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Improving Student Performance in Secondary School Chemistry through Strategic Intervention Materials Integrating Real-World Scenarios

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Abstract

This study used a quasi-experimental pretest-posttest design with non-equivalent groups to assess the effectiveness of a Strategic Intervention Material (SIM) incorporating interactive real-world scenarios on secondary school chemistry performance. Eighth-grade students from a rural public secondary school in southern Nueva Vizcaya, Philippines, participated, with the experimental group receiving the SIM intervention and the control group receiving traditional classroom instruction. The findings demonstrated significant improvement in posttest scores among students exposed to SIM integrated with real-world scenarios, contrasting with minimal gains observed in students taught through conventional methods. These results highlight the effectiveness of integrating real-world contexts into educational materials to enhance student engagement and comprehension of complex chemistry concepts. The findings underscore the importance of incorporating real-world scenarios into educational strategies to optimise learning outcomes in secondary school chemistry. Educators are encouraged to adopt innovative teaching approaches that stimulate active engagement and practical and contextualised application of knowledge to enhance student academic achievement.

Keywords: Contextualisation of learning, real-world application, chemistry education, Strategic Intervention Material, SIM-based teaching

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INTRODUCTION

Teaching chemistry to secondary school learners presents challenges due to its complex and abstract nature, involving formulas, memorisation, and calculations that often deter student interest (Alina et al., 2016). To counteract this, contextualising chemistry education becomes crucial. By integrating real-world applications and practical examples into lessons, educators can bridge the gap between theoretical concepts and students' everyday experiences (Soenarno, 2019). This approach not only makes chemistry more relevant and understandable but also enhances students' motivation and engagement in learning. Contextualisation in chemistry education not only addresses the perceived difficulty of the subject but also nurtures critical thinking and problem-solving skills essential for students' academic and professional growth (Alina et al., 2016). By illustrating how chemistry concepts apply to real-life scenarios, educators can inspire students to explore and understand the subject more deeply. This approach not only improves learning outcomes but also prepares students to tackle challenges beyond the classroom, fostering a more comprehensive and meaningful learning experience in chemistry.

The need for this study stems from the challenges faced in Philippine secondary school chemistry education, where students demonstrate low engagement and proficiency in the subject. International assessments, such as the OECD's PISA, highlight this underperformance, with Filipino students ranking among the lowest in science globally (OECD, 2023). This underperformance in science is a critical issue across many schools. Research indicates that chemistry is perceived as more challenging than physics and biology (Woldeamanuel et al., 2014), and student engagement in chemistry remains notably low (Vaino et al., 2012). Contemporary science educators face significant challenges, particularly in teaching chemistry, a subject that requires students to master specific learning competencies (Valdez & Bungihan, 2019). This issue underscores the urgent need for innovative teaching strategies that can effectively bridge the gap between theoretical knowledge and practical applications.

Strategic Intervention Materials (SIM) present a promising solution to these challenges. Designed to reteach and reinforce concepts that students find difficult, SIMs are tailored resources that address individual learning needs, fostering independent and successful learning (Peñaflor, 2019; Jotia & Matlale, 2011; Bunagan, 2012). Research has consistently shown the effectiveness of SIMs in improving academic performance, conceptual understanding, and scientific attitudes (Bastida & Bastida, 2022; Suarez & Casinillo, 2020; Zahara et al., 2018). Additionally, incorporating real-world applications into SIMs enhances student engagement by making lessons more relevant and meaningful, as supported by studies emphasising the benefits of contextualised and interactive learning experiences (Hulleman & Harackiewicz, 2009; Semilarski et al., 2021).

This study aims to explore the effectiveness of SIM embedded with interactive real-world scenarios in addressing the gaps in chemistry education. By integrating dynamic and relatable contexts into teaching materials, the study seeks to enhance student motivation, critical thinking, and practical understanding of chemistry concepts. This approach not only promises to improve academic outcomes but also equips students with essential skills for success in science and real-world problem-solving. Through this innovative framework, the study aspires to contribute to the advancement of chemistry education in the Philippines, empowering learners to overcome the complexities of the subject and achieve academic and personal growth.

Conceptual and Theoretical Basis

This study can be visually understood through the framework shown in Figure 1, which outlines the research design. The research framework of this study is structured around the relationship between the mode of teaching as the independent variable (IV) and student performance in chemistry as the dependent variable (DV). Specifically, the mode of teaching is categorised into two distinct approaches: traditional classroom instruction and the use of Strategic Intervention Materials (SIM) that integrate interactive real-world scenarios. Traditional classroom instruction typically involves standard lectures and textbook-based learning with limited interactive or practical applications. In contrast, the innovative SIM approach embeds real-world scenarios within the teaching material, aiming to enhance student engagement and understanding by linking theoretical knowledge to practical, real-life contexts.

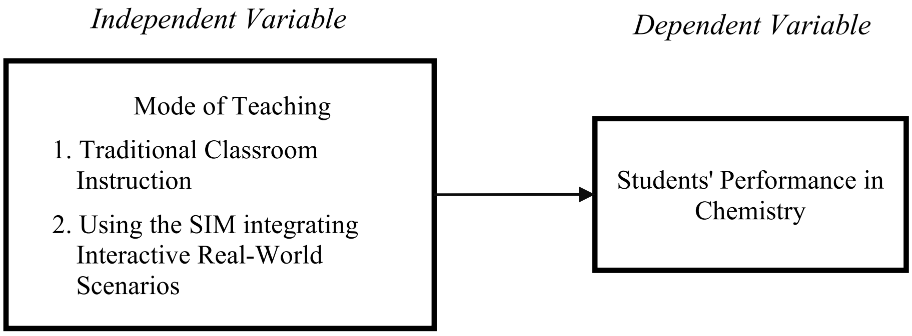

Figure 1. Research Paradigm of the Study

This framework posits that the mode of teaching directly impacts student performance in chemistry. By comparing the pretest and post-test scores of students subjected to these two different teaching modalities, the study seeks to determine which method more effectively enhances students' understanding and comprehension of chemistry.

The hypothesis driving this research is that students taught using the SIM with real-world scenarios exhibit significant improvement in their chemistry performance compared to those taught through traditional classroom methods. The underlying mechanism for this hypothesis is that SIMs, by making learning more relevant and interesting, engage students more effectively. This engagement is expected to foster better critical thinking and problem-solving skills, which are crucial for understanding complex chemistry concepts. The practical application of knowledge through real-world scenarios is anticipated to lead to higher post-test scores, indicating improved academic performance. Thus, by analysing the differences in student performance between these two teaching approaches, the study aims to highlight the effectiveness of innovative educational strategies over conventional methods, underscoring the importance of interactive and contextual learning in enhancing student outcomes in science education.

The paradigm exploring the use of interactive real-world applications as an independent variable to enhance student performance, with improved learning outcomes as a result, exemplifies Lev Vygotsky's constructivist theory (Rathert & Cabaroğlu, 2024). Vygotsky posited that learning occurs within a sociocultural context, where individuals construct knowledge through collaborative interactions and engagement in authentic activities. This study, grounded in Vygotsky's sociocultural theory, aims to investigate the effectiveness of SIM enriched with interactive real-world scenarios in enhancing students' performance and predictive proficiency in understanding chemistry.

Constructivism is a pedagogical approach that emphasises how learners actively build their understanding and knowledge of the world through experiences and reflection (Sepriyanti & Kustati, 2024). It fosters students' natural curiosity about the world and its workings. Students do not replicate existing knowledge from scratch; instead, they strive to understand its mechanisms and operations. This approach encourages deep engagement and meaningful learning experiences, aligning with the principles of constructivist theory and enhancing educational outcomes (Bada & Olusegun, 2015).

METHODS

In this study, a quasi-experimental pretest-posttest design with non-equivalent groups was employed to investigate the effectiveness of SIM embedded with interactive real-world scenarios in improving student performance in secondary school chemistry. The design allowed for comparison between an experimental group that received the SIM intervention and a control group that received traditional classroom instruction. This approach is well-suited for evaluating the impact of interventions in educational settings while accounting for pre-existing differences between groups.

The study involved 58 eighth-grade students from a rural public secondary school in southern Nueva Vizcaya, Philippines. The sample was chosen to reflect broader educational trends despite its smaller size. By examining educational dynamics within this rural context, the research provides insights applicable to larger educational settings. The selection criteria ensured validity by including students with no prior exposure to the intervention, focusing on changes directly attributable to the SIM. Additionally, students were chosen from a heterogeneous class to represent diverse abilities, backgrounds, and learning styles typical of classroom settings. This diversity enabled a comprehensive assessment of the SIM's effectiveness across varied student needs. Highlighting challenges specific to rural areas, the study aims to tailor educational strategies suited to similar environments and enhance the effectiveness of interventions across diverse contexts.

Ethical considerations were rigorously prioritised throughout the study. Formal permissions were obtained from the school principal and the division office to conduct the research within the school premises. Informed consent was sought from students and their parents or guardians, emphasising voluntary participation and data confidentiality. The study adhered strictly to ethical guidelines for research involving human subjects, ensuring participants' rights and well-being were upheld at all stages of data collection and analysis.

The primary tools utilised in this study were the Strategic Intervention Materials (SIM) and a chemistry test administered during the pretest and posttest. These instruments were meticulously designed to assess students' knowledge and comprehension of chemistry. The pretest established a baseline for students' understanding before any intervention, ensuring subsequent improvements could be accurately attributed to the SIM. The posttest, administered after implementing the SIM, measured its effectiveness in improving student performance.

The pretest and posttest assessments consisted of a 40-item chemistry test, initially developed as a 50-item instrument. Following pilot testing with a separate group, the test was refined to 40 items to enhance clarity, validity, and reliability. Pilot test results identified and eliminated redundant or less effective questions. The test underwent rigorous validation, including reviews by three secondary school chemistry teachers and two graduate school professors, ensuring alignment with grade-level expectations and the ability to measure targeted knowledge and skills accurately. Additional pilot testing with a similar student group further validated the test's reliability and appropriateness. The test's reliability was assessed using the KR-20 coefficient (KR20=0.99), indicating excellent internal consistency and dependability as a measure of students' chemistry knowledge.

The SIM used in this study comprised researcher-designed contextualised chemistry activities to engage students through real-world scenarios. These activities aimed to make chemistry learning more relevant and interesting by connecting theoretical concepts to practical applications. The SIM underwent rigorous Evaluation. Three college professors specialise in chemistry education, ensuring the materials are pedagogically sound and effectively integrated into real-world scenarios. This thorough development and validation process provided a robust foundation for assessing the SIM's impact on student performance.

Data analysis included calculating means and standard deviations and conducting data assumption tests, such as distribution and equal variance tests. Parametric tests of difference, including dependent and independent t-tests, were used to compare pretest and posttest scores between the experimental and control groups. The analysis was carried out at a significance level of 0.05, ensuring robust statistical conclusions about the effectiveness of the SIM intervention in enhancing student understanding of chemistry.

RESULTS & DISCUSSION

Results

Table 1 presents a comparative analysis of the pretest and posttest scores of students taught using conventional methods and those taught using real-world scenarios embedded within the designed Strategic Intervention Materials (SIM Integrated Teaching). This comparison aims to demonstrate the effectiveness of the SIM in enhancing students' performance in chemistry relative to traditional teaching methods.

The results reveal that students taught using the conventional method showed no significant improvement, with pretest and posttest mean scores of 17.62 (SD = 5.49) and 18.10 (SD = 4.85), respectively, both categorised as low ($t(29) = -0.335$, $p = .740$). Conversely, students exposed to the SIM exhibited a marked improvement from a pretest mean score of 13.93 (SD = 3.46), categorised as low, to a posttest mean score of 28.55 (SD = 2.56), indicating a statistically significant shift to high performance ($t(29) = -20.089$, $p < .001$). These findings underscore the efficacy of the real-world scenario-embedded SIM in enhancing student learning outcomes compared to traditional instructional methods.

Table 1. Pretest and Posttest Scores of Students Taught using Conventional Methods and Real-World Scenario Embedded SIM

Mode of Instruction	Test	Mean	SD	QD	*t*	df	*p*
Conventional Teaching	Pretest	17.62	5.49	Low	-0.335	29	.740
	Post-test	18.10	4.85	Low			
SIM Integrated Teaching	Pretest	13.93	3.46	Low	-20.089	29	.000*
	Posttest	28.55	2.56	High			

Qualitative Description (QD)*: 0-10.00=Very Low; 10.01-20.00=Low; 20.01-30.00=High; 30.01-40.00=Very High; * Difference is significant, p<.001*

Table 2 illustrates the significant difference between the posttest mean scores of the students taught using conventional methods and those taught using real-world scenario-embedded Strategic Intervention Materials (SIM Integrated Teaching).

Table 2. Comparison of Chemistry Posttest Scores Between Students Instructed via Conventional Teaching and those with Real-World Scenario Embedded SIM

Mode of Teaching	Mean	SD	QD	t	df	p
Conventional Teaching	18.10	4.85	Low	-10.261	56	.000*
SIM Integrated Teaching	28.55	2.56	High			

Qualitative Description (QD)*: 0-10.00=Very Low; 10.01-20.00=Low; 20.01-30.00=High; 30.01-40.00=Very High; * Difference is significant, p<.001*

It can be gleaned from the table that students taught using the conventional teaching method achieved a low mean score (M=18.10, SD = 4.85). In contrast, students who were taught using the designed SIM attained a significantly higher mean score

(M=28.55, SD = 2.56). The difference in mean scores between the groups was statistically significant ($t(56) = -10.261, p < .001$), indicating that the SIM-integrated teaching approach led to substantially better post-test performance compared to conventional teaching methods.

Discussion

The results of this study highlight the effectiveness of integrating real-world scenarios into Strategic Intervention Materials (SIM) for improving student learning outcomes in secondary school chemistry. The substantial increase in posttest scores from a low pretest baseline to high performance indicates that these scenarios significantly enhance student engagement and comprehension of complex chemistry concepts compared to traditional teaching methods. The negligible improvement observed in students taught through conventional approaches highlights potential limitations in engaging students and effectively conveying subject matter. Teachers may need to reconsider the efficacy of traditional methods and explore more dynamic approaches to maximise educational outcomes. Moreover, integrating practical, real-world applications into educational materials not only enhances academic understanding but also develops critical thinking skills essential for real-life problem-solving and future career success. These findings advocate for adopting innovative teaching strategies that incorporate real-world scenarios to optimise student learning experiences in chemistry education.

Several pieces of literature align well with the findings of the study regarding the effectiveness of strategic intervention materials (SIM) embedded in real-world scenarios. SIMs promote student participation, boost their knowledge (Alboruto, 2017), and improve students' science achievement (Sinco, 2020; Villonez, 2018). Abad (2005), Abdo and Semela (2010), Adewale (2014), and Ogbondah (2008) collectively emphasise the importance of interventions or stimulations to enhance students' academic achievement. This resonates with the significant improvement observed in students exposed to the SIM in the current study, where their performance shifted from a low pretest baseline to high posttest scores.

Okobia (2011) defines teaching resources as tools that aid educators in promoting effective teaching and learning, echoing the role of SIM as a multifaceted educational tool that enhances learning competencies beyond regular classroom instruction. The findings are further supported by Kamran et al. (2023), who highlight that interactive teaching methods promote critical thinking, collaboration, active engagement, and self-efficacy among students. These outcomes are consistent with the enhanced engagement and comprehension observed in students using the real-world scenario embedded SIM in the study. Moreover, Bete's (2020) study reinforces that SIM can elevate science instruction and improve academic performance by addressing competencies that may not have been fully mastered during conventional classes. This aligns with the study's emphasis on the SIM's effectiveness in bridging gaps in student understanding and fostering deeper learning through practical, real-world applications.

Moreover, the literature collectively emphasises the transformative impact of innovative instructional strategies on student learning outcomes across various subjects. Kahar and Rahmawati (2020) highlight significant improvements in students' performance through the development of tailored learning materials, which underscores the importance of well-designed teaching resources. Harianja et al. (2023) and Berhitu et al. (2020) demonstrate the efficacy of practical learning activities in enhancing students' critical thinking, conceptual understanding, retention, and social attitudes, showcasing the benefits of engaging students in active learning experiences. Furthermore, Sudrajat et al. (2024) explore the interaction between instructional strategies and student motivation in natural science education, advocating for personalised teaching approaches based on student motivation levels. Warmadewi and colleagues (2024) further underscore the superiority of an innovative teaching strategy and material over conventional methods in science education, demonstrating improvements in science process skills and cognitive learning outcomes. Collectively, these studies provide compelling evidence for adopting innovative, context-based teaching methods to optimise student engagement and performance (Kahar & Rahmawati, 2020; Berhitu et al., 2020; Harianja et al., 2023; Sudrajat et al., 2024; Warmadewi et al., 2024).

While the benefits of SIM are evident, their implementation in real classroom settings may encounter several challenges. One significant barrier is time constraints. Teachers often face tight schedules due to rigid curriculum requirements, which can limit their ability to develop and implement SIM. Creating high-quality, contextualised materials requires significant time investment for research, development, and validation, potentially making it less feasible for teachers with heavy workloads. Another critical challenge is the need for teacher training. Effective use of SIM demands not only a strong understanding of the subject matter but also skills in designing and facilitating interactive, student-centred learning experiences. Many educators may lack the necessary training or professional development opportunities to create and implement such materials effectively. Without adequate preparation, teachers might struggle to maximise the potential benefits of SIM in fostering engagement and learning. Resource availability is another constraint, particularly in underfunded schools. Rural or public schools may face challenges in accessing materials or technology needed to implement real-world scenarios effectively. For instance, SIM often requires tools, experiments, or multimedia resources to create engaging scenarios, which might be difficult to obtain in resource-constrained environments. Additionally, classroom management in larger or diverse classes can be a barrier. Implementing interactive activities may lead to varying levels of student participation and engagement, requiring teachers to adopt differentiated instructional strategies. Ensuring that all students benefit from SIM, especially in heterogeneous classrooms, can be demanding without adequate support and resources.

To address these barriers, it is essential to provide structured support for teachers, including professional development programs focused on designing and implementing SIM. Workshops and training sessions can equip educators with the necessary skills and confidence to create and facilitate interactive, real-world scenarios in their teaching. Moreover, incorporating SIM into standardised teaching resources can reduce the time burden on teachers and promote wider adoption. Policy interventions to increase funding and resource allocation, particularly in rural schools, can mitigate the resource constraints that hinder SIM implementation. By equipping schools with the necessary materials and infrastructure, educators can more effectively integrate real-world scenarios into their lessons. Furthermore, fostering collaboration among educators to share best practices and co-develop materials can reduce the workload on individual teachers and promote innovation.

CONCLUSION

The study clearly shows that integrating Strategic Intervention Materials (SIM) containing real-world scenarios significantly improves student learning outcomes in secondary school chemistry compared to traditional teaching methods. The notable increase in post-test scores among students exposed to SIM illustrates the effectiveness of this approach in promoting deeper understanding and engagement with complex scientific concepts. By embedding theoretical knowledge within authentic contexts, the SIM not only boosts academic performance but also cultivates critical thinking skills crucial for solving real-world problems. These findings underscore the importance of adopting innovative educational strategies that encourage active learning and practical application of knowledge. Educators and curriculum developers should consider incorporating SIM into their teaching practices to enhance student learning experiences and achieve superior academic results in chemistry education. Furthermore, the research emphasises the necessity of transitioning away from conventional instructional methods towards more dynamic and interactive approaches that cater to diverse learning styles and foster increased student motivation and achievement. In the long term, this research advocates for the inclusion of innovative, context-based instructional methods like SIM as a core component of science education policy to address gaps in student engagement and performance. By institutionalising such approaches, policymakers can ensure a more relevant and effective science education system that equips students with the skills needed to thrive in a rapidly changing, technology-driven world.

CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest regarding the publication of this manuscript.

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