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Concept Retention among Senior High School Science, Technology, Engineering, and Mathematics (STEM) Students Exposed to a Strategic Intervention Material (SIM)

Selma C. Paco[1], Joji D. Linaugo[2]

[1]Ayungon Science High School, Ayungon, Negros Oriental, Philippines, [2]Carlos Hilado Memorial State University, Talisay City, Negros Occidental, Philippines

selma.paco001@deped.gov.ph, joji.linaugo@chmsu.edu.ph

Abstract. Using strategic intervention materials (SIM) in Science class is essential for achieving students' needed competencies, which they could have succeeded in regular classroom instruction. This study examines the retention of concepts among Grade 11 learners in Central Philippines after exposure to teacher-made Strategic Intervention Materials (SIMs). It utilized the Quasi-Experimental Research Design, Post-test Post-Post-Test, Experimental Group only design. To determin0e the significant difference in the level of proficiency right after and a semester after exposure to SIMs intervention Wilcoxon signed-rank test for paired samples was employed. Results showed that the SIMs helped students exceed the core knowledge, skills, and understanding requirements. Learning is best transferred through authentic performance tasks which made retention of Science concepts evident.

Keywords. Science education, Strategic Intervention Materials, retention, quasi-experimental, Central Philippines

1. Introduction

The achievement of an effective interplay between teaching and learning depends heavily on the use of Strategic Intervention Materials (SIMs). [1], [2]. In schools and learning centers, educators must recognize the importance of instructional materials. If adequately prepared, these will be useful for improving, facilitating, and making the teaching-learning process simple, interactive, and authentic. Intervention materials assist teachers in providing students with the assistance they require to progress [3], [4]. These SIMs must be employed to respond to the dearth of resources to achieve maximum learning outcomes. Since its inception in 2005, various studies have proven that SIMs improved performance in Science [1], [2], [5]–[10].

The Department of Education featured SIM creation as one of the contests at school, divisional, regional, and national science fairs as part of its efforts to increase and develop strategic intervention materials for remediating weak Science performance. Currently, educational research, especially in basic education, focuses on students' learning strategies. This research suggested that students might use different learning methods.

In most nations and economies participating in the 2018 Program for International Student Assessment (PISA) [11], fifteen-year-old pupils scored worse in Mathematics and Science in the Philippines. Poor socioeconomic level and the absence of material resources in rural public schools greatly contribute to low accomplishment [12]. The lack of learning materials is only one of the difficulties still plaguing the Philippines' basic education program. The Philippines has a significant teacher and classroom shortage, which negatively impacts student performance and their ability to remain in school. The ratio of teachers to students that the Department of Education (DepEd) recommends is 1:38. Nonetheless, the United Nations Educational, Scientific, and Cultural Organization (UNESCO) suggests 1:30. Big classes make it difficult for professors to maintain order and direct students' education [15], resulting in pupils not receiving the education they need.

The primary purpose of classroom instruction is to give pupils with relevant and applicable instruction. The use of instructional materials has a substantial correlation with the academic achievement of secondary pupils [16]–[18]. Creating instructional materials is a crucial part of the teaching and learning process [19]. In today's competitive and globalized education, the importance of the student in constructing understanding and making sense of knowledge is emphasized over other learning materials [20]. Therefore, it is the responsibility of the Science teacher to create and provide the necessary materials for use in Science lessons [21], [22].

The Department of Education tackled this problem by issuing DepEd Memo 117 s. 2005 encouraging training workshops on Strategic Intervention Materials (SIMs) for effective learning to capacitate teachers in developing various intervention materials for remediation and enrichment of knowledge. The Department of Education recommends SIMs to increase performance of students in Science. The Department of Education highlighted SIMs, making it available to all Science teachers and even organized competitions in the annual Science fairs at the school, divisional, regional, and national levels to promote the extensive utilization of the material.

Given the promise of strategic intervention materials in improving performance, the researcher implemented it in her class. The intervention was adequate, but the focus must go beyond assessment to student retention. Retention is the process by which long-term memory stores information so that it can be found, recognized, and retrieved correctly in the future [23], [24]. To learn and maintain knowledge for students at every grade level, they need to find a sense to associate with the content being learned and participate in quality practice to achieve mastery of the material [25]. There need to be more investigations as to the contributions of SIMs or similar materials towards the retention of concepts [26], [27] among the limited few.

In this study, the researchers wanted to determine if the developed Strategic Intervention Material aided the concept retention of Senior High School STEM students after a semester. Considering how much literature there is on this topic, the studies that were looked at may not have gone into as much detail about the factors of changing how people learn. Still, the study had already talked about the conceptualization of the baseline information and done the current study, which led to a hypothesis that the Strategic Intervention Material might help students learn and perform better, including remembering what they have learned.

2. Framework of the Study

Amin & Malik [28] and Khishfe [29], [30] presented an analysis of theories that contribute to our understanding of memory retention and the recall process. They raised five models: Atkinson and Shiffrin's Memory Model, the Dual-coding theory of memory, Baddeley's Model of Working Memory, Cognitive Load Theory, and the Cognitive Theory of Multimedia Learning. Among those presented, the most appropriate and applicable to this present study is that of the Cognitive Load Theory [31]. This theory came from the idea that working memory has a limited amount of space and functions. It has partially independent subcomponents that deal with auditory/verbal information and visual/2- or 3-dimensional information. Long-term memory, on the other hand, holds schemas that vary in how much they are automated.

Cognitive Load Theory was developed to provide suggestions for presenting information in a way that stimulates behaviors that enhance academic performance among learners. These elements and functions of human cognitive architecture have been used to build a wide variety of innovative educational techniques, all of which are based on the concept that the burden of working memory should be minimized and that schema creation should be encouraged [32]. The means–ends analysis is the most significant and well-known general problem-solving technique mentioned in the literature. This theory investigates how cognitive resources are targeted and utilized during learning and problem solving. It helped students to use their working memory effectively when addressing complex problems. It has implications for the development of instructional materials intended to lessen cognitive strain. Among its merits are developing approaches to lessen superfluous cognitive burden in learning and launching research into successful instructional design tactics. When content is given in a manner that does not connect to actual performance, however, the transfer of learning will be more difficult [28], [31].

Decreased goal-specificity or goal-free situations constituted the first strategy studied [33]–[35]. In STEM Education, design and design thinking have been studied by analyzing specific cognitive aspects, such as cognitive load [36], [37].

This study posits that the employment of Strategic Intervention Materials may have an impact on the concept retention of a group of learners, and recall performance is facilitated by prior testing, be it recall or recognition [38], [29], [30]. Dating all the way back to Ebbinghaus's investigation of spacing effects in the 1880s, the work on retention is one of the earliest and most methodical to be found in the field of the science of learning. [39], [40]. Researches on retention explicitly overlap with that of memory but differ in that for knowledge to be recognized as remembered, students must be able to remember it when needed in response to prompts such as those commonly used in schools [26], [41]. Recent studies on the long-term retention of Science concepts prove that some learners need help retaining the ideas learned after four months [29], [30].

This research is also based on the significance of instructional materials in any teaching-learning process in order to provide intervention materials to improve students' low achievement in Science education [4], [42] Due to the limited involvement of students with the campus, the classroom is frequently the only location for academic and social integration that may be connected with academic participation in the school. As previously stated, neither grade retention nor social promotion will serve students' needs [28], [44].

This teaching method should be considered and utilized frequently by educators. Similarly, Selahattin & Ilknur [45] posit that teachers' expertise in material preparation is vital to achieving educational objectives of all remediation, such as media printed materials, thus making SIMs significant. The association between instructional materials and the academic performance of secondary pupils is substantial [42], [45]–[49]. Due to the fact that there is no single strategy that guarantees success in all learning scenarios, teachers must acquire the knowledge and abilities necessary to satisfy student learning needs [50].

When available, sufficient, and strategically prepared instructional and intervention materials appropriate for a large number of students are made available, science education will be improved [1], [26].

As stipulated in the DepEd Order No. 39, s. 2012, interventions must be made to arrest the further decline in Science achievement. DepEd Memo No. 117, s. 2005, entitled ―Training Workshop on Strategic Intervention Materials (SIMs) for Successful Learning, provided secondary Science teachers the training to prepare SIMs. Using students' learning styles, personality types, and stress–coping mechanisms, strategically created instructional and intervention resources that are appropriate for the diversity of students enhance the effectiveness of teaching Science [1], [2], [6], [7].

Article I. **3. Methodology**

The researchers adapted the Quasi-Experimental, particularly experimental group only, Post post-test design. Because of how things are set up, the researcher is unable to make artificial groups, thus they have no choice but to employ complete groups because that is the only way to ensure that they have enough participants. In quasi-experiments, participants are put into groups, but they are not chosen at random. This is because the experimenter cannot make groups for the experiment [51]. This research aims to evaluate the concept retention among Senior High School STEM students exposed to Strategic Intervention Materials (SIM) in a Science High School in Central Philippines in the second half of the academic year 2020-2021 and 2021-2022. Thus this study design relied on three installment phases of SIM research, first the development of the Strategic Intervention Materials itself, second being tested on its effectiveness, and third, this present study to check the retention of science concepts among Grade 11 STEM students a semester after exposure to the SIM intervention materials.

This study was conducted at a Science High School in Central Philippines in the second half of the academic year 2021-2022. The post-posttest was given to the respective residences of the respondents due to restrictions brought about by COVID-19 Pandemic. The subjects of the research study are the 28 STEM students of Grade 11 Science High School in the academic year 2020–2021.

Beforehand, the researcher used a self-made SIM validated and quality-assured based on the standards prescribed by DepEd Memo No. 117, s. 2005. The researcher used a valid and reliable ($\kappa = 1.0$) teacher-made test to assess the efficacy of the SIM in examining the retention of concepts in teaching Science to Grade 11-STEM students in Science. The teacher-made test comprises a 60-item multiple-choice, objective, and matching form. It covers all the competencies of Grade 11 Biology within the K to 12 curriculums for the first semester. The researcher has drawn out scores related to the least mastered topic, Biomolecules, from the SIM, which was developed.

The data collection method includes self-made test administration wherein the researchers recorded the test results before and after the intervention. Upon approval of the Schools Division Superintendent of the conduct of the study, the researchers began designing a SIM tool based on the least learned topic from the given pre-test. After this, ten (10) experts validate the SIM tool. DepEd Memo 225 s. 2009, Enclosure No. 2 was used as the basis for SIM making. Then, applying the SIM tool as a mode of intervention on the least learned topic in Science occurred. Conducting individual Science post-test and keeping records of the results for data analysis, a post-post-test was given to the same group of students to determine if they retained the Science concepts using the teacher-made SIM. Lastly, students' academic performance ratings in both situations are recorded and compared to see the retention of identified students who were recipients of the teacher-made Strategic Intervention Materials (SIM). A semester after the post-test was given, the same test was administered again to the learners in their respective residences following the protocols set by the local authorities regarding the COVID-19 Pandemic.

Mean and standard deviation was used to answer descriptive problems. Given the nature of the data, a non-parametric test, specifically, Wilcoxon signed rank, was used to compare post and post-posttest scores.

The researchers addressed the general principles of respect for persons, beneficence, and justice to ensure the ethical soundness of the study. These principles include social value, informed consent, the vulnerability of the research participants, risk and benefits, privacy and confidentiality, justice, transparency, adequacy of facilities, and community involvement.

4. Results and Discussions

4.1 Proficiency of Grade 11 Learners in Science after Exposure to SIM Intervention

As shown in Table 1, the proficiency level of Grade 11 Science students who have been exposed to the SIM intervention surpasses the minimum requirements in terms of knowledge, skills, and understanding, and they are able to transfer these competencies automatically and flexibly through authentic performance tasks. An overall MPS of 96.83% was verbally interpreted as "advanced." The learner at this level surpasses the requirements for fundamental knowledge, abilities, and comprehension and can transfer them naturally and flexibly through authentic performance assignments.

Table 1. Level of Proficiency of Grade 11 Learners in Science after Exposure to SIM Intervention

Score (N = 28)	SD	MPS	Level	Interpretation
26.14	1.27	96.83	Advanced	The student at this level exceeds the core requirements in terms of knowledge, skills and understandings, and can transfer them automatically inflexibly through authentic performance tasks.

Students retained Science concepts better after exposure to SIM intervention. These results are confirmed by the studies that have proven that SIMs improved performance in Science [1], [2], [5]–[10]. The use of SIMs is an effective intervention that increased students' post-test scores. This outcome showed the necessity of establishing intervention programs, such as remediation or enrichment. Section 5 of Republic Act No. 10533, or the Improved Basic Education Act of 2013, encourages the production and development of contextualized teaching materials.

Table 2. Level of Proficiency of Grade 11 Learners in Science a Semester after Exposure to SIM Intervention

Score (N = 28)	SD	MPS	Level	Interpretation
26.50	0.82	98.41	Advanced	The student at this level exceeds the core requirements in terms of knowledge, skills and understandings, and can transfer them automatically inflexibly through authentic performance tasks.

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Table 2 displays the level of proficiency of Grade 11 learners in Science a semester after exposure to SIM intervention. The learners at this level surpass the requirements for fundamental knowledge, abilities, and comprehension and can transfer them naturally and flexibly through authentic performance assignments. The learners' MPS of 98.41% indicated an "Advanced" level of proficiency. Additional findings indicate that Science education will be improved when available, sufficient, and strategically developed instructional and intervention materials are suited to the diverse student population [1], [49]. Among those presented, the most suitable and applicable to this present study is that of the Cognitive Load Theory [31], [37]. Cognitive Load Theory was developed to provide suggestions for presenting information in a way that stimulates behaviors that enhance academic performance among learners.

4.2 Difference in the Level of Proficiency Right After and a Semester after Exposure to SIM Intervention

Table 3 shows the significant difference in the level of proficiency right after and a semester after exposure to SIM intervention. Based on the findings, the mean is 26.14 after SIM intervention, while a semester after SIM intervention, the mean is 26.50. The *p*-value of 0.023 is lesser than the alpha at 0.05, which leads to the rejection of the null hypothesis. There is a significant difference in academic performance right after and a semester after exposure to SIM intervention.

Table 3. Significant difference in the level of proficiency right after and a semester after exposure to SIM intervention.

Measure 1	Measure 2	Test	Statistic	*p*	Effect Size	95% CI for Effect Size Lower	95% CI for Effect Size Upper
Post-Test	Post-Post Test	Wilcoxon	12.000	0.023	-0.692	-0.904	-0.209

Note. The effect size is given by the matched rank biserial correlation.

In general, SIMs enable students to surpass the fundamental knowledge, abilities, and comprehension criteria and transmit them automatically and flexibly through authentic performance tasks. Hence these results better and improve the academic performance of the students. In addition, As stipulated in the DepEd Order No. 39, s. 2012, interventions must be made to arrest the further decline in Science achievement. Finally, a semester after using SIM materials, the Retention level of science concepts among STEM students is improved. Studies have proven that instructional materials have a high correlation with the academic achievement of secondary school students [45]–[49], [52]. This strategy should be considered and utilized frequently in the classroom by educators.

5. Conclusion

In terms of knowledge, skill, and comprehension, the level of competence of Grade 11 Learners in Science one semester after exposure to SIMs exceeds the minimum standards, and they can transfer this proficiency automatically and flexibly through authentic performance tasks. Time and using SIM materials improved the Retention level of Science concepts among Grade 11 STEM students at Northern Negros Oriental.

The main implication derived from this study relates to the level of proficiency after exposure to SIM and the retention level of Science concepts after using SIMs. Given the promise that SIMs improved students' performance, the researcher confirmed that the SIMs could retain science concepts and improve proficiency since the study's results indicated "Advanced" in its verbal equivalent.

The result of this study disclosed that SIMs could aid concept retention of Science in Senior High School STEM students after a semester, which merits a good recommendation.

6. Recommendations

Strategic Intervention Materials must be used for students needing remediation for a topic to improve their academic performance and retain science concepts. The curriculum planner may consider enhancing the existing SIM training workshop program, especially for the Science majors, on creating and innovating instructional materials. DepEd Memo No. 117, s. 2005, entitled ―Training Workshop on Strategic Intervention Materials (SIMs) for Successful Learning, provided secondary Science teachers the training to prepare SIMs. Thus, the K to 12 science educators must have a more profound knowledge of crafting and designing instructional intervention materials, particularly SIM. With regards to academic performance using intervention materials, this may serve as a basis for prospective researchers on conducting a further study in teaching-learning activities and students' academic performance as it is revealed that when available, sufficient, and strategically prepared instructional an intervention materials appropriate for the plurality of learners are at hand, Science education will be improved.

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