepted : November 17, 2024	Online : November 29, 2024

Abstract

Science education benefits greatly from the supplementary learning materials that provide hands-on, interactive experiences, enhancing student engagement and understanding scientific concepts. This study evaluated the effectiveness of the Quantom Kit as a supplementary learning material to improve the academic performance of Grade 8 students at Looc Integrated School. Using a quasi-experimental design, 50 students were divided into two groups: an Experimental group that used the QuanTom Kit and a Comparison group that relied solely on the Periodic Table. Results showed that the Experimental group consistently outperformed the Comparison group in pretests, posttests, and six formative tests. Independent Samples T-tests revealed a significant difference in mean scores between the groups ($p < .01$), confirming the Quantom Kit's positive impact on student performance. Paired Sample t-tests also demonstrated significant improvements in mean scores between pretest and post-tests within each group. While both groups showed improvement, the Experimental group achieved significantly higher post-test scores and larger effect sizes, highlighting the Quantom Kit's effectiveness in enhancing academic performance. This study underscores the value of incorporating interactive learning materials into science education to enhance student achievement.

Keywords: *academic performance, atomic structure, Periodic table, Quantom Kit, supplementary learning materials*

INTRODUCTION

Science education is a critical component of the Philippine Education System and is essential for preparing students for future careers and contributing to the country's scientific and technological development. Assessment like Program for International Student Assessment (PISA) provides valuable insights into the effectiveness of science education in the Philippines by measuring students' proficiency in science. This approach evaluates students globally in reading, mathematics, and science, providing insights into strengths and weaknesses. Policymakers will use these results to improve education quality, especially in science. However, PISA recently revealed that Filipino students are still struggling with science and show little progress in performance. These results highlight an ongoing challenge in improving science education in the country and emphasize the need for effective strategies to enhance learning outcomes in this field (OECD, 2019).

These results highlight an ongoing problem in education, as students continue to have difficulty understanding important scientific ideas and putting them into practice. The evidence shows that the methods, materials, and assistance in place for teaching might not effectively meet students' needs, resulting in negative results. This continuous problem underscores the importance of specific strategies to enhance science education by improving student comprehension, involvement, and achievement. If there are no interventions, the gap in science literacy is expected to continue, affecting students' chances in a world that is becoming increasingly focused on science.

Corresponding author's email: manilyn.galarosa@r4a-2.deped.gov.ph

The Department of Education has introduced measures such as DepEd Order No. 054 s. 2023, which includes the Adoption of the National Learning Recovery Plan (NLRP), aimed at identifying and addressing challenges in implementing education reforms. This initiative reflects the department's dedication to fostering a robust educational system that enhances the country's international standing in STEM subjects and prioritizes the development of foundational skills like literacy through the implementation of the MATATAG Curriculum (Department of Education, n.d.).

Additionally, the Looc Integrated School promotes science literacy through initiatives like the SciVocab project, which enhances critical thinking. Teachers are also encouraged to create science learning materials to facilitate effective teaching. Science kits are beneficial for developing cognitive and social skills because effective instructional materials have the potential to significantly transform science teaching and learning (Edelson et al., 2021). Constructivism, as a pivotal learning theory emphasizing learners' active involvement in knowledge construction, supports the use of interactive and engaging tools in learning environments. According to constructivist principles, learning is most effective when students actively engage with content, constructing their understanding through hands-on experiences and problem-solving. Research by Tursyngozhayev et al. (2024) demonstrated that innovative tools can improve students' understanding and enjoyment of chemistry. However, research on the effectiveness of learning kits in chemistry, especially for topics such as atomic structures and the periodic table, remains limited.

The atomic structure, consisting of a nucleus with protons and neutrons surrounded by electrons in orbitals, forms the basis of modern atomic theory. Understanding the atomic structure and periodic table is vital for scientific disciplines and for Grade 8 students' progress in science. Suryelita et al. (2019) found that students struggle to understand atomic structure and periodic trends, highlighting the need for improved educational strategies and innovative teaching tools.

This study aimed to determine the effectiveness of the Quantom Kit in enhancing the academic performance of Grade 8 science students. Specifically, it answered the following questions:

1. What is the level of academic performance of the students in both groups in terms of their pretest, formative, and posttest mean scores?
2. Is there a significant difference between the formative test mean scores of the students in the experimental and comparison groups?
3. Is there a significant difference between the post-test mean scores of the students in the experimental and comparison groups?
4. Is there a significant difference between the pretest and post-test mean scores of the students in each group?

This study investigated the effectiveness of the Quantom Kit as a supplementary learning material for enhancing the academic performance of Grade 8 science students. The Quantom Kit, which consists of illustration boards, colored papers, and paper strips, resembles a Periodic Table with individual boxes representing different elements. Each box provides instructions on building atomic structures for each element, helping students identify the number of orbitals and accurately calculate the number of particles in each part of an atom. This kit enables students to gain a thorough understanding of atomic structures and their relationship to the Periodic Table. Studies by Saithongdee and Sirirat (2024) and Pinthong et al. (2024) demonstrated that educational games and digital tools significantly improve student engagement and understanding of complex chemistry and biochemistry concepts.

This study used a quasi-experimental design to examine the impact of the Quantom Kit on Grade 8 students' science performances. The Experimental Group used the Quantom Kit, and the comparison group relied on the Periodic Table for learning. A matched-pair sampling method ensured that both groups were equivalent based on their science scores. Formative assessments tracked progress in understanding the atomic structure and periodic table concepts, and a posttest evaluated the effectiveness of the instructional materials.

LITERATURE REVIEW

Constructivism as a Learning Theory

Constructivism, a fundamental educational theory that highlights the active role of learners in constructing their own knowledge, is applied across diverse educational settings. Jean Piaget's constructivist theory of learning revolutionized educators' and psychologists' understanding of child development (Waite-Stupiansky, 2022). Piaget's meticulous observation of children in natural settings and clinical interviews provided valuable insights into cognitive, social, and moral aspects of development from infancy to adolescence. Piaget's theory extends beyond cognitive development, encompassing various facets of growth. Its application in early childhood education has significant implications, influencing classroom dynamics, advocating active learning, and optimizing teaching methodologies to enrich children's educational experiences.

Alharthi and Alsufyani (2020) highlighted that fostering student engagement through collaborative discussions and guided problem-solving sessions, aligning with constructivist principles, can enhance cognitive skills and problem-solving capabilities. Studies collectively highlight the effectiveness of integrating gamification and strategic interventions in mathematics education, aligning with Constructivism Theory, which emphasizes active learning and personal engagement in constructing knowledge. The use of the gamified application significantly enhanced Grade 11 learners' performance in statistics and probability, demonstrating how interactive tools can facilitate deeper understanding (Malabayabas et al., 2024). Similarly, the Strategic Intervention Material (SIM) markedly improved 9th graders' mathematics skills, particularly in geometry, by fostering active engagement and addressing mathematics anxiety (Ebajan & Tamban, 2024). The Katto-Katto game, popular in Sinjai Regency, effectively incorporated mathematical concepts such as spatial reasoning and measurement into classroom learning, further illustrating how real-world applications can enrich students' understanding (Irmayanti & Hikrawati, 2023). Gamification in lessons increased student enthusiasm and engagement, although perceptions varied by performance, highlighting the importance of considering individual preferences in the learning process (Solekhah et al., 2023).

The study of Suhendi and Purwarno (2018b) supported John Dewey's constructivist theory, focusing on its application in Indonesian education. Dewey's theory emphasized the construction of individual and social knowledge through meaningful learning processes. Using a case study approach, this study clarified constructivism's principles and its role in language teaching. The results demonstrated that constructivism positively impacted education by improving students' abilities, encouraging curiosity, and enabling the creation of knowledge tailored to their needs.

Moreover, a study by Bennie et al. (2019b) found that integrating interactive molecular dynamics simulations in virtual reality (iMD-VR) into a computational chemistry class was more engaging for students and enhanced their perceived educational outcomes and interest in computational sciences. This aligns with constructivist principles, as it emphasizes active learning through immersive, hands-on experiences that allow students to construct their own understanding. By interacting directly with complex molecular concepts in a virtual environment, students can build knowledge in a meaningful context, which is a key aspect of constructivist learning theory, where learning is seen as an active process of creating rather than passively receiving knowledge. The study of Cano et al. (2022) supported this theory, finding that the use of simulation-based instructional materials significantly improved Grade 12 learners' understanding and mastery of the concepts of the Central Dogma of Molecular Biology, enhancing their engagement through experiential learning. This aligns with constructivism theory, which posits that learners construct their own understanding and knowledge through active engagement and hands-on experiences.

Previous studies have explored constructivist principles in education but often overlook the impact of specialized tools like learning kits in science education, particularly Chemistry. There is a notable research gap in examining tools like the Quantom Kit, especially for complex topics such as atomic structure and particle quantification. This study aims to address this gap by investigating the effectiveness of the Quantom Kit in enhancing Grade 8 students' understanding of these intricate concepts. By focusing on its role in improving academic performance and integrating constructivist principles, this research demonstrates how hands-on learning experiences can enhance educational practices. The findings provide valuable insights into the efficacy of innovative science education instructional tools.

Hypotheses of the Study

The hypotheses were evaluated at a significance level of 0.01:

1. There is no significant difference between the formative test mean scores of the comparison and experimental groups.
2. There is no significant difference between the post-test mean scores of the comparison and experimental groups.
3. There is no significant difference between the pretest and posttest mean scores of the students in the comparison and experimental groups.

Conceptual Framework

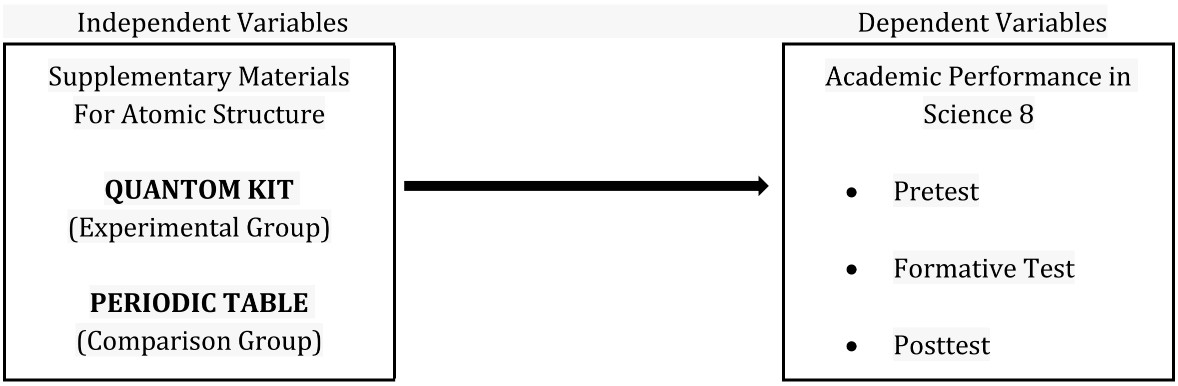


Figure 1. Research Paradigm

RESEARCH METHOD

Research Design

This study employed a quasi-experimental research design, specifically a pretest-posttest nonequivalent group design, which incorporates essential elements of experimental research but lacks the random assignment of participants characteristic of true experimental designs. The inclusion of both an experimental and a comparison group aligned with quasi-experimental criteria, although the limitation of the study was the absence of random assignment. Instead, the participants were matched into pairs based on predetermined criteria, reflecting the nonequivalent group design approach. The pretest-posttest design involved evaluating participants' responses before and after the intervention, following a structured methodology (Stratton, 2019).

Initially, a pretest is administered to establish the baseline levels of students' understanding of the topics. Subsequently, participants are matched into pairs based on predetermined criteria. Following the intervention phase, which involved the implementation of the Quantom Kit for the experimental group, both the experimental and comparison groups underwent a post-test assessment.

After the pretest, the students were matched to ensure equivalence. This step involved carefully pairing participants based on predetermined criteria to minimize potential confounding variables and ensure comparability between the experimental and comparison groups. This approach enhanced the validity of reducing the likelihood of systematic differences between the groups that could influence the outcomes (Stratton, 2019).

Participants of the Study

The study involved Grade 8 students from the Looc Integrated School, comprising 50 participants divided into the Experimental and Comparison Groups. Out of the initial pool of students, only 50 participants were selected through the matched pairing process to eliminate potential biases. This approach controlled for differences in pretest Science scores, ensuring that both groups were comparable before the intervention. Table 1 presents the total number of participants.

Table 1. Participants of the Study

Section	Total number of Students	Total number of students participants	Blind Participants
Onyx	37	25	12
Aquamarine	48	25	23
Total	85	50	35

Sampling Technique

Matched pair sampling, also known as paired or dependent samples (Matched Samples: Definition, Examples, 2019), was used in this study to ensure comparability between the Experimental and Comparison Groups. After the initial pretest, students with similar pretest scores were paired and randomly assigned to either group, ensuring balanced initial academic abilities. This method is particularly useful in studies with limited sample sizes because it reduces variability between groups and enhances statistical power. Although blind participants were included in both groups, their scores were excluded from data collection to maintain study integrity.

Research Instruments

The research employed instruments to evaluate Grade 8 students' comprehension of the quantification of atomic particles and atomic structure formation.

Quantom Kit. The Quantom Kit, consisting of illustration boards, colored papers, and paper strips, was designed to mimic the Periodic Table, with interactive guides for constructing atomic structures. The model was validated by three experts, including two Master Teachers and a Head Teacher. The validation covered four areas: Format and Design, ensuring visual appeal and logical organization; Language Style, focusing on clarity and appropriateness; Content, verifying accuracy and curriculum alignment; and Usability, assessing practicality and student engagement. The experts rated the Quantom Kit as "Very Satisfactory", with a score of 4 across all dimensions.

Pretest and Posttest. The research instrument for this study consisted of a pretest and a posttest, each consisting of thirty (30) questions based on the Table of Specifications (TOS). These tests were specifically described to evaluate students' comprehension of the quantification of atomic particles and formation of atomic structures. They assessed the students' level of understanding before and after the intervention using the Quantom Kit. The study covered the following topics: a) Parts of the Atom and Subatomic particles, b) Computation of the number of subatomic particles in the energy levels, c) Parts of the Periodic Table, d) Application of parts of the Periodic Table to illustrate atomic structures, e) Energy levels, and f) Electron Configuration.

Before implementation, these instruments were thoroughly validated by experts, including two Master Teachers and a Head Teacher, to ensure their appropriateness and effectiveness. The validation process involved assessing various criteria, including clarity, overlapping responses, appropriateness of the listed responses, wordiness, balance, the use of jargon, negative wording, and the relationship to the problem. Each criterion was evaluated on a scale of 1 to 4, with 1 indicating "not acceptable" (major modifications needed) and 4 indicating "exceeds expectations" (no modifications needed). The results of the validation indicated that the pretest and posttest instruments consistently met or exceeded expectations across all the criteria, with an average score of 4. This outcome confirmed the clarity, relevance, and effectiveness of the tests in assessing students' understanding of the specified topics.

Formative Test. Following each lesson, both the Experimental and Comparison Groups underwent a formative test consisting of five (5) questions. This assessment served as a pivotal tool to gauge the understanding and retention of concepts taught, facilitating a comparative analysis of the groups' learning progress.

Research Procedure

Part 1. Development of the Quantom Kit

Creating the Quantom Kit involved careful planning to learn about atom interactions. It was made of boards, colorful papers, and strips. The kit looked like the Periodic Table and had boxes for different elements. These boxes helped students understand atoms. They provided clear instructions and pictures for building atom models. Students can follow the steps to make accurate models and learn about the parts of atoms, such as orbitals and particles.

Part 2. Implementation of the Quantom Kit

The implementation phase involved several crucial steps to evaluate the effectiveness of the Quantom Kit in terms of enhancing students' understanding of atomic structures. Data were collected from February to April 2024.

A. Validation of the Quantom Kit and Pretest and Posttest. The instruments were validated to ensure their effectiveness in enhancing students' understanding of atomic structure concepts. The validation process involved review and assessment by two Master Teachers and one Head Teacher, who provided expert feedback on the kit's content and instructional design. Additionally, both the pretest and posttest assessments underwent validation processes to confirm their reliability in measuring students' comprehension levels before and after the intervention. These assessments were also pilot-tested to identify and address any potential issues with regard to clarity, appropriateness, and administration procedures. The validation outcomes revealed that all instruments, including the Quantom Kit and the pretest and posttest assessments, exceeded expectations regarding their effectiveness and reliability. The rigorous validation processes confirmed their suitability for assessing and enhancing students' understanding of atomic structure concepts.

B. Participants' Consent. Prior to the pretest, consent was obtained to uphold ethical standards. Consent forms detailed the study's purpose, procedures, and risks and emphasized voluntary participation. Only students who signed the consent forms were included, ensuring full awareness and agreement from participants and their guardians.

C. Pretest and Matched Pairing. The second step was administering a 30-item pretest to all participants (Grade 8 students) to gauge their baseline knowledge of quantifying atomic particles and comprehending atomic structure concepts. Initially, a total of 85 students participated in the pretest assessment. Subsequently, students were paired based on their pretest scores using the matched-pair sampling technique. This pairing ensured that individuals with similar levels of initial understanding were grouped. Following the match pairing process, only 50 students were selected from the initial pool of 85 participants, ensuring balanced groups for fair comparison between the experimental and comparison groups.

D. Experimentation Phase. During the experimentation phase, the Quantom Kit served as the supplementary learning material for the experimental group, while the Comparison Group followed the traditional teaching method using the Periodic Table only. Throughout the study, the teacher-researcher used the Daily Lesson Plan (DLP), which employed the 5E's instructional model, as a guiding framework.

E. Formative Test. During the intervention, six (6) formative tests were administered after each lesson to both the experimental and comparison groups. These tests assessed students' understanding of the material covered with the Quantom Kit in the experimental group and traditional methods in the comparison group, serving as checkpoints to monitor progress.

F. Posttest. Following the intervention involving the Quantom Kit, a 30-item posttest, mirroring the pretest questions, was conducted in both groups. The test measured the effectiveness of learning materials on students' academic performances.

Statistical Treatment of the Data

The statistical treatment of data in this study comprised a comprehensive approach using various statistical analyses. To answer the first statement of the problem, descriptive statistics, including mean and standard deviation, were employed to separately analyze the pretest, formative test, and posttest scores for both the experimental and comparison groups. Additionally, to answer the second and third research questions, if there is a statistically significant difference in mean scores between the experimental and comparison groups, Independent Samples t-tests were conducted in the formative tests and posttests. Moreover, a Paired Samples t-test was used to answer the last research question, which was to evaluate the significant difference between the pretest and post-test mean scores of the students in each group. These analyses provided insights into the intervention's effectiveness by comparing scores and identifying significant improvements or differences within and between groups. Cohen's d was used to calculate the effect size of the intervention, evaluating its practical significance. A significance level of 0.01 was used to guide the analyses, providing valuable insights into the effectiveness of the Quantom Kit in improving the academic performance of Grade 8 science students. SPSS software was used for all statistical analyses. The proposed software provides a reliable platform for data management and analysis, ensuring accurate and efficient computation of statistical measures. The use of SPSS facilitated a systematic and detailed examination of the data, providing valuable insights into the effectiveness of the Quantom Kit in improving the academic performance of Grade 8 science students.

FINDINGS AND DISCUSSION

To begin, this section compares the pretests of the Experimental and Comparison groups to demonstrate their similarity following match pairing. In addition, it showcases the mean scores of the formative and post-tests for both groups. Table 2 presents the outcomes of the pretest mean scores for the Experimental and Comparison groups.

Table 2. Pretest Mean Scores of the Experimental and Comparison groups

Test	Group (n=25)	Mean	SD	Interpretation
Pretest	Experimental	8.44	2.53	Developing
	Comparison	8.44	2.53	Developing

Interpretation: 0-7.99=Beginning 8-13.99= Developing 14-19.99 Approaching Proficient 20-26.99=Proficient 27-30=Advanced

As indicated in Table 2, the pretest results for both groups demonstrated similar levels of academic skills (M = 8.44, SD = 2.53) interpreted as demonstrating a "Developing" proficiency level. This suggests equivalence between groups following matched pairing. This equivalence is crucial for the validity of the study's findings because it helps to isolate the impact of the Quantom Kit on the academic performance of the students.

Table 3 presents the formative mean scores of the experimental and comparison groups. It also describes the performance level of the students across six (6) lessons.

Table 3. Formative Test Mean Scores of the Experimental and Comparison groups

LESSONS	**EXPERIMENTAL**			**COMPARISON**		
	Mean	**SD**	**Interpretation**	**Mean**	**SD**	**Interpretation**
1.Parts of the Atom and Subatomic particles	3.8	1.19	High	2.92	0.81	Average
2.Determining the number subatomic particles in the energy levels	3.92	1.29	High	3.12	0.60	Average
3. Parts of the Periodic Table	3.76	1.09	High	3.32	0.75	Average
4. Application of parts of the Periodic Table to illustrate atomic structures.	3.96	1.21	High	3.28	0.98	Average
5. Main Energy Levels and Sublevels	3.64	1.22	High	2.76	0.72	Average
6. Electron Configuration	3.88	1.07	High	3.20	0.63	Average
Overall	22.96	6.38	Proficient	18.60	3.47	Approaching Proficient

Interpretation: 5-item quiz: 5.00 - 3.50 = High, 2.50 - 3.49 = Average, 2.49 and below = Low
Interpretation: 0-7.99=Beginning 8-13.99= Developing 14-19.99 Approaching Proficient 20-26.99=Proficient

As shown in Table 3, the experimental group consistently outperformed the comparison group across all lessons, achieving "High" mean scores. In lesson 1, the experimental group scored (M = 3.8, SD = 1.19) compared to the comparison group's "Average" scores (M = 2.92, SD = 0.81). In lesson

2, the experimental group's scores (M = 3.92, SD = 1.29) surpassed the comparison group's (M = 3.12, SD = 0.60). Similarly, in lessons 3, 4, 5, and 6, the experimental group maintained higher mean scores (M = 3.76, SD = 1.09; M = 3.96, SD = 1.21; M = 3.64, SD = 1.22; M = 3.88, SD = 1.07) than the comparison group (M = 3.32, SD = 1.09; M = 3.28, SD = 0.98; M = 2.76, SD = 0.72; M = 3.20, SD = 0.63).

In total, the experimental group demonstrated a notably higher mean score (M = 22.96, SD = 6.38), interpreted as "Proficient," and a narrower score distribution, in contrast to the comparison group, which achieved a mean score of (M = 18.60, SD = 3.47), translated as "Approaching Proficient." These results consistently indicate that the use of the Quantom Kit in the experimental group led to higher formative assessment scores across all lessons compared with the use of the Periodic Table in the comparison group. The results suggest that the Quantom Kit is a more effective instructional tool for enhancing students' understanding of the atomic structures and related concepts.

The findings of this study align with Bennie et al. (2019b), who demonstrated improved student learning outcomes through virtual reality simulations in chemistry education. Similarly, this research observed enhanced academic performance in the experimental group using the Quantom Kit, suggesting that innovative learning materials can significantly increase student achievement. The emphasis on the Quantom Kit supports their findings, highlighting that active, inquiry-based learning can enhance academic performance and conceptual understanding.

Table 4 illustrates the posttest mean scores of the participants in the experimental and comparison groups.

Table 4. Mean Posttest Scores of the Experimental and Comparison Groups

Test	Group (n=25)	Mean	SD	Interpretation
Posttest	Experimental	17.20	6.14	Approaching Proficient
	Comparison	12.04	2.67	Developing

Interpretation: 0-7.99=Beginning 8-13.99= Developing 14-19.99 Approaching Proficient 20-26.99=Proficient 27-30=Advanced

The data in Table 4 unveiled that in the Posttest, the Experimental group exhibited a higher mean score (M = 17.20, SD= 6.14) interpreted as "Approaching Proficient" while the Comparison group only attained a mean score (M = 12.04, SD = 2.67) interpreted as "Developing". The results also show that the comparison group had a much narrower score distribution than the experimental group.

Shofawati et al. (2023) supported the findings of this study, demonstrating that interactive learning materials effectively enhance students' understanding of complex scientific concepts. Their research indicated a significant increase in science literacy skills following the intervention, which is similar to the improvements observed with the use of the Quantom Kit in this study. These results suggest that interactive and multimedia instructional tools are crucial for facilitating deeper understanding and retention of scientific concepts.

Furthermore, to delve deeper into the contrast in students' scores on the Formative Test, the Independent-Samples t-test was used to assess the statistical variance, as depicted in Table 5.

Table 5. Test for Difference in Formative Test Scores Between Experimental and Comparison Groups

Lessons	Group (n=50)	Mean	SD	t	Mean-Diff	Cohen's d	Effect Size
1.Parts of the	Experimental	3.8	1.19	3.05	0.88	0.89	Large

Lessons	Group (n=50)	Mean	SD	t	Mean-Diff	Cohen's d	Effect Size
Atom and Subatomic particles	Comparison	2.92	0.81	**			
2.Determining the number subatomic particles in the energy levels	Experimental	3.92	1.29	2.81 **	0.8	0.85	Large
	Comparison	3.12	0.6				
3. Parts of the Periodic Table	Experimental	3.76	1.09	1.66 **	0.44	0.49	Small
	Comparison	3.32	0.75				
4. Application of parts of the Periodic Table to illustrate atomic structures.	Experimental	3.96	1.21	2.19 **	0.68	0.62	Medium
	Comparison	3.28	0.98				
5. Main Energy Levels and Sublevels	Experimental	3.64	1.22	3.10 **	0.88	0.91	Large
	Comparison	2.76	0.72				
6. Electron Configuration	Experimental	3.88	1.07	2.68 **	0.68	0.80	Large
	Comparison	3.20	0.63				
Overall	Experimental	22.96	6.38	3.06 **	4.44	0.86	Large
	Comparison	18.52	3.47				

** - Test is Significant @ p-value<0.01. df=48.
Cohen's d <=0.19: Very Small, d <=0.49: Small, d <=0.79: Medium, d <= 1.19: Large, d<=1.99: Very Large; d>=2.0: Huge.

Table 5 shows that the experimental group consistently outperformed the comparison group across all six lessons on atomic structures. In Lesson 1, the experimental group (M = 3.8, SD = 1.19) significantly exceeded the comparison group (M = 2.92, SD = 0.81), t(3.05) = **, p < .01, with a large effect size (d = 0.89). Similar results were found in Lesson 2, with the experimental group (M = 3.92, SD = 1.29) surpassing the comparison group (M = 3.12, SD = 0.60), t(2.81) = **, p < .01, and a large effect size (d = 0.85). Lessons 3 through 6 continued this trend, with the experimental group showing significantly higher performance in each case, all with effect sizes ranging from small to large (d = 0.49 to 0.91). Overall, the experimental group (M = 22.96, SD = 6.38) significantly outperformed the comparison group (M = 18.52, SD = 3.47), t(3.06) = **, p < .01, with a large effect size (d = 0.86), supporting the rejection of the null hypothesis. These results demonstrate the Quantom Kit's effectiveness in enhancing students' understanding compared to traditional methods.

The results align with Twizeyimana et al. (2020) and Campbell and Lee (2021), emphasizing the positive impact of locally developed instructional materials on science education. The experimental group that used the Quantom Kit achieved significantly higher scores than the conventional methods group, demonstrating the effectiveness of the innovative materials in improving learning. The very large effect size (d = 1.94) mirrors the findings of Li et al. (2022), who observed similar gains with the Orbital Explorer and BingOrbital tools, highlighting the importance of context-specific instructional materials in enhancing science learning outcomes.

Table 6 presents the outcome of the Independent-Samples t-test employed to test the statistical difference in the post-test scores between the experimental and comparison groups.

Table 6. Test of Difference for Mean Posttest Scores

Test	Group (n=25)	Mean	SD	t	Mean-Diff	Cohen's d	Effect Size
Posttest	Experimental	17.20	6.14	3.86 **	5.16	1.09	Large
	Comparison	12.04	2.67				

** - Test is Significant @ p-value<0.01. df=48.
Cohen's d <=0.19: Very Small, d <=0.49: Small, d <=0.79: Medium, d <= 1.19: Large, d<=1.99: Very Large; d>=2.0: Huge.

Table 6 shows that the experimental group (M = 17.20, SD = 6.14) achieved higher mean posttest scores than the comparison group (M = 12.04, SD = 2.67). This difference was significant [t (48) =3.86**, p < .01] leading to the rejection of the null hypothesis, which posits no significant difference in posttest mean scores between the two groups. Furthermore, given the highly significant outcome of the Independent-Samples t-test, Cohen's d was computed to evaluate the effect size on the difference in posttest means between the experimental and comparison groups. The effect size (d=1.09) is interpreted as "Large," indicating a substantial disparity in mean post-test scores between the experimental and comparison groups.

The findings aligned with Asrizal et al. (2018), who explored integrated science materials to boost students' digital literacy, showing that innovative tools like the Quantom Kit can enhance student learning outcomes, as evidenced by higher posttest scores in the experimental group. Similarly, Setiawan and Suhandi (2020) demonstrated the effectiveness of "Kits for Kids" in improving elementary students' science understanding through discovery learning. The significant difference in posttest scores and the large effect size underscored the Quantom Kit's substantial impact on student performance, paralleling the benefits observed with "Kits for Kids" in science education.

Illustrated in Table 7 is the outcome of the Paired-Samples t-test, which was performed to test the statistical difference between the pretest and post-test scores of the experimental and comparison groups.

Table 7. Test of Difference between Pretest and Posttest in Each Group

Group (n=25)	Test	Mean	SD	t	Mean-Diff	Cohen's d	Effect Size
Experimental	Posttest	17.20	6.14	9.26 **	8.76	1.87	Very Large
	Pretest	8.44	2.53				
Comparison	Posttest	12.04	2.67	11.78 **	3.60	1.38	Very Large
	Pretest	8.44	2.53				

** - Test is Significant @ p-value<0.01. df=24.
Cohen's d <=0.19: Very Small, d <=0.49: Small, d <=0.79: Medium, d <= 1.19: Large, d<=1.99: Very Large; d>=2.0: Huge.

Table 7 reveals a notable distinction between the pretest (M = 8.44, SD = 2.53) and posttest (M = 17.20, SD = 6.14) mean scores of the experimental group exposed to the Quantom Kit, indicating a clear enhancement in students' understanding of atomic structures. The findings indicate a significant difference (t (24) = 8.76 **, p-value < .01) between the pretest-posttest mean scores of the experimental group, leading to the rejection of the null hypothesis. These findings strongly support the effectiveness of the Quantom Kit in facilitating learning outcomes. Moreover, the calculated value of Cohen's d, (d= 1.87), underscores a profound effect size between the pretest and posttest means, categorized as a "Very Large." This suggests that the Quantom Kit intervention not only helps students grasp complex scientific concepts but also significantly boosts their overall academic achievement in Science 8.

Table 7 also illustrates the pretest scores (M = 8.44, SD = 2.53) and posttest mean scores (M = 12.04, SD = 2.67) of the comparison group, which was exposed to Periodic Table only. With a pretest-posttest mean difference in (M =3.60), learners engaged in Periodic Table also demonstrated improvement in their pretest and posttest scores. Consequently, with the t-value of t (24) = 11.78 **, p-value < .01, the null hypothesis suggesting no significant difference between the pretest and posttest mean scores of the comparison group was rejected. Furthermore, the calculated value of Cohen's d, (d = 1.38) indicates a significant effect size between the means of the pretest and posttest, categorized as "Very Large." Although the Comparison group also showed improvement, the Experimental group still achieved a higher posttest mean score and a much higher effect size, indicating that the utilization of the Quantom Kit in the teaching-learning process can lead to greater improvement in academic performance in science.8

These results align with the research conducted by Pinthong et al. (2024), who investigated learning activities designed to motivate students and improve learning in complex subjects like biochemistry. Similarly, this study revealed notable academic performance improvements in both groups, affirming the effectiveness of instructional interventions. Additionally, the findings support Rodriguez (2023), who examined the impact of task-based supplementary materials in chemistry, emphasizing the value of tailored educational resources. The significant gains achieved with the Quantom Kit highlight the potential of innovative instructional materials to enhance student learning outcomes. The following chapter will summarize the study's conclusions.

CONCLUSIONS

Based on the study's findings, the following conclusions were drawn. The hypothesis stating that there was no significant difference between the formative test mean scores of the experimental and comparison groups was rejected since the difference of the mean scores was significant. The experimental group, which used Quantom Kit obtained higher mean scores than the comparison group.

Additionally, the hypothesis stating that there was no significant difference between the post-test mean scores of the experimental and comparison groups, was also rejected. The post-test mean scores of the experimental group were higher than those of the comparison group, and the difference was significant.

Furthermore, the hypothesis stating that there was no significant difference between the pre-test and post-test mean scores of the students in the comparison and experimental groups was also rejected, as the differences between the pre-test and post-test mean scores of each group were statistically significant. Although, both groups obtained higher mean scores in the post-tests, it was revealed that experimental group, which used Quantom Kit, achieved much higher scores.

This study demonstrated that the implementation of the Quantom Kit in the experimental group led to substantial improvements in both formative and posttest scores compared to conventional teaching methods. The use of the Quantom Kit not only enhanced students' understanding but also resulted in significantly higher test scores. Overall, it was concluded that the Quantom Kit was more effective than traditional teaching approaches.

Based on the study's findings, it is recommended that teachers integrate the Quantom Kit into Grade 8 science lessons to foster an interactive and engaging learning environment. School administrators should support this initiative by providing the necessary resources and training for educators, creating a conducive atmosphere for innovative teaching methods. Additionally, ongoing professional development should be encouraged for educators to ensure they possess the skills and strategies to effectively utilize the Quantom Kit, ultimately enhancing students' academic performance in science.

LIMITATION AND FURTHER RESEARCH

One limitation of this study is the small sample size of 50 participants, which may limit the generalizability of the results. To strengthen the findings, future research should include a larger sample size to verify and validate the results across a wider population. Furthermore, additional studies should focus on the long-term effects of integrating the Quantom Kit into science education.

REFERENCES

Alharthi, M., & Alsufyani, N. (2020). Constructivism as a Learning Theory Applied to Thinking in Solving Physics Problems: An Interpretive Study. *International Journal of Education and Research, 8*(3). https://www.ijern.com/journal/2020/March-2020/06.pdf

Asrizal, A., Amran, A., Ananda, A., Festiyed, F., & Sumarmin, R. (2018). The Development of Integrated Science Instructional Materials to Improve Students' Digital Literacy in Scientific Approach. *Jurnal Pendidikan IPA Indonesia*, 7(4). https://doi.org/10.15294/jpii.v7i4.13613

Bennie, S. J., Ranaghan, K. E., Deeks, H. M., Goldsmith, H. E., O'Connor, M. B., Mulholland, A. J., & Glowacki, D. R. (2019b). Teaching Enzyme Catalysis Using Interactive Molecular Dynamics in Virtual Reality. *Journal of Chemical Education, 96*(11), 2488–2496. https://doi.org/10.1021/acs.jchemed.9b00181

Campbell, T., & Lee, O. (2021). Instructional Materials Designed for a Framework for K-12 Science Education and the Next Generation Science Standards: An Introduction to the Special Issue. *Journal of Science Teacher Education, 32*(7), 727-734. https://doi.org/10.1080/1046560X.2021.1975359

Cano, J. S., Olvis, P. R., Disca, B. Y., & Docena, A. F. (2022). Simulation-Based Instructional Materials on Central Dogma of Molecular Biology: Basis in Studying Genetics for Grade 12 Learners. *International Journal of Technology in Education, 5*(2), 249–268. https://eric.ed.gov/?id=EJ1343001

Department of Education. (n.d.). *K to 12 Basic Education Curriculum*. Department of Education. https://www.deped.gov.ph/k-to-12/about/k-to-12%20basic-education-curriculum/

Ebajan, R. D., & Tamban, V. D. (2024). Effectiveness of Feedback, Reframe, Assess, Model, and Enhance (FRAME) in the Enhancing of Learners' Performance of 9 Grader Students in Mathematics. *Advanced Journal of STEM Education, 2*(1), 54–65. https://doi.org/10.31098/ajosed.v2i1.2540

Edelson, D. C., Reiser, B. J., McNeill, K. L., Mohan, A., Novak, M., Mohan, L., … Suárez, E. (2021). Developing Research-Based Instructional Materials to Support Large-Scale Transformation of Science Teaching and Learning: The Approach of the OpenSciEd Middle School Program. *Journal of Science Teacher Education*, *32*(7), 780–804. https://doi.org/10.1080/1046560X.2021.1877457

Irmayanti, I., & Hikrawati, H. (2023). Exploration of Mathematical Concepts in the Katto-Katto Game. *Advanced Journal of STEM Education, 1*(1), 10–19. https://doi.org/10.31098/ajosed.v1i1.1560

Li, X., Muñiz, M. N., Chun, K., Tai, J., Guerra, F., & York, D. M. (2022). Online Orbital Explorer and BingOrbital game for Inquiry-Based activities. *Journal of Chemical Education, 99*(5), 2135–2142. https://doi.org/10.1021/acs.jchemed.1c01277

Matched Samples: Definition, Examples. (2019, June 4). https://www.statisticshowto.com/matched-samples/#:~:text=Matched%20samples%20(also%20called%20matched,a%20person%2C%20object%20or%20thing.

Malabayabas, M. E., Yazon, A. D., Tessoro, J. F. B., Manaig, K. A., & Sapin, S. B. (2024). Effectiveness of Mathematics-Gammified Applications for Learners Interactive Numeracy Growth (Math-Galing) in Enhancing the Academic Performance of Grade 11 Learners. *Advanced Journal of STEM Education*, *2*(1), 31–42. https://doi.org/10.31098/ajosed.v2i1.2324

OECD. (2019). *PISA 2018 Results (Volume I): What Students Know Can do*. OECD. https://doi.org/10.1787/5f07c754-en

Pinthong, C., Poungkaew, N., Ampaipis, T., Thanyaphongphat, J., Pimviriyakul, P., & Maenpuen, S. (2024). Metal Demon Conqueror Game: a New Digital Game-Based Learning Tool on Factors Affecting Enzyme Activity. *Journal of Chemical Education, 101*(4), 1718–1725. https://doi.org/10.1021/acs.jchemed.3c01212

Rodriguez, N. (2023). Task-based Supplementary Instructional Materials in Learning Grade 10 Chemistry. *International Journal of Multidisciplinary: Applied Business and Education Research, 4*(4), 1077-1083. https://doi.org/10.11594/ijmaber.04.04.03

Saithongdee, A., & Sirirat, T. (2024). Learning Mole Calculation through a Board Game in an Engaging and Enjoyable Environment: Design, Implementation, and Evaluation. *Journal of Chemical Education, 101*(4), 1551–1563. https://doi.org/10.1021/acs.jchemed.3c01010

Setiawan, S., & Suhandi, A. (2020). The Usage of Kit-For-Kids in Discovery Learning Model to Improve the Understanding of Science Teaching Materials on Elementary School Students. *JPsd (Jurnal Pendidikan Sekolah Dasar), 6*(1), 43-54. https://jurnal.untirta.ac.id/index.php/jpsd/article/viewFile/7279/5100

Shofawati, A., Widodo, W., & Sari, D. A. P. (2023). The Use of Multimedia Interactive to Improve Students Science Literacy in the New Normal Era. *Jurnal Pijar Mipa, 18*(1), 65–71. https://doi.org/10.29303/jpm.v18i1.3832

Solekhah, H., Kutni, I. D., & Pamungkas, A. B. (2023). Student's Engagement and Perception of Gamification in Mathematics. *Education Policy and Development, 1*(2), 1–13. https://doi.org/10.31098/epd.v1i2.1779

Stratton, S. (2019). Quasi-Experimental Design (Pre-Test and Post-Test Studies) in Prehospital and Disaster Research. *Prehospital and Disaster Medicine, 34*(6), 573–574. https://doi.org/10.1017/s1049023x19005053

Suhendi, A., & Purwarno. (2018b). Constructivist Learning Theory: The Contribution to Foreign Language Learning and Teaching. *KnE Social Sciences, 3*(4), 87. https://doi.org/10.18502/kss.v3i4.1921

Suryelita, S., Guspatni, G., & Defriati, P. (2019, October). Description of Learning Difficulties on Atomic Structure and Periodic Table Topics of Tenth Grade Students in SMAN 7 Padang. In *Journal of Physics: Conference Series* (Vol. 1317, No. 1, p. 012147). IOP Publishing.. https://doi.org/10.1088/1742-6596/1317/1/012147

Tursyngozhayev, K., Kavak, N., & Akhmetov, N. (2024b). Enhancing Chemistry Education for Students through a Novel Card Game: Compound Chain. *Journal of Chemical Education, 101*(3), 1367–1372. https://doi.org/10.1021/acs.jchemed.3c00983

Twizeyimana, E., Renzaho, A., & Mujawimana, E. (2020). Effectiveness of Locally Made Instructional Materials on Students Academic Performance and Retention in Science Education in Eastern Province of Rwanda. *International Journal of All Research Writings, 1*(11), 29-37. http://www.ijarw.com/Users/ManuScript/ManuScriptDetails/a4b8faca-e82f-4a73-a2c4-c21875c07985

Waite-Stupiansky, S. (2022). Jean Piaget's Constructivist Theory of Learning. In *Theories of Early Childhood Education* (pp. 3-18). Routledge. https://www.taylorfrancis.com/chapters/edit/10.4324/9781003288077-2/jean-piaget-constructivist-theory-learning-sandra-waite-stupiansky

APPENDICES:

Republic of the Philippines
Laguna State Polytechnic University
Province of Laguna

College of Teacher Education
Graduate Studies and Applied Research

CONSENT FORM

February 18, 2024

A blessed day!

I, ____ here by given my permission to Ms. Manilyn M. Galarosa to allow me to respond to a questionnaire and quote my responses in a scholarly research paper. I understand that their work is for academic purposes.

I also understand that I waive any claim for copyright to this material should the researchers ever publish it in a scholarly journal or in electronic format online.

I understand that the Research Title is **Effectiveness QuanTom Kit as Supplementary Learning Material in Enhancing the Academic Performance in Science among Grade 8 Students** at Looc Integrated School.

I also understand that the researcher, hereby named Ms. Manilyn M. Galarosa, will maintain my confidentiality regarding my responses to Questionnaire items.

I hereby give my permission in the form of my signature below:

______________________ ______________________

Signature over Printed Name Date

Contact of Researcher:
Manilyn M. Galarosa [manilyn.galarosa@deped.gov.ph]
0995-367-5714

Science 8

PRE-TEST/POST-TEST

Name: ________________________________ Score: _________________________

Grade & Section: ______________________

DIRECTION: Read each question carefully and encircle the correct answer.

1. Which subatomic particle has a positive charge?
   a) Proton b) Neutron c) Electron d) Nucleus
2. What does the atomic number of an element represent?
   a) Number of protons b) Number of neutrons
   c) Number of electrons d) Option A & B
3. Which subatomic particle/s is/are in the nucleus of an atom?
   a) Proton & Neutron b) Proton & Electron
   c) Neutron d) Positron
4. What are the vertical columns in the periodic table called?
   a) Groups b) Periods
   c) Families d) Series
5. Beryllium has atomic number four (4), what is its maximum number of electrons in the 1^{st} energy level?
   a) 2 b) 6 c) 8 d) 18
6. What is the maximum number of electrons that can occupy the *2p* subshell?
   a) 2 b) 6 c) 8 d) 10
7. The 3^{rd} shell has *s,p,d* subshell , what is the total number of electrons it can occupy?
   a) 2 b) 6 c) 8 d) 18
8. Which of the following subshells consist of one orbital?
   a) *2p* b) *3d* c) *1s* d) *3p*
9. How many valence electrons does Hydrogen (H) have ?
   a) 1 b) 2 c) 3 d) 4
10. Calcium (atomic number =20) is in Group 2 and Period 4, how many shells/orbitals does it have ?
   a) 2 b) 4 c) 20 d) 1
11. What are the subshells present in the 5^{th} energy levels?
   a) *s* b) *s,p* c) *s,p,d* d) *s,p,d,f*
12. What are the major portion of an atom's mass composed of?
   a) electrons and protons
   b) electrons and neutrons
   c) neutrons and positrons
   d) neutrons and protons
13. An atom has an electron distribution of $1s^22s^22p^63s^23p^5$ on its orbitals. Which Group does this element belong to?
   a) Group 1 b) Group 2
   c) Group 7 d) Group 8
14. What is the total number of electrons that can occupy the 5^{th} energy level (n=5)?
   a) 32 b) 48 c) 50 d) 72
15. Helium is in Period 1, what is the maximum electrons can they hold?
   a) 1 b) 2 c) 3 d) 0
16. How many electrons can the second energy level (n=2) hold at maximum?
   a) 2 b) 6 c) 8 d) 18

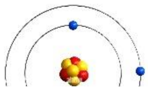
What is the structure of a krypton-85 atom?
a) 49 electrons, 49 protons, and 85 neutrons
b) 49 electrons, 49 protons, and 49 neutrons
c) 36 electrons, 36 protons, and 85 neutrons
d) 36 electrons, 36 protons, and 49 neutrons

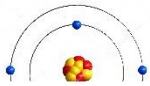
18. What is/are the subshell/s present for Hydrogen?
a) *s* b) *s,p* c) *s,p,d* d) s,d

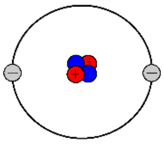
19. Aluminum^{13} is in Group 3 and Period 3, how many sublevels are present in its 3rd orbital/shell?
a)3 b) 6 c) 13 d) 2

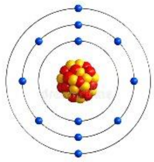
20. Phosphorus has atomic number 15 and atomic mass of 31, how many neutrons does it have in its nucleus?
a)5 b) 15 c) 16 d) 31

21. Which of the following is the correct atomic structure of Lithium?

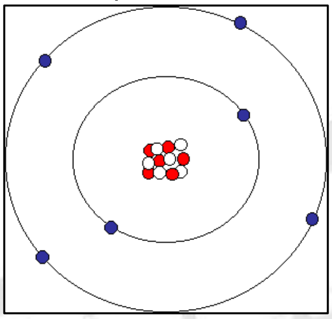
a) 

b) 

c) 

d) 

*For question numbers **22-24,** refer to the atomic structure below:*



22. From the picture of atomic structure above, what is this element base on the number of protons and neutrons?
a)Hydrogen b) Lithium c) Carbon d) Boron

23. What is Group number of this element?
a)6 b) 4 c) 2 d) 8

24. What is Period number of this element?
a)6 b) 4 c) 2 d) 8

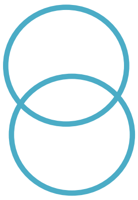
25. How many valence electrons does Potassium K^{19} have?
a)1 b) 4 c) 19 d) 20

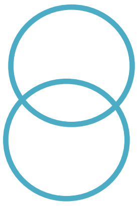
26. Krypton (atomic number=35) is in Period 4 and Group 8, how many electrons does the 4th orbit have?
a. 7 b. 8 c. 35 d. 30

27. What is the correct electron distribution of Nitrogen^{7} on its 1st and 2nd orbital/shell?
a. 2,2 b. 2,5 c. 2,7 d. 3,4

28. Xenon has atomic number of 54 and 131 atomic weight, what is the correct atomic structure of its nucleus?

a. 54+ 77n
b. 54+ 131n
c. 54+ 54n
d. 54+ 55n





29. How many orbital/shell does Tin (Sn) have?

a. 4
b. 5
c. 50
d. 118

30. What is the correct electron distribution for Beryllium (Be) which is in Group 2 and Period 2?

a. 2,1
b. 2,2
c. 2,3
d. 2,2,2