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Project SWORD-MMs: Science Words Optimisation via Reading and Devised Mind Maps to Develop Student's Metacognition

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Abstract

The study aimed to determine the effect of Project SWORD-MMs: Science Words Optimisation via Reading and Devised Mind Maps to develop students' cognition. Specifically, it sought to answer to what extent student's manifest metacognition as they engage in Project SWORD-MMs: Science Words Optimisation via Reading and Devised Mind Maps. It has been a combination of qualitative research and quantitative research. The study was conducted at Luis Aguado National High School in Trece Martires City, Cavite, Philippines. The study participants were 40 students in the control group and 35 in the experimental group; totalling 75 from the 7th, 8th, 9th, and 10th graders. They were carefully chosen students through a collaboration with English teachers, considering their overall reading level to determine the probable respondents and categorise them as frustrated students. As a qualitative study, triangulation was done by conducting interviews and gathering documentation of the students' reflections and feedback about the compensatory interventions. As researchers, observation was done during the activity, which was recorded in the Learner's Progress Monitoring Report. All clarifications regarding the students' thinking and doing were recorded. In addition, some sessions were also recorded and accomplished the document analysis. Quantitative analysis was used to determine if there was a significant difference in the achievement level and metacognition of the students before and after engagement with Project SWORD-MMs as a compensatory intervention. The present study has attempted to intensify collaboration and peer tutoring among science teachers to transform and develop the potential and skills of learners. The identified students in the frustration level were promoted to instructional and independent levels. They were able to enhance their science vocabulary knowledge, improve their reading comprehension, and develop metacognition, thinking, and creativity. Finally, these significant actions could withstand great foundations in promoting quality and inclusive science education among our learners. As the greatest slogan of the school is 'Excellence, Reaching Out, Sacrifices' no learners will be left behind. Nourishing the skills and potential of the learners would greatly contribute to transforming quality education and sustainable programmes for them.

Keywords: Science and Mathematics Integration, STEM Integration, Teacher beliefs, Teacher perception

Introduction

Based on the article entitled "The Science of Reading Comprehension" written by Nell K. et al. (2021), it was stated that comprehension instruction should begin early, teaching word-reading and bridging skills to support reading comprehension development. Relatively, for a real situational background at Luis Aguado National High School, 25 out of 45 students in the class had difficulty understanding science vocabulary words, especially when introducing new lessons. Based on the interview, it was denoted that they feel confused, affecting their level of understanding. That is the reason why one integral and resilient intervention to address these gaps is Project SWORD-MMs: Science Words Optimisation via Reading and Devised Mind Maps to Develop Student's Metacognition. Moreover, as we appreciate and look at the significance of science to mankind and the efforts of researchers to develop its teaching

and learning, the achievement of students in the subject remains low in the Philippines. Specifically, the results of the National Achievement Test in science subjects of high school students in Trece Martires City are shown in this table for the past five years.

Table 1. National Achievement Tests in Science among Students in Trece Martires City (Based on the data of Division of Cavite)

Name of School	Mean Percentage Score				
	2014-2015	2015-2016	2016-2017	2017-2018	2018-2019
Luis Aguado National High School	49.75%	51.39%	35.34%	35.67%	36.30%

As shown in Table 1, it emphasises the results of the National Achievement Test of Luis Aguado National High School and refers to the data analyses in terms of mean percentage score. The performance of the students shows a discrepancy and has not achieved the 75% criterion. This assessment is based on the National Achievement Test administered by the Department of Education (DepEd) in the Philippines. It is a set of standardised tests administered to fourth-year high school students cited in the Philippine Basic Education-NAT Overview and Test Results School Year 2018-2019.

Table 2. Target Percentages of the TIMSS 2023 Science Assessment Devoted to Content and Cognitive Domains at the Fourth and Eighth Grades.

Fourth Grade	
Content Domains	Percentages
Life Science	45%
Physical Science	35%
Earth Science	20%
Eighth Grade	
Content Domains	Percentages
Biology	35%
Chemistry	20%
Physics	25%
Earth Science	20%
Fourth Grade	
Cognitive Domains	Percentages
Knowing	40%
Applying	40%
Reasoning	20%
Eighth Grade	
Cognitive Domains	Percentages
Knowing	35%
Applying	35%
Reasoning	30%

Based on the TIMSS 2023 Science Framework published by Victoria AS. Centurino and Dana L. Kelly mentioned that content domains vary between the fourth and eighth grades, reflecting the differences in the nature and difficulty of the science curriculum at each grade. Relevantly, in 2023, TIMSS Science will assess essential science practices. Moreover, the three cognitive domains (knowing, applying, and reasoning) are the same in both grades, encompassing the range of cognitive processes involved in learning, applying, and reasoning these science concepts.

In the Philippines, Torres (2019) states that reading is one of the most essential skills and a starting point for the individual to learn everything around him. An emphasis that it is fundamentally important to attain and achieve learning in school and throughout life. Another point is that reading comprehension is the ability to define word by word and create a profound idea from the talks given or read, as quoted by Caraig and Quimbo (2022). Globally, it was published by Duke et al. (2021), the syntheses of the research documenting the following: (1) Reading difficulties have a number of causes, not all of them align with decoding and listening comprehension as posited in the simple view; (2) instead of solely influencing reading independently, as conceived in the simple view, decoding and listening comprehension (or, using more commonly used terms today, word recognition and language comprehension) overlap in important ways; and (3) there are many contributors to reading not named in the simple view, include as active, self-regulatory processes that play a substantial role in reading. Science performance is highly affected by students' reading comprehension. According to Mousavian and Siahpoosh (2018), one of the factors that have been identified is the efficacy of pre-teaching vocabulary pre-questioning strategy in improving reading comprehension. This study proved that effective reading strategies are an effective means to support students in their academics. Related to this, Suwanaroa (2021) study examined the factors affecting reading comprehension problems among 2nd, 3rd, and 4th-year students at the Rajamagala University of Technology Lanna Tak. Based on the result of the study, students reflected different perceptions related to the reading problems and the factors that impacted their reading comprehension.

Metacognition is a fundamental skill in learning. However, some students fail to deliver strong metacognitive skills in Science (Dori *et al*., 2018). This study seeks to introduce a new intervention method to the selected students of Luis Aguado National High School in the full-face-to-face classes. This approach aligns with the proposed intervention plan to achieve a solid desired outcome for developing the students' metacognitive skills through reading and devising mind maps. By introducing the intervention through Project SWORD-MMs, the researchers anticipate a significant outcome that will enhance the different stages of metacognition and improve the existing intervention practices within the school.

Based on the study by Sentyawati (2022), it was shown that the students have a positive perception of the use of mind mapping as a visual learning tool. Most of the students agreed that mind mapping could help them make summaries and take notes, allowing them to be more creative and helping them develop their ideas. Moreover, when used for group brainstorming sessions, mind mapping enhanced critical thinking and cooperation, providing a solid basis for collaborative problem-solving. According to Setianingsih et al.' thinking processes, wherein they are asked to move from one topic to another. This concept was also cited by Saori, S (2020), indicating that the use of mind mapping significantly affects students' reading comprehension.

With these immense related studies and an enduring science reading-comprehension intervention, the Project SWORD Version 1.0 was initiated in the previous school year,

consequently, is upgraded into the new version called Project SWORD-Mms. It is a sustainable learning recovery SPARKS programme of S.Y. 2022-2023. The participants will be struggling learners in the frustration level and students who are in the remediation programmes during Independent Cooperative Learning. A letter of intent and project proposal will be submitted to the school head for approval. Then, a planning meeting with the science teachers such as preparation for the profiling of targeted participants, matrix, and schedule of the programme will be conducted. The next step is securing consent from the parent/guardian of the struggling learners under Project SWORD-MMs as well as orientation of the programme and the targeted participants. This will be done every Friday during Independent Cooperative Learning. After that, there will be updating and tracking the Learners Progress Monitoring Report. At the end of the assessment and evaluation, it is expected that identified students in the frustration level will be promoted to instructional and independent levels. They were able to develop their science vocabulary knowledge and improve their reading comprehension and metacognition.

Through the collaborative effort of science teachers and a partnership with English teachers of Luis Aguado National High School, a transformative intervention aims to empower science vocabulary words and concepts via reading and devised mind maps. As the greatest slogan of the school, "*Husay, Kalinga at Sakripisyo, Dito sa Luis Aguado, walang batang maiiwan… #Bayanihan ng Pamilyang LANHS*". As a sustainable avenue towards learning recovery to help struggling learners improve their ability and comprehension as well as critical thinking and, surprisingly, their creativity. With a unified goal to develop the level of metacognition of the students via reading and devised mind maps toward inclusive and resilient quality science education.

Materials and Methods

The study was conducted at Luis Aguado National High School in Trece Martires City, Cavite, Philippines. The study is a mixed design. It has been a combination of qualitative research and quantitative research. This study will be a qualitative look at how students' metacognition in science improved as a result of using Project SWORD-MMs (Science Word Optimisation via Reading and Devised Mind Maps) in teaching. Being a qualitative study, triangulation was done via interviews and documentation of the students' reflections and feedback about the compensatory interventions. As researchers, observation was done during the activity, which was recorded in the Learner's Progress Monitoring Report. All clarifications as to what the students are thinking and doing were recorded. In addition, some sessions were also recorded and accomplished the document analysis.

Quantitative analysis was used to determine if there was a significant difference in the achievement level and metacognition of the students before and after engagement to Project SWORD-MMs as compensatory intervention. Furthermore, it was used to determine if there is a significant difference between the initial, during and final implementation of Project SWORD-MMs among and if there is a significant correlation between the students' metacognition and achievement level in science.

The participants were 40 students in the control group. They were engaged into empowering science vocabulary words via drills. Another 35 students in the experimental group wherein they utilised devised mind maps while empowering science vocabulary words via reading cum drills. A total of 75 students from 7^{th}, 8^{th}, 9^{th}, and 10^{th} graders, they were carefully chosen students through a collaboration with English teachers, considering their overall reading level to determine the probable respondents and categorise them as frustrated students.

Adopting the Inventory Metacognitive Awareness Inventory developed and validated by Schraw and Dennison (1994) is a 52-item questionnaire that was used as an instrument to determine the metacognitive behaviour of the students. It was divided into two constructs, namely: (1) Knowledge of Cognition and (2) Regulation of Cognition. The study was conducted in four phases. The four major phases of the study are presented below:

Table 3. Phases of the Study

Phase	Activities	Instruments Needed
1	- Validation of Research Instruments - Adopting Metacognitive Awareness Inventory	- Modified Metacognitive Awareness Inventory Survey Form
2	Pre-testing	- Quality Assured Science Vocabulary Words Sheet
3	Teaching Proper	- Engaging Students into - Project SWORD-MMS - Integration of Reading and Devised Mind Maps during the Intervention Programme and Independent Cooperative Learning every Friday
4	- Post-testing and Conduct of Individual - Interview	- Quality Assured Science Vocabulary Words Sheet - Document Analysis - Student's Progress Monitoring Report

As cited by Peter Yongqi Gu (2018) in his paper presented evidence of content validity, construct validity, internal consistency reliability, and predictive validity. It also provides suggestions for interpreting and using the questionnaire for both research and instructional purposes. Therefore, the first phase of the study was the validation of a modified instrument survey form to assess the metacognitive behaviour of the students. The students were categorised with low, intermediate, and high metacognitive behaviours. Secondly, it involved comparative analysis via the administration of pre-test focusing into Science Vocabulary Words based on the least mastered learning competencies. The questionnaires were validated by the Division Learning Resource Evaluator in Science by Ms. Dianne Therese V. Perido, dated September 2022. She suggested aligning test items based on the cognitive domain of the learners.

The third phase of the study was done in four weeks (the 2nd week of October 2022 up to the 1st week of November 2022). Based on the study conducted by Hasanah et al. (2018), wherein they applied the mind mapping strategy and facilitated the applications. Throughout the teaching proper and engagement to Project SWORD-MMs, students were able to grasp and improve their level of comprehension. Throughout the unit, the students process and add information. Optimising and understanding science vocabulary via reading and devised mind maps were conducted every Friday from October to November 2022. The 40 students in the control group were engaged into empowering science vocabulary words via drills, while the 35 students in the experimental group were engaged in empowering science vocabulary words via reading drills as well aided by devised mind maps.

The final phase of the study was conducted for two (2) weeks, dated the 3rd and the 4th week of November 2022. It involved the administration of the post-test and the conduct of the interview. As cited again by Peter Yongqi Gu (2018) for the reliability and interpretation of the study if there is a significant difference between the control and experimental group. Questions were thrown to the identified students under the compensatory intervention to seek their perceptions and takeaways from Project SWORD.

Result and Discussion

The study attempted to find out the effectiveness of the 75 students in the control group (40 students) and experimental group (35 students), wherein both groups took the metacognitive behaviour assessment as the initial procedure of the study then comparative analysis of the result of the pre-test and post-test after they are engaged in Project SWORD-MMs (Science Word Optimisation via Reading and Devised Mind Maps) as a compensatory intervention to assist struggling learners who had least mastered and low comprehension in Science at Luis Aguado National High School. Afterwards, they were interviewed and gave their feedback about programme implementation.

One of the findings of the study revealed that the control group and experimental group significantly improved metacognition among the identified students based on the comparative analysis as they engaged in Project SWORD-MMs.

Table 4. Result of Pre-Test and Post-Test as Identified Students Engaged in Project SWORD-MMs (Science Word Optimisation via Reading and Devised Mind Maps

Comparative Analysis of Pre-Test & Post Test				
1st week and 2nd week of October 2022				
Control Group	PRE-TEST		POST-TEST	
	Mean	SD	Mean	SD
40 students	77.67	1.55	79.35	4.6
Experimental Group	Mean	SD	Mean	SD
35 students	75.83	3.37	79.3	3.7
3rd week and 4th week of October 2022				
Control Group	PRE-TEST		POST-TEST	
	Mean	SD	Mean	SD
40 students	80.2	3.44	83.75	4.14
Experimental Group	Mean	SD	Mean	SD
35 students	80.29	3.32	80.81	3.37

From Table 4, there is comparative analysis on the result of the pre-test and post-test among the 40 students in the control group and 35 students from the experimental group. Based on the pre-test result from the control group, the mean value is 77.67 wherein it was administered prior to engagement in Project SWORD-MMs (Science Word Optimisation via Reading and Devised Mind Maps), and it significantly increased the mean value to 79.35 after exposing and utilising the programme in teaching every Friday during the Independent Cooperative Learning. Relatively, on the pre-test result from the experimental group, the mean value is 75.83 wherein it was also administered prior to engagement in Project SWORD-MMs (Science Word Optimisation via Reading and Devised Mind Maps) and there is also a significant increase in the mean value 79.3 after exposing and utilising the programme in teaching every Friday during the independent cooperative.

On the second attempt, there is also a significant difference from the pre-test and post-test before and after engaging the identified students in Project SWORD-MMs (Science Word Optimisation via Reading and Devised Mind Maps).

This graphical analysis shown below in Figure 1 compares the pretest of two groups: the control group composed of 40 students and the experiment group having 35 students. It interpreted that both groups took the pre-test before engaging themselves into Project SWORD-MMs (Science Word Optimisation via Reading and Devised Mind Maps).

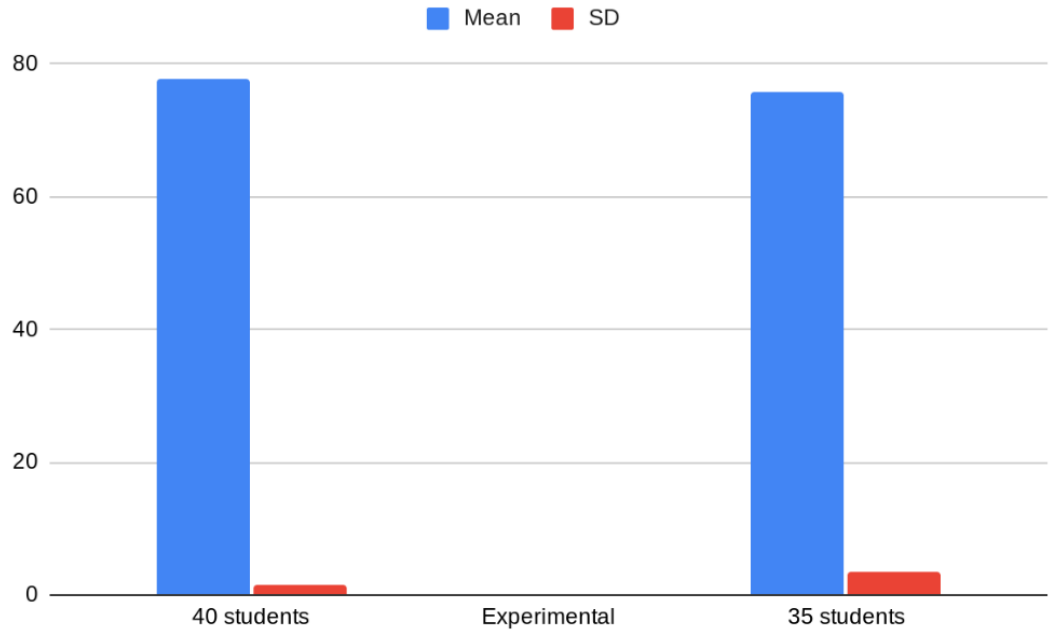

Figure 1. Result of Pre-Test of Control Group and Experimental Group before engaging to Project SWORD-MMs (Science Word Optimisation via Reading and Devised Mind Maps)

To compare the significant differences before and after engaging the identified students, the graphical analysis shown below depicted a significant difference in the level of metacognition of both groups as they engaged in Project SWORD-MMs (Science Word Optimisation via Reading and Devised Mind Maps).

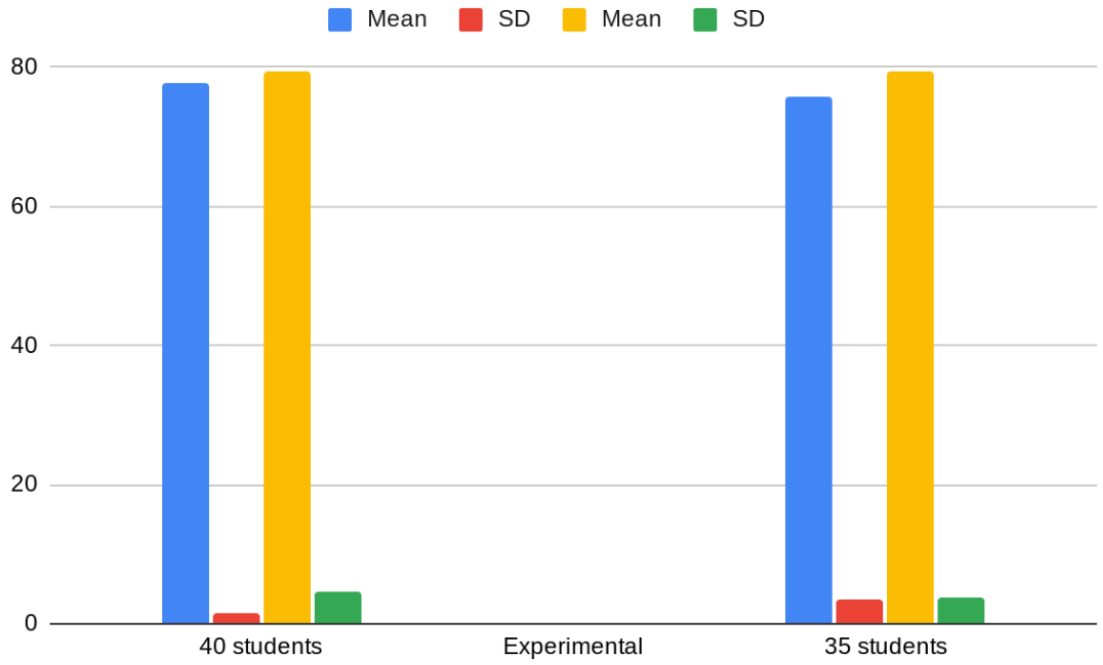

Figure 2. Result of Pre-Test and Post Test of Control Group and Experimental Group before and after engaging to Project SWORD-MMs (Science Word Optimisation via Reading and Devised Mind Maps)

In Figure 2, the pretest result from the control group is 77.67 and after exposure to the programme, it significantly increased to 79.35 on their post-test. While from the experimental group, the mean initial is 75.35 and after engaging the identified students in the experimental group, there is a significant increase to 79.3.

Similarly, the effectivity of the programme will be verified on the result in Table 1 Result of Pre-Test and Post Test as Identified Students Engaged in Project SWORD-MMs (Science Word Optimisation via Reading and Devised Mind Maps) showing on the second trial on the 3rd and 4th week of October,2022 there is significant changes while identified students underwent on the implementation of the programme.

In 2021, UNESCO adopted the first global recommendation for open science, so that knowledge is no longer the privilege of a minority, but a common good accessible in a more equitable way. This was immensely manifested in the study wherein English and Science teachers of Luis Aguado National High School fostered immense partnership to develop the reading and comprehension of our learners. The result was the identified 75 students in frustration level were promoted to instructional and independent level. They were able to develop their science vocabulary knowledge and improve their reading comprehension and metacognition. Evidently, the study has attempted to intensify collaboration and peer tutoring among teachers to transform and develop the potential and skills of learners.

For the teachers, enhancing their pedagogical approaches in uplifting the achievement level and utilising it as a tool for class intervention and recognise Mind Mapping as a fun, interesting and motivating approach to science. Relatively, upskilling training sessions such as utilisation of Information, Communication and Technology as an innovative tool and upgraded PROJECT SWORD-MMs: Science Words Optimisation via Reading and Devised Mind Maps on their development and metacognition.

For the curriculum, based on Baron and Cruz (2023) who aims to add knowledge on the implementation of the Spiral Progression Approach with a special focus on its

volatility, uncertainty, complexity, and ambiguity/ This serves the basis of future programmes and policies to illuminate the current set of understanding about this educational reform programme developing approaches and strategies that may improve the national achievement level and apply this in the spiral progression in science.

The results of the study support using PROJECT SWORD-MMs: Science Words Optimisation via Reading and Devised Mind Maps to develop student's metacognition and a successful tool in helping low achievers improve their grades. Nevertheless, PROJECT SWORD-MMs: Science Words Optimisation via Reading and Devised Mind Maps may become effective for high achievers too as they nurture their high order thinking skills through I-Mind map application.

While promising, the results of this on using PROJECT SWORD-MMs: Science Words Optimisation via Reading and Devised Mind Maps are not conclusive. Consequently, more research should be conducted to test further the effect of PROJECT SWORD-MMs: Science Words Optimisation via Reading and Devised Mind Maps as a compensatory intervention with a larger number of students, in different types of schools, and for different age groups. Other areas for further investigation include the amount of time needed to reap the benefits of using mind maps as reading-comprehension tool in a classroom setting and the possible benefits derived from using computers in the process.

Finally, these significant actions were able to withstand great foundations in promoting quality and inclusive science education among our learners. As the greatest mantra of the school, "*Husay, Kalinga at Sakripisyo, Dito sa Luis Aguado, walang batang maiiwan"*. Nourishing the skills and potential of the learners would greatly contribute to a more sustainable new normal possibilities and opportunities for them.

Conclusion

The study attained the goal of determining the effect of PROJECT SWORD-MMs: Science Words Optimisation via Reading and Devised Mind Maps wherein identified students under the programme had a significant development in their metacognition. Specifically, it was achieved during the implementation and engagement in PROJECT SWORD-MMs: Science Words Optimisation via Reading and Devised Mind Maps. Correlatively, there is a significant difference in the achievement level and metacognition of the students before and after engagement in Project SWORD-MMs as a compensatory intervention. The study also showcased an immense collaboration and peer tutoring among science teachers to transform and develop the potential and skills of learners. The identified students in the frustration level were promoted to instructional and independent levels. In most interviews and student's feedback is positive and the researchers suggest the PROJECT SWORD-MMs: Science Words Optimisation via Reading and Devised Mind Maps shall be adopted by other learning areas or subject areas. Looking forward as days go by, the effective use and implementation of PROJECT SWORD-MMs: Science Words Optimisation via Reading and Devised Mind Maps will be one of the optimum solutions to address learning gaps, and it will make learning easier for learners at Luis Aguado National High School and a way forward to other neighbouring learning institutions.

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