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Director's Message

Dear readers,

It is my pleasure to once again greet you, our dearest readers, in SEAQIS Journal of Science Education (SciEd) volume 3, issue 2. Through SciEd, SEAQIS realises that teachers and education personnel need a platform to show their innovation in written works. Therefore, we are committed to being a liaison between these writers to reach science-loving readers.

As SEAQIS' vision aims to be the Centre of excellence in the professional development of teachers and education personnel in science towards sustainable development in Southeast Asia, we collaborate with authors from this region to present high-quality and up-to-date research.

I would like to take this opportunity to express my most profound appreciation to the authors, SEAQIS staff, and other parties for their contribution that made this publication possible. In addition, this is the last time I will be able to address our beloved readers through SciEd. Due to the upcoming year 2024, I will no longer be able to accompany SEAQIS on its journey. Hence, I hope that SciEd can make a real contribution to the development of science education in the near and distant future. I also encourage SciEd writers and readers to rise and realise their love for science, one of which is through research. Dare to innovate!

Sincerely,

Dr Indrawati
Director, SEAMEO QITEP in Science

From the Editor-in-Chief

Greetings and welcome to the 3rd volume, issue 2 in SEAQIS Journal of Science Education (SciEd). Firstly, I extend my sincere appreciation to all the authors, the Editorial Board, the designer, the Publishing Office Staff, and everyone who has contributed to this publication. Your endeavours have been instrumental in bringing this journal to fruition.

Quoting Stephen Hawking, who said, "Intelligence is the ability to adapt to change," I acknowledge that, despite the hard work, there may be areas where improvements can be made in this issue. Therefore, I encourage readers to provide constructive criticism, comments, and suggestions. Your feedback is essential for enhancing the quality of SciEd.

Furthermore, I kindly invite you to contribute to the enrichment of this journal by submitting your best articles for consideration in upcoming volumes. Your contributions will not only improve this journal but also contribute to the broader landscape of scientific understanding.

Thank you for your support and encouragement. Let us, hand in hand, strive for the advancement and enrichment of science education.

Warm regards,

Dr Elly Herliani

Editor-in-Chief

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Research Paper Open Accsess

A Systematic Literature Review on the Perceptions of Teachers of STEM Integration

John Michael A. Guerzon*[1] and Stephenie O. Busbus[1]

[1]*School of Advanced Studies, Saint Louis University, Baguio City 2600*
[*]*Corresponding author, e-mail: jmaguerzon@slu.edu.ph*

Abstract

Low academic performance of students has always been a challenge in science and mathematics education despite the introduction of different constructivist approaches, like STEM integration, to promote student learning. The beliefs and perceptions of teachers about a certain approach were believed to shape curriculum implementation. This necessitates a review of the perceptions of teachers of STEM integration. PRISMA 27-item components of reporting systematic literature review were employed to extract patterns relevant to the benefits, challenges, and recommendations identified by K-12 teachers. From n=721, only five research articles were left for final review after a four-phase screening process. Teachers generally view STEM integration as promoting student achievement (problem-solving skills) and motivation or interest. There is an emerging view that science integration in mathematics instruction is stronger than mathematics integration in science instruction. Interestingly, a misperception was identified about technology education integration. This implies incorporation of STEM integration concepts in the undergraduate curriculum as teacher preparation was identified as one of the main problems on which improvements may be focused. The lack of equipment to support technology education integration as well as the appropriate skills needed to deliver the lesson was another emerging theme. In turn, the need for upskilling programmes to support the teachers in delivering 21st-century learning approaches is emphasised. Content knowledge is a prerequisite to pedagogical knowledge. To implement STEM integration, teachers need to know the contents of the different disciplines integrated.

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

Introduction

In the Programme for Student Assessment (PISA), the Philippines was ranked second lowest in mathematics and science among 79 countries that participated in the assessment. This prompted the Department of Education (DepEd) to provide additional policies to address this concern (Haw *et al.,* 2021). Golla and Reyes (2020) revealed in their analysis of Grade 7 to10 mathematics curriculum vis-à-vis the PISA mathematics literacy framework that there was a misalignment, especially in terms of competencies related to interpretation, evaluation, and higher-level reasoning skills. It was emphasised that applications to real-life and practical situations must be expanded in the curriculum. In the introduction section, the authors did not state the objectives of the work at the end of the section. In addition, the authors did not provide an adequate background and very short literature survey to record the existing solutions/methods, to show the best of previous research, the main limitation of the previous studies, the outcomes (to solve the limitation), and the scientific merit or novelties of the paper.

In another study, the alignment between the mathematics teacher education curriculum in the Philippines and the 2021 PISA mathematics literacy framework was examined. There was an observed alignment of PISA mathematics literacy standards with those of programme outcomes, performance educators, and course descriptions of the mathematics teacher education curriculum (graduates before SY 2021 to 2022). However, some of the performance outcomes and indicators of the mathematics teacher education curriculum are too broad to target the specific standards of PISA. In addition, there are concerns with the standards involving applications in different contexts. In general, this may indicate that the CHED-mandated courses do not fully satisfy the standards of PISA; hence, TEIs cannot fully produce the desired quality of mathematics teachers (Balagtas, 2021). This only articulates the need to review the preparation of pre-service and in-service teachers in terms of content and pedagogical knowledge in mathematics education to meet such international standards.

Based on the Trends in International Mathematics and Science Study (TIMSS), another international assessment, Balagtas et al. (2019) and Mullis et al. (2020) revealed that the results of all assessments indicate poor performance in mathematics and science competencies. In their examination of the alignment of the mathematics and science competencies in the current curriculum assessed in TIMMS, they found out that grade 4 mathematics and science curricula are more aligned with the TIMSS 2015 assessment framework than the grade 8 mathematics and science curriculum (95% alignment and 88% alignment versus 85% alignment and 61% alignment, respectively). The mathematics curriculum is generally more aligned with the said framework than the science curriculum. This gap in the curriculum needs to be addressed, and this could offshoot into another concern in the educational scene.

Mathematics and science curricula are intertwined because computational skills that are needed in their science subject (i.e., physics that is written in the DepEd curriculum guide as Force and Motion) are acquired in the students' mathematics subjects. Moreover, to concretize abstract concepts in their mathematics subject, teachers can anchor them on scientific information that can be taken up in their science lessons. Another constructivist approach to integrate these topics is through STEM integration which considers Science, Technology, Engineering, and Mathematics disciplines.

Science and mathematics integration has been reviewed for decades driven by the movement to integrate curricula from the discipline-based curriculum. There is a need for science and mathematics integration. Mathematics is an abstract subject, and the sciences can provide realistic examples to concretise these mathematics concepts. They both share the goal of promoting problem-solving skills (Basista & Mathews, 2002).

Kiray (2012) developed a model that integrates science and mathematics that is suited to the context of the teachers in Turkey, which is called the Balance Model. There are five integration approaches that can be derived from this model summarised in Figure 1.

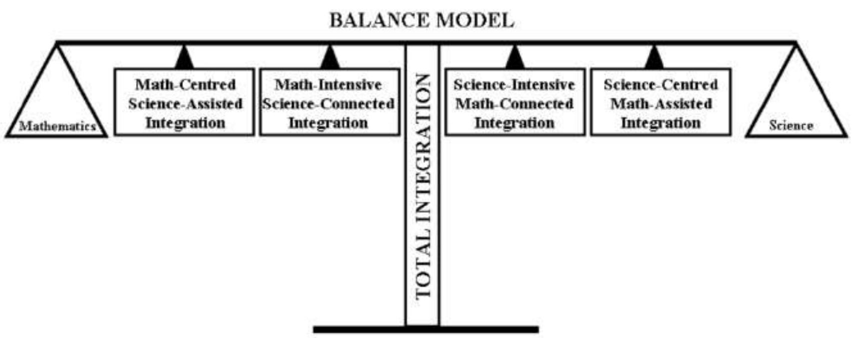

Figure 1. Mathematics and science content knowledge integration for each approach.

Several studies say that mathematics and science learning complement each other with the goal of increasing student achievement. Satchwell and Loepp (2002) reported that mathematical content and skills promote students' understanding of their science courses. Moreover, in two separate studies, Koirala and Bowman (2010) and Berlin and White (2010) point out in their empirical work that scientific content can reinforce out-of-mathematics applications to make learning in this subject more meaningful. Conflicting ideas concerning the sequence of science and mathematics content in the integration of these two subjects, there are studies stating that mathematics concepts must be presented before science. There are also those indicating that science and mathematics content is to be presented simultaneously. Kiray and Kaptan (2012) investigated the effectiveness of Science-Intensive Mathematics-Connected Integration to students and found out that achievement level is increased with the use of the experimental approach. No other studies were conducted to examine the effectiveness of other approaches in the balance model.

The study sought to review existing literature about the perceptions of elementary and high school teachers about STEM integration. The following questions were answered to evaluate the literature:

1. What do the teachers believe as the benefits and challenges of STEM integration in the classroom?
2. What are the recommendations needed by these teachers to implement STEM integration in their classrooms?

Methodology

This study was guided by the 27-item components of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement for reporting systematic literature studies. To be selected for review, the research articles must be peer-reviewed empirical research studies. The most recent systematic literature review was conducted by Margot and Kettler (2017) and published in the International Journal of STEM Education. With this, the criteria for the timeframe of the review will start from 2016 to 2022. The research article should also include information that could at least answer one of the research questions identified. Academic Search Complete and Education Resources Information Center (ERIC) databases were searched via Elton B. Stephens Company Host (EBSCOhost).

To ensure thoroughness, articles found were rechecked in Google Scholar. Through the suggestion of Haddawayet et al. (2015), the first 300 results in Google Scholar will be considered. One research article that is unique to Google Scholar was added to the review. The last search was done on 9 August 2022.

Table 1. Inclusion and Exclusion Criteria

Parameters	Inclusion Criteria	Exclusion Criteria
Timeframe	Research articles published from 2016-2022	Research articles published before 2016-2022
Type of Research	Primary research articles that are published in peer-reviewed journal publications	Systematic reviews, editorials, books, and other non-primary research documents
Participants	Study participants included teachers in the K-12 levels	Study participants included teachers who are not in the K-12 levels

Research Design	Empirical Studies (includes qualitative, quantitative, mixed-methods, and meta-analysis)	Studies that are not empirical
Language	Research articles published in English	Research articles that are not published in English
Database	Research articles in Academic Search Complete and ERIC via EBSCO	Research articles that are not in Academic Search Complete and ERIC via EBSCO

The search terms that were placed via the advanced search setting of EBSCOHost are "teachers, perceptions, beliefs, or attitudes," and "STEM education or science, technology, engineering, and mathematics education". Restrictions were placed, such as the availability of the complete text, the article must be peer-reviewed, and others that align with the inclusion and exclusion criteria presented in Table 1.

Nine articles were retained after the screening process as shown in Figure 2. Consider that the previous systematic literature conducted by Margot and Kettler (2017) was undertaken only five years ago and reviewed 29 articles in the timeframe inclusion criteria of 2000-2016.

Considering the article-to-number-of-year ratio, this study and the previously shown systematic literature review are almost proportionate. The quality of the research articles was evaluated with the use of a rubric that was introduced by Margot and Keller (2017), cited from the work of Mullet (2006). This led the researcher to retain five research articles for review.

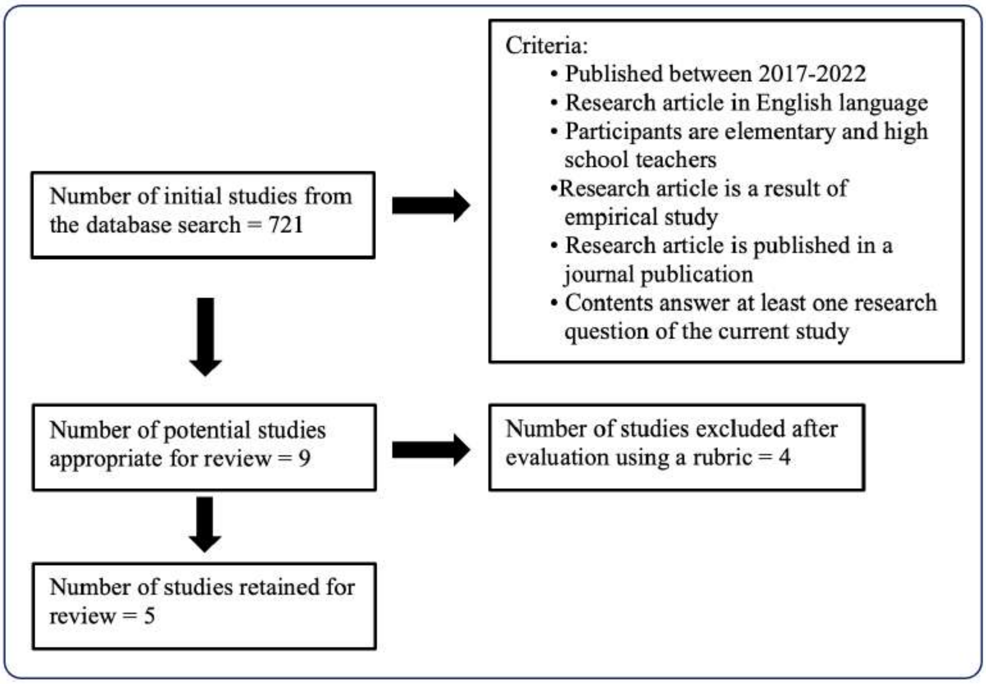

Figure 2. Research Article Screening Process

Thematic analysis was utilised as a method of reporting the different patterns formed from the data. Six phases of thematic analysis suggested by Braun and Clarke (2006) were used in data analysis.

Results and Discussion

1. Perception of Teachers on STEM Integration

1.1. Positive Impacts of STEM Integration on Learners

Reviewed articles reveal that teachers perceive STEM integration to benefit student learning. Two prevailing themes are related to this perception. First, STEM integration promotes academic achievement, as all articles point out that problem-solving skills are developed by providing real-life and concrete examples through this integrative approach. AlMuraie et al. (2021) added that STEM integration is perceived as a way to provide a conducive learning environment for these cognitive skills to be acquired. Sen and Ay (2017) and Fırat (2020) further explained that higher-order thinking skills are targeted through this integrated approach because it concretises the ideas by giving real-world examples and also improves the attention of the learners; hence, enhancing the retention of concepts.

Second, teachers perceive STEM integration to have a positive effect on student motivation. Participants in the study of Stubbs and Myers (2016) have provided examples such as having more students venture into STEM-related (agriculture) courses and careers in the future. Since models are given in this integrative approach, it may be due to the concept that it is more hands-on (Fırat, 2020) and real-world problems and applications are presented, making it more relevant to the learners.

1.2. Weaker Mathematics Integration

Teachers generally view that STEM integration is possible, although there are other contradictory views revealed in some of the responses of the teachers. One of the participants in the study of Sen and Ay (2017) said that Mathematics is unrelated to any other discipline, considering that it is a part of their undergraduate preparation. Also, in Fırat's (2020) work, one of the partakers mentioned the inapplicability of STEM integration in every subject. Although, all of the studies reviewed point out that Mathematics and Science are easily integrated.

It is noteworthy that the integration of mathematics and engineering concepts is viewed to be weaker compared to others; that is, there is more integration of science in mathematics instruction versus mathematics in science education. Hence, Sen and Ay (2017) said that the integration process weakens teaching. This also led the researchers to recommend the inclusion of integration practices in the undergraduate curriculum to solve this. In Kiray's (2012) Balance Model that presents how content knowledge in science and mathematics integration is introduced, their results point out that Science-Centered Mathematics-Assisted Integration (SCMAI) is more observed than Mathematics-Centered Science-Assisted Integration (MCSAI). The other reviewed articles further supplemented this finding. Asli and Zsoldos-Marchis (2021) stated that physics is the discipline where most mathematics applications are introduced. Moreover, Sen and Ay (2017) said that most of their teacher respondents believed that Mathematics is related chiefly to science compared to other disciplines.

1.3. Misperception of Technology Education Integration in Mathematics

Another important component of STEM integration is technology education. It is important to take note of the distinction between technology education and technology-assisted instruction. Stubbs and Myers (2016) found a misperception in the teachers' responses that technology integration in instruction is included as part of STEM education. STEM education concerns learning about the use of technology. Interestingly, Sen and Ay (2017) reported that most participants have a positive view of technology integration in mathematics. They view technology integration in coded responses as "solving mathematics problems," "visualising the geometric objects," "watching the video," "simulation," and "homework". It can be observed that the idea of the teachers of technology integration is in instruction. It is supported by the last codes they were able to form which is about integrating technology to make mathematics instruction effective. This misperception may be further supported by the findings of AlMuraie et al. (2021). The teachers' least common interpretation of the definition of STEM is that it is about using simulation software to predict engineering design performance and developing engineering practices for creating engineering designs as well as testing them with scientific problem-solving skills.

2. Recommendations for the Improvement of STEM Integration

2.1. Teacher Preparation Programmes

It was acknowledged in all of the reviewed articles the significant role of teacher preparation in implementing STEM integration. In the study of AlMuraie et al. (2021), a difficulty in teacher preparation is identified, leading them to recommend stronger programmes that target the professional development of the teachers. In addition, Fırat (2020) suggested that pre-service training can be provided using engineering and technology-based learning because the participants identified them as the areas in which they need support. Moreover, Sen and Ay (2017) said that the participants did not receive an education that prepared them to integrate science into mathematics instruction. It is then suggested that they be trained through in-service training programmes. Furthermore, Asli and Zsoldos-Marchis (2021) found a significant difference in teaching mathematics applications when the respondents are compared according to their computer user skills. Teachers with higher computer skills integrate more mathematics applications. The respondents requested that teaching mathematics applications be included in the Israeli curriculum.

2.2. Lack of Equipment and Appropriateness of the Curriculum

Concerning the results of Asli and Zsoldos-Marchis (2021) about the importance of equipping teachers to increase integration in mathematics instruction, physical facilities are required. The lack of equipment is the most frequently mentioned reason for not integrating mathematics applications. AlMuraie et al. (2021) found out that the teachers' least common interpretation of the definition of STEM is that it is about using simulation software in the prediction of engineering design performance and the development of engineering practices for creating engineering designs as well as testing them with the use of scientific problem-solving skills. This further supports the need for more facilities to be provided for teachers to strengthen their integration mechanisms.

Another emerging need identified was the call for curriculum review to make it fit into STEM integration. For example, Sen and Ay (2017) revealed that most participants believed that the curriculum is not appropriate for integrating science and technology into mathematics instruction. Additionally, Fırat (2020) reported that STEM integration may have a negative impact on learners when it is related to the preparedness of the curriculum they currently have.

Conclusion

The systematic literature review revealed a generally positive view of STEM integration benefiting the learners. They believe that STEM integration can promote student achievement, specifically in acquiring problem-solving skills, as STEM integration requires using real-world and real-life situations as a springboard or application of the lessons. Furthermore, the teachers believe it motivates the students more and increases their interest in STEM careers. However, on their side, as teachers, several challenges were identified. The teachers feel that it is easier to integrate scientific concepts into mathematics instruction than integrate mathematics concepts into science instruction. This research gap may be addressed by introducing a model, such as Kiray's (2012) Balance Model, to fully integrate lessons from the disciplines. However, this requires teachers to have content knowledge in both disciplines, as content knowledge is a prerequisite to pedagogical knowledge. In addition, a theme that emerged was the misperception of teachers on technology education integration. The lack of equipment to support them in technology education integration was common in all the research reviewed. This suggests enough adequate facilities be in place coupled with upskilling programmes. The researchers also call for constant curriculum review to ensure that STEM integration fits into the curriculum currently followed by the teachers. Lastly, all of the research articles reviewed acknowledge the importance of teacher preparation in the process, which is the basis in the recommendation for a review of the undergraduate curriculum that education majors are having, as well as more focused pre-service and in-service programmes, training, and workshops about STEM integration.

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

Joan C. Tobilla*[1], Christian D. Battad[2], Dianne Therese V. Perido[3], and Gee-I S. Nalunat[4]

[1,2,3,4]Luis Aguado National High School, Science Department, Trece Martires City, Cavite, 4109, Philippines
**Corresponding author, e-mail: joan.tobilla@deped.gov.ph*

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 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.

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).

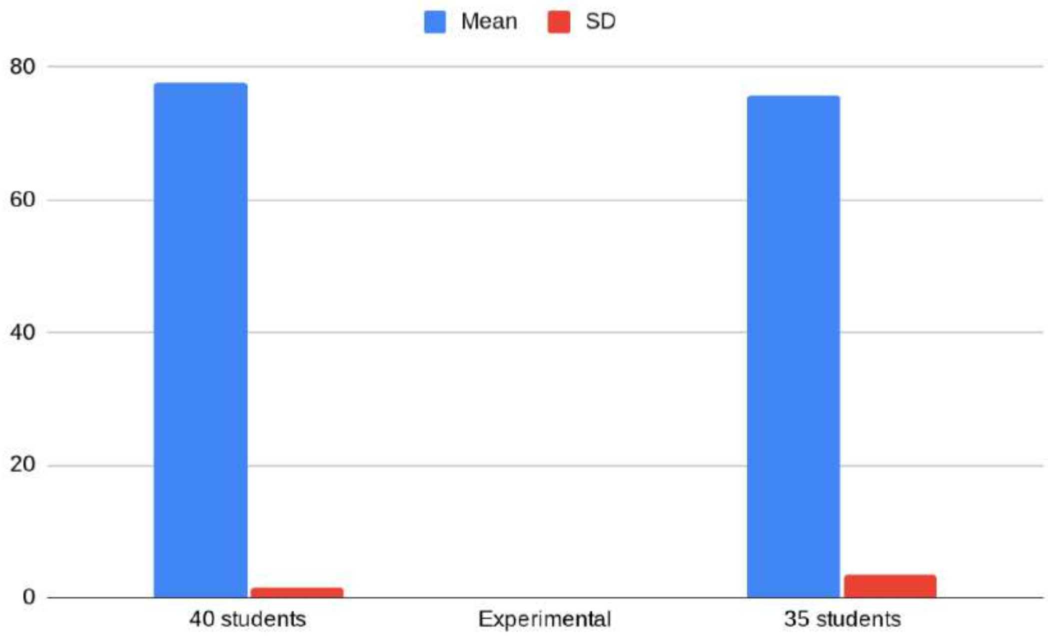

Figure 1. Result of Pre-Test of Control Group and Experimental Group before engaging to Project SWORD-MMs (Science Word Optimisation via Reading and Devised Mind Maps)

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).

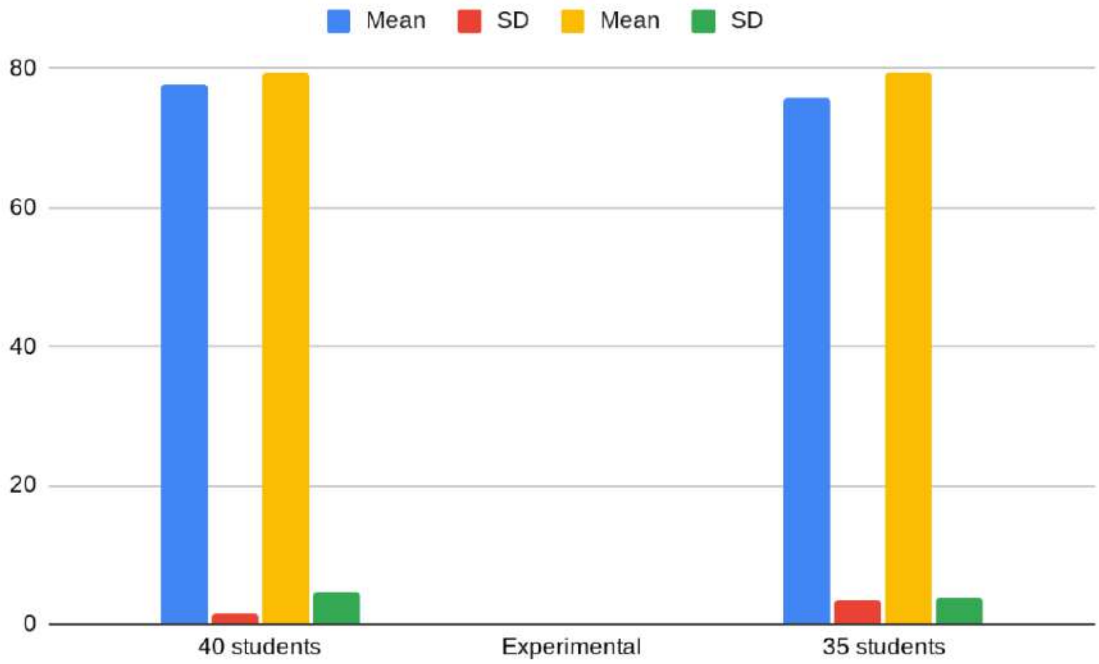

Figure 2. Result of Pre-Test and Post Test of Control Group and Experimental Group before and after engaging to Project SWORD-MMs (Science Word Optimisation via Reading and Devised Mind Maps)

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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Revival and Resurgence of Science Education in India: Lessons from the Hoshangabad Science Teaching Programme

Navneet Sharma*[1], Yusuf Akhter[2], Showkat Ahmad Mir[1], and Anamica[3]

[1]Department of Education, School of Education, Central University of Himachal Pradesh, Dharamshala, Himachal Pradesh, India
[2]Department of Biotechnology, School of Life Sciences, Babasaheb Bhimrao Ambedkar University, Lucknow, Uttar Pradesh, India
[3]Department of Humanities and Social Sciences, Indian Institute of Technology, Bombay, and Faculty of Arts, Monash University, Melbourne
**Corresponding author, e-mail: navneetsharma29@gmail.com*

Abstract

Education, particularly science education, aims to encourage people to think, learn, solve problems, and make sound decisions. Science Education, as a discipline, focuses on disseminating and expanding scientific content as knowledge that produced in and through science. There have been very few social pedagogical interventions, in which learners are forced to 'do' science. The Hoshangabad Science Teaching Programme (HSTP) was launched in the 1970s, in the Indian hinterland by some zealous and concerted educators. It is demonstrated and believed that people generally have the capacity and capability to do science. The scientific method could be used to construct knowledge if learners are assisted and guided to think and reflect in procedural steps to construct observation, data collection, categorisation, and analysis. The HSTP operated for three decades before being abruptly shut down in 2003. This article attempts to highlight the lessons that can be drawn from running a progressive science education programme in a populist democracy. It is also important to consider why progressive science education harms the nation ideology. The final goal of this article is to explain why such programmes are still considered "alternative" education and why they cannot be integrated into "mainstream" education. Finally, we want to emphasise that if science education in India is going to change the discourse about how people should critically reflect on and construct their 'justified true beliefs.' Furthermore, this issue needs to revive and resurrect science teaching and learning in India by following and emulating the HSTP.

Keywords: Education, Science, Science Education, Scientific method, Pedagogy of science.

Introduction

Science and its method do not come naturally to us, but it does shape our understanding of the world and actions thereof. Intriguing questions, such as why the sun emits heat, why there are days and nights, or why the sky is blue may have different answers for different socio-cultural backgrounds of individuals. Furthermore, there are also answers and explanations to these questions that are provided by science. The obvious question that immediately comes to mind is, 'Why should we prioritise the answers offered by science over mythical and cultural narratives?'

The discipline of science is marked by hegemony and paradigmatic constraints that define the acceptable theories, methods, and approaches of the field while rejecting any alteration and change within the already established models used within the scientific community (Rogers, 2006, p.5). However, while proclaiming universality, reliability, and precision, the method of science emphasis that every individual has the potential and ability to reach an accurate and justifiable knowledge if a specific path of knowledge construction is followed.

Science learning and learning how to learn science that challenges the conventional and normal process of learning in schools must be learned by heart because it is predetermined and rigid. Meaningful science learning is contrasted to rote memorisation, which is practiced by many students, encouraged by instructional, and evaluation practices (Edmondson & Novak, 1993, p.547). Conventional learning discourages learners' curiosity and creativity as the act of wondering, contemplating, and uncovering knowledge is impeded by predefined curricula, teacher-centred pedagogy, and deterministic evaluation. The tightly defined and heavily standardised curricula is failing students and teachers as they are robbed of their professional agency and creative capacity in such educational settings (McCabe, 2017).

The process of engaging in science or conducting scientific inquiry, adheres to a constructivist teaching approach. While this approach may not be difficult to fathom, it can be challenging to follow as it disrupts the traditional hierarchy of knowledge production and acquisition. This approach to science and knowledge led to the start of the Hoshangabad Science Teaching Programme (HSTP) in 1973, with the joint efforts of two organisations: Friends Rural Center and Kishore Bharti (Mukherjee et al., 1999). These organisations and their volunteers 'somehow' managed to persuade the education department of the then government of Madhya Pradesh to allow them to run a science education programme for classes VI to VIII, centred on experiential learning and learning by doing. The 'progressive' attitude of the said government has been lauded multiple times by the founders of the HSTP, which allowed these organisations to conduct their 'pedagogical experiments' in 16 government middle schools in and around Rasulia and Bankheri, rural hinterlands within the Hoshangabad district. This programme was developed to response to the traditional education system's shortcomings and aimed to provide a more holistic and practical approach to teaching science to rural and underprivileged children. The curriculum of the HSTP was designed with a focus on local relevance and integrated traditional knowledge with modern scientific concepts to make learning more engaging and relatable for students. A key component of the HSTP was the training of teachers in innovative pedagogical techniques to effectively implement the programme's teaching methods in their classrooms. The assessment system of this programme went beyond traditional exams. It focused on continuous evaluation through an open-book examination system, practical skills test, critical thinking abilities, and scientific concepts understanding among learners.

The HSTP was initially launched as an experiment by some collective individuals; for instances, young scientists, researchers, and students from prestigious scientific institutions. They aimed to transform and reform science education in rural areas. Within a decade, its scope expanded significantly. By 1978, it had made substantial contributions to reshaping science education in 200 schools within the Hoshangabad region and subsequently extended its reach to other areas of the country, encompassing over 450 schools by 1990 (Mukherjee et al., 1999). The programme was designed to be compatible with the government school system, albeit it believed in the freedom and autonomy of learners and emphasised the role of teachers as a facilitator in knowledge construction. This programme had specific 'commitments' with the most importantly being "a commitment to teaching science through experiments that children themselves perform in the classrooms. This was eventually elevated to a guiding principle, which said nothing that could not be demonstrated by such experiments would form part of the curricula" (Mukherjee et al., 1999).

The programme commenced by reorienting science teachers as the role of teachers holds utmost significance in any teaching and learning process. Teachers were made to unlearn the notion that science is esoteric and exclusive that all scientific theories originate in sophisticated laboratories only. As an alternative, the methods of science can be applied in one's daily construction of knowledge. The HSTP sought to demystify science and show that science is not confined to textbooks and laboratories. Instead, it is a tool for understanding and improving the world around us, an approach that encourages students to view science as an integral part of their everyday lives, and their day-to-day quest for knowledge.

Nonetheless, following this view can be challenging. The perception that science learning has no relevance in everyday life, except as a means to pursue financially rewarding careers such as engineering and medicine, is a complicated challenge disposition. This challenge is further compounded by the absence of 'accountability' within the teaching system, rewards for work well done. and no penalties for non-performance. This significant demotivator for numerous teachers has been consistently highlighted to all stakeholders associated with the HSTP program (Mukherjee et al., 1999). Encouraging teachers to engage in additional work without offering any extra benefits, whether monetary or otherwise, presented a challenging task. However, "the younger schoolteachers in Hoshangabad district who are the products of HSTP accept that experiments and inquiry are the main ingredients of good science teaching" (Mukherjee et al., 1999). These teachers were receptive to 'change.'

In 1972, this intervention was, and is still, critically necessary because science education in particular, and education in general, remained predominantly authoritarian. In the absence of infrastructure, laboratories, and equipment, science was predominantly validated and legitimised solely through the authority of textbooks and teachers. It was often perceived as a body of pre-established and received knowledge. The conventional depiction of a science classroom is vividly illustrated in the satirical novel 'Raag Darbari' by Shrilal Shukla. In this novel, the teacher, Master Motiram, attempts to explain the concept of 'relative density' with a parallel example of 'comparable higher profits from a flour mill.' He leaves in the middle of the class, exclaiming, "Do read the chapter on relative density; it is important" [This is important because there will be a question on relative density in the examination]. This narrative simultaneously emphasizes the notion that proficiency in English is necessary to acquire the scientific knowledge and science cannot be learned without (knowing) English. Unfortunately, this description of science classrooms and science education sounds realistic even today.

When the HSTP was abruptly and arbitrarily terminated in 2003, the primary justification provided was that the students of Hoshangabad were not performing as per the standards in class 10th (Board) exams, even though HSTP explicitly clarified that its focus was on middle school students, ranging from grades VI to VIII (Joshi, 2022). Nevertheless, these comparisons were fundamentally flawed as "the present examinations at Class X level are largely confined to information recall testing with little or no emphasis on testing a student for problem-solving, experimental or analytical skills, or conceptual understanding" (Kamal Mahendroo, 2002). The HSTP prioritises the cultivation of these skills (in alignment with the National Curricular Framework) and actively discourages rote learning; evaluating the effectiveness solely based on the results of these examinations would be unfair. In addition, the nature of the data was inadequate to support such a hypothesis (Mahendroo, 2002). The differing effectiveness of the high school system across various districts must be accounted for through a research design that examines samples with comparable conditions in high schools. The two variables –the percentage of students scoring above 60% marks in science and the overall pass percentage –as indicators to conclude whether the HSTP had minimal or no impact on high school performance, reveal a notable absence of correlation. This implies that an entirely different set of variables could potentially yield a contrasting perspective. For example, consider the case of Chhindwara, which secures the second position in overall pass percentage but is absent from the top 15 districts in terms of students scoring 60 percent and above in science. Conversely, 7 districts ranked within the top 15 for overall pass percentage do not appear in the top 15 of the lists of students achieving 60 percent and above in science.

Notwithstanding these inconsistencies in the claims made, the HSTP was suddenly and unexpectedly terminated. But before delving deeper into the investigation of the factors behind the abrupt closure of the program, it is imperative to trace the evolution of the HSTP, acknowledge its accomplishments, and the lessons derived from the program, for which the distinguished physicist Yashpal observed that "such efforts come only once or twice in a century" (Ramachandran 2002).

The Rule of Thumb: Eklavya and Self-learning

The HSTP originated with a group of enthusiastic science practitioners and educators who held specific assumptions and beliefs. Primarily amongst them were that a) interventions can bring in innovations and fruitful changes in education systems by bringing together professionals, teachers, and children, b) education can be a process rather than a product by altering the way government schools function, which is both possible and necessary, and c) science is not an exclusivist domain of knowledge but can be rooted in people's 'rational' understanding, to be people's science and lead to 'scientific temper' (Kidwai K., 1999; Sharma *et al.*, 2020). These assumptions and the initial groundwork by the HSTP led to the envisioning and establishment of a non-profit voluntary organisation in October 1982, known as Eklavya. Thus, Eklavya emerged as an extension of HSTP's vision and aims to transform the learning landscape of India. It advocates for an experiential and activity-based approach to education and develops teaching-learning materials that encourage students to explore, experiment, and understand concepts through practical engagement. It aims to bridge the educational divide by ensuring that quality education is accessible to students across diverse socio-economic backgrounds.

This organisation drew inspiration from the legendary archer Eklavya, a prominent figure in the epic Mahabharata, who hailed from the Bheel tribe. This tribe represents one of the largest tribal communities in India, with a substantial presence in the state of Madhya Pradesh. As the meta-narrative of the epic Mahabharata emphasises that only a chosen few can have access to knowledge, an inquisitive learner can surpass all the obstructions and barriers to acquire knowledge. The monopoly over knowledge and consequential hegemonising of knowledge was challenged by this legendary character−Eklavya. There could not have been a better name than this, as this mythical character eulogises that a) anyone and everyone can know and has a right to know, b) self-learning, discovery-based learning, or guided learning can equally and efficiently help a learner to know, and c) those who have 'controlled' knowledge production and consumption cannot bear with its subalternation. This is the reason why the legend Eklavya had to give away his thumb as guru-dakshina (a requirement for archery; from that myth onwards, Bheels and Bhilals do not use the thumb in archery anymore) and "the Government of Madhya Pradesh [could] shut down the HSTP without assigning any reason for its abrupt decision" (Rozario, 2004-2005, p.7).

However, Eklavya, besides evolving innovative curriculum, learner-centric pedagogy, and learning material for science, social science, and primary education, has also engaged with issues and concerns of rural health, technology, and planning and development of panchayats as resource centres for the above. This article will concentrate on the endeavours of Eklavya in education in rural areas and specifically its school science programme- the HSTP. However, it will also discuss science-society issues to comprehend and understand the lessons and learning from the HSTP and its closure.

Therefore, when he discovered how malaria was transmitted and spread into the tropics through a microscope, he would have realized that his discovery would safeguard the British soldiers and authorities from this disease. Eventually, this would empower Britain to extend and affiliate its colonial control. They guaranteed that science was something other than a handy or ideological instrument when it came to the realm. Since its introduction to the world around a similar time as Europeans started vanquishing different pieces of the world, present-day Western science was inseparably trapped with expansionism, particularly the British government. Furthermore, the inheritance of that imperialism affects science today. This kind of argument based on the pretext of imperialism sounds illogical when delving into the details of the malaria pandemic in terms of diminishing mortality rates globally and especially in the colonised countries. Malaria researchers have won numerous prizes along with Ross's Nobel Prize for their accomplishments, even though the ailment keeps on harassing around 200 million patients every year, killing more than 600,000. Artemisinin from the Qinghao plant (Artemisia annua L, China, 4th century) and Quinine from the Cinchona tree (South America, 17th century) are two widely used anti-malarial medications extracted from plants whose medicinal properties have been known for generations (CDC website 2005: Arrow 2004: Roser & Ritchie 2019: Byrne 2008). Along with these two medicines, Quinine and Artemisinin, DDT was also used as a weapon in WHO's global programme for malaria eradication (Pearce, 2007). With this advent, there may also be "continuous decrements in the mortality rates, especially in the countries of Africa and Asia" (Nigera *et al.*, 2011), which were previously colonized by the imperialists. This punctures the imperialist science argument completely. Therefore, this demonstrates how science and scientific endeavours help people to come out from miseries; consequently, science is a universal phenomenon, and there is no merit in the 'imperialist sciences' in argument and framework.

The above example elucidates how the content of science has to be universal to be science. The method followed, and the conclusions arrived, have to follow precision, universality, replicability, and clarity. Thus, the process will be two-fold for decolonising science learning, wherein pedagogy and evaluation need to be reworked for both the learner and the decolonized state. First decolonisation "seeks to counteract the de-humanisation that colonization, slavery, settler colonialism, imperialism, and their vestiges have instilled within communities; on the other, it seeks to reconstitute systems and processes in ways that unearth and advance subjugated knowledge through Indigenous and collective forms of learning that are radically humanising for all" (Bajaj, 2022). HSTP as an experiment and interaction in science pedagogy was also a process for decolonising science learning.

HSTP and Decolonisation of Science Education

It sounds bizarre that Newton observed an apple falling from a tree, invented gravity, set down some equations, and now that logical truth has been imposed on the world forever. In order to comprehend the position taken by the 'decolonisation' researchers, some individuals may accept the milk miracle – an incident that happened in September 1995, in which statues of the deity Ganesha were believed to drink milk offerings (Subramaniam & Mitra, 1995). However, because this is not testable_by "Western" science, this might be considered as native knowledge, and along these lines is a case of Western imperialism stifling indigenous insight. To sustain colonisation, Europeans used "firearms, germs, and steel," along with a deeply bigoted worldview, to do some unnatural and abnormal things to indigenous communities. This includes imprinting colonised people with Western culture. Reclaiming indigenous culture is not problematic, and this can be considered an attempt at decolonisation. Science is essentially unique in comparison to art, religion, and music, regardless of what extreme postmodernism one would have accepted.

The utter manifestation of science is to seek the prospective truth that is not dependent on the premises of any particular culture. Science has the purpose of breaking social stigmas, ousting authority and custom, and utilising a straightforward and libertarian procedure to make sense of what is truly valid. On the off chance that science is working accurately, at that point, a laboratory in India ought to get a similar outcome as a laboratory in Sweden. There is a worldwide network of researchers teaming up and cooperating to push aggregate information forward. Science, in this way, has a place with humankind, not with any one culture. The historical backdrop of science is brimming with disappointments to accomplish this perfection, as science is a human endeavour. The method of science has been overturned to seek after social and ideological finishes, with the attempts to show that one race, one social group, one caste, or one sex is better than another. For example, science is subverted when it is utilised, trying to demonstrate that a strict conviction is authentic or to construct history in a manner that is pleasing to one social group. It is not interested in a white man thrusting his beliefs on the rest of the world through Western imperialism. Comprehending the concept of gravity and mechanics was the aftereffect of a procedure of revelation and experimentation. Not just that, Newton was later challenged (as it were) by Einstein (Bolejko, 2015). His depiction of gravity was right, however fragmented, and must be modified by the theory of general relativity. Our comprehension of gravity is not forced by power, yet it is addressed, tried, and tested. It is temporarily acknowledged now since it has withstood committed endeavours to discredit it. The discrepancy is, that by pushing for the nullification of "Western" science for "Indian" science, they are advancing a social and frontier perspective on science. They contend that science does not have a place with humankind and that Indian researchers would concoct unexpected replies in comparison to different researchers. What they truly need is for science to validate their social convictions, so they are committing a similar error as creationists, deniers, and revisionists. This would be a gigantic injury to India and Indians. This would, again, amusingly, amplify the mischief that expansionism did to the mainland by propelling them to isolate themselves from the collective human excursion of science, to dismiss the standards of science itself, and to oppress themselves to the conventions of their past. Some portion of bigotry is to deny indigenous individuals the chance to partake in science. Contending that India ought to free itself of science is along these lines, giving way to the schemes of frightful conventions. The 'pseudoscience' that they need to protect from the segregating eye of science is anything but something to be thankful for. Confidence in a portion of some Indian traditions may legitimise discrimination against individuals from different social groups, genders, or sexual orientations. It might likewise deny Indians successful clinical consideration and is enormously chickenpox endemic, which was considered before as 'Mata' (a goddess) in this part of the world. This issue of seeing science as Western expansionism and supporting indigenous science is not exceptional in India. Disappointingly, it has critical ideological help from benevolent individuals who are fittingly alarmed by prejudice and misuse. Assaulting science is simply misinformed and will accomplish the specific inverse of what its advocates trust. In any case, such exposure to destructive "cultural constructs" is extremely popular in the scholarly world. Of late, consideration has gone to science, assaulted by Andrew Ross, Sandra Harding, and others as a Western "cultural construct" whose guarantee to a substantial all-around discernment is close to a feeble spread of colonialism and racism (Keith Parsons, 2003; Nanda, 2006). These scholars assume they are doing great service to the Third World, yet they accidentally open a scholarly entryway for strict fundamentalists. In India, narrow Indian nationalists have reacted to the required "decolonizing the science" campaign by forcefully advancing "Indian methods of knowing." They demand in their ongoing Humanistic Approach to Economic Development that "the social ethos of the so-called ancient pride culture" must be re-established. They have the last authority over what parts of 'remote' science and innovation are conceded into schools and different establishments" (Nanda, 1997). Some time back in 1992, in the Indian province of Uttar Pradesh, "Vedic arithmetic" was made mandatory for secondary school studies. In government-prescribed courses, books, standard algebra, and math were supplanted with 16 Sanskrit stanzas that just give equations for quick calculation. History reading material in India has likewise been utilisation of science as a method for social upheaval. Those included tried to utilise relevant information to challenge the predominant, to a great extent, Indian world perspectives on different social groups and ladies. However, when compellingly savvy people contend that logical discernment itself is a "pioneer build," just the interests of Indian nationalism are served.

There is nothing like Western science, Indian science, African science, Native American science, or any other customary science; such sciences do not exist. It is science only when it strives to overstep power and authority, beyond the beliefs and presumptions of one single culture, and when it is non-exclusive and accessible. Okere (2005) argues that “no one can deny the overwhelming contribution of the West to science so understood. But it would be absurd to suggest that such overwhelming dominance amounted to a monopoly or to discount the contribution of other civilizations or other branches of the human family to science.” Furthermore, “The notion that there is only one science, western science is pure dogma, a dogmatic belief supported by purely ideological positions, some stated, and others not.” this argument can be extrapolated to Indian, African, and American sciences. In science, ideas should be judged purely based on their merits, their logic, and their proof. Hence, those who seek to fight racism, colonialism, or any other evil must work within the fundamentals of science. The attempt at cultural undermining of science is principally detrimental for those who espouse such beliefs while amplifying the ills of racism and colonialism.

Science is a universal subject; however, the strategy to teach science would not be global. It may be different for the residents of separate geographical areas, economic strata, and social milieus. We may include the genotypic details of populations living in a specific geographic area. Therefore, how we think and what we comprehend and learn through formal education and training may generate a population-specific response. Thus, the strategy to teach kids in Western countries may not be apt to apply in underdeveloped or developing countries, which were the colonies of these Western countries in the past. The implementation and learning of science should be locally customised based on the socio-economic conditions of the local milieu. Bajah (1984) argues that the “tragedy of science education in Africa which adults and children have shared is that it has not always paid attention to the culture of the African”. Furthermore, “the teaching of science should also provide an introduction to the application of science in everyday life, but to the socio-economic, cultural and environmental implications of scientific and technological development.”

In this regard, the strategy adopted by the HSTP programme could serve in the best way as it is a tailor-made pedagogy of science targeting the indigenous population. This programme was designed by educationists, academics, researchers, scientists, engineers, and activists who aimed to create a school science teaching programme based on the ideal envisioned in various policies focusing on the indigenous population. The HSTP project had the objective to investigate the scope of innovative and progressive changes that may be brought into the government school system. For this purpose, the HSTP project set out to see if it is possible to implement the 'discovery' approach in the teaching and learning of science in village schools rather than the traditional textbook and rote-memorization-centric approach. HSTP was a singular and only of its kind experiment in the Indian education system and an inspiration for other initiatives in science education. HSTP had begun focused micro-level educational experiments, starting pilot projects, developing teacher training packages, co-curricular packages, and administrative reforms. Eklavya also devised various educational programmes for left-out or drop-out children for this purpose; the basket activities included bal-melas, poster exhibitions, street plays, jathas, public campaigns, and touring exhibitions that covered several villages in campaign mode; also, creative activity workshops to train children to teach others.

Therefore, environment-based education, based on observation and analysis, was started as a fundamental component of science education. The fundamental perception behind this effort was that learning science via methods like observation, experimentation, and field studies would help children develop a questioning and analytical mindset. This programme encouraged learning rightly from the local and neighbourhood environment, and it was hoped that through this, the children would sooner or later start questioning the conventional social structure of society. As this envisaged learning from the local environment, it could be a copycat of the Western science school teaching strategy. Therefore, a programme like the HSTP would decolonize science teaching in India. However, it is not exactly how the so-called nationalists would like to decolonize science. In conclusion, science is a universal concept, and it can be decolonized. Still, the strategy to teach should be decolonized, and as Patrick Geddes, a contributor in the area of urban planning who inspired the transformation of some of the worst urban areas in Scotland, has said rightly, 'think globally, act locally', therefore, in this regard, the HTSP-like strategy seeks global knowledge. Nevertheless, the implementation and learning of that information remained locally customised based on home conditions.

Conclusion

Science education refers to the teaching and learning of content, theories, methods, processes, implications, and applications of science. Science education deals with the system of knowledge about the natural and physical world and its phenomena. Along with knowledge, science education is also concerned with the method of establishing that knowledge. The purpose of science education is to cultivate and nurture the curiosity of the children about the world around them. Curiosity will encourage them to develop scientific knowledge by inquiring, exploring, and investigating. It involves the active engagement of the child with methods like prediction, observation, experimentation, categorization, classification, and inference. Science and its methods do not come naturally to us, as it requires the efforts of systematic teaching and learning. However, once learned, science education does shape our understanding of the world and actions thereof. Children start to acknowledge more and more that the world and its phenomena are shaped and defined by science. The government should promote science education and interventions like HSTP to fulfil the goals of the constitution regarding the promotion of scientific temper in our country. This intervention acknowledges that the prevailing non-scientific temper in people's attitudes may lead to devastating catastrophes for future generations and is also an attempt to decolonize science and science education in the country whilst emphasising indigenous knowledge and methods of doing science. Learning science by rote and routine will not only dissuade the curiosity for and about human learning endeavours, but rather it may develop a disdain for science and scientific temper. In contrast, scientific temper in people and learners may produce extraordinary science, when they become professionals in their chosen fields. Kuhn distinguishes extraordinary or revolutionary science from normal science, and as per Kuhn, the growth of science is not linear and uniform; rather, it has changing 'normal' and ‘revolutionary’ periods. The revolutionary periods are not just phases of advanced developments; but there is a qualitative difference between normal and revolutionary science. Normal science is not dramatic; to explain this, Kuhn presents an example of solving a puzzle, for instance, in a chess game, a crossword, or a jigsaw.

The puzzle solver hopes to have a rational prospect of resolving it because the puzzle and its resolution are both well-known, and the puzzle solver is not venturing into an uncharted field. Since the puzzles and their answers are comparatively known and simple, normal science can assume to amass an increasing share of puzzle solutions. Nevertheless, revolutionary science is not accumulative as all the revolutions of scientific, include a reconsideration of prevailing scientific notions and their applications.

Not all the achievements attained in the former era of normal science can be protected through a revolution. In the ensuing phase of science, there might be certain phenomena that do not have an appropriate explanation but were convincingly explained in earlier times. This characteristic of scientific revolutions is called 'Kuhn-loss'. Popper also highlights the detrimental consequences of the lack of scientific or non-scientific temper. The lack of scientific temper leads to the inculcation of conservative orthodoxy, and people believe in the things they have been told to find without proper reasoning. They do not remain open to challenging the existing dogmas their previous generations have established; there is no revision possible in the existing ideas. The nature of science contrasts with this as according to Popper, all scientific theories are conjectures and always remain open for better refutation (Popper 1963). This encourages people to innovate and come up with better theories, which can explain an existing phenomenon in better ways. Therefore, these people, who will be trained in compliance with Popper and Kuhn's thesis by the HSTP-like programme, will be more prone to make innovations and discoveries in comparison to the people trained by conservative orthodoxy. So, it is required to revive and resurge science education in India; not only to help the state strive for the directive principle of scientific temper, but also to bolster the spirit to argue, question, and test every piece of information and knowledge before believing it–a hallmark of science, decolonized pedagogy, and a democratic society.

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Science Laboratory Learning Environment and Students' Practices on Laboratory Safety

Mercy Joy R. Mendez [1*] and Eula Mae B. Sening [2]

[1,2]University of Mindanao, Matina, Davao City, Philippines
[*]Corresponding author, e-mail: mercyjoy_mendez@umindanao.edu.ph

Abstract

This paper aims to identify the significant relationship between the science laboratory learning environment and students' practices on laboratory safety for education students who took at least one subject or course with laboratory unit in face-to-face classes. The data from this study came from 201 education students, collected through an online survey using Google Forms. The non-experimental descriptive correlational design, census approach was used to select the study participants, and standardised questionnaires were also utilised. The weighted mean, standard deviation, Pearson product-moment correlation design, and linear regression analysis were employed as statistical techniques. The study found that the science laboratory learning environment is at a very high level. Meanwhile, the students' practices on laboratory safety, especially emergency response plans, work procedures, and chemical waste management, are at a very high level, while safety equipment and handling of experiments are observed at a high level. The results also showed a significant relationship between the science laboratory learning environment and students' practices on laboratory safety. The domain of science laboratory learning environment that significantly predicts students' practices is the material environment. The result implied that the institution may provide and maintain a conducive laboratory learning environment, which is essential for students to perform laboratory safety, enhance the handling of experiments, and upgrade the safety equipment in the science laboratory.

Keywords: *Education***,** *Laboratory Learning environment, Students' practices on laboratory safety, Correlation, Regression*

Introduction

Laboratory safety should come naturally and must become a habit, especially for science teachers and students. Some reasons for compromising safety are overconfidence, ignorance, defiance, carelessness, work stress due to fear of not meeting targets, and poor planning and hygiene (Deepak, 2016). Incidents leading to severe injuries or even fatalities among students and staff occur frequently in university laboratories worldwide (Yang, Reniers, Chen, & Goertlandt, 2019). Meanwhile, laboratory exercises serve as a vital bridge between theory and practical experience in science education, enhancing students' understanding of scientific concepts. For example, the study of Duban, Aydogdu, and Yuksel (2019) demonstrated that laboratory work engagement significantly improved students' comprehension of scientific principles and reduced the likelihood of misconceptions.

The science laboratory provides a unique learning environment where students collaborate to investigate scientific phenomena in a less formal setting, fostering interaction with teachers (Olubu, 2015). Students employ scientific processes to explain phenomena, emphasising the need for well-grounded practical ideas in all science subjects to enhance understanding and academic performance (Oginni, 2016). Correct handling of materials and equipment is crucial in preventing accidents, highlighting the importance of students knowing the appropriate experimental tools (Ali et al., 2018).

Science teachers need to be clear about the rules and responsibilities of their students, have precise monitoring methods, and always decide what specific procedures will be documented (Mulholland, 2020). Furthermore, Threeton and Walter (2013) stated that students must be prepared for an active safety laboratory model by adhering to safety guidelines and standards in the laboratory learning environment. Safety equipment is typically available in school science laboratories due to the need to interact with various materials, necessitating regular checks and monitoring to ensure student safety (Bakhtiar et al., 2019). Without adequate safety equipment, science laboratory users are at great risk (Ali et al.,2018).

Additionally, safety equipment should be available in or near all laboratories that use hazardous chemicals in clearly labelled, highly visible, and convenient locations (Indiana University, 2019). Improper chemical waste disposal could potentially have a severe consequence for both humans and the environment (Kaufman, 1990, as noted in the study by Ali et al., 2018). Hazardous waste must be controlled from the time it is created inside the lab until it is taken to an off-site facility for treatment or disposal (Environmental Health and Radiation Safety, 2017). Similarly, an emergency response plan involving teacher, lab assistants, and students is crucial to prevent fatalities and minimise injuries during a crisis, encompassing response strategies, drills, equipment readiness, and clear leadership (Muenz, 2017).

It is also important to keep an eye on students' safety practices in the laboratory when conducting experiments. One of the first topics that students encounter when they enter a science laboratory is work procedures. During this time, students are informed of the rules that must be followed when conducting laboratory activities and are given enough information to help them avoid and prevent incidents that may happen if laboratory activities are not carried out carefully (Ali et al., 2018; Mulholland, 2020).

Otherwise, Chinese scientists are also concerned about a lack of control and uniform safety measures, particularly in teaching laboratories, after fatal explosions in university laboratories (Silver, 2021). The use of school science laboratories is hampered by several challenges and issues that prevent their effective activation, such as risks associated with improper use of laboratory tools or equipment, inadequate storage and preservation of some materials, or errors caused by improper handling of materials or the application of some operating procedures (Fagihi, 2018).

In addition, one incident was reported from the chemistry laboratory at the University of Mindanao where a student's careless use of a Bunsen burner resulted in an unexpected, uncontrollable flame that slightly caught her hair and eyelashes (Chem Lab Report, 2020). As reported by the respective laboratory custodians in Chemistry, Biology, and Microbiology at the University of Mindanao, the most common incidents happening during laboratory class were minor breakages and damage to some equipment by students.

The study by Wong and Fraser in 1994 on the Science Laboratory Classroom Environments and Student Attitudes in Chemistry Classes in Singapore marked the beginning of research in science education that focused on the classroom environment because as most attention at the time was focused on learning difficulties related to science achievement, general abilities, the sex of students, and attitudes towards science. As a result of their investigation, they were able to assess the teachers' and students' perceptions of the learning environment in the chemistry laboratory environment. More importantly, they were able to compare their findings conducted in Singapore to the data from Australia, the USA, Canada, Israel, England, and Nigeria, wherein they found out that there are similarities and differences in the science laboratory classroom environment between Singapore and those countries.

In the same manner, the results of this study can be used as a basis to further explore this area of research and to give importance to the safety of students in the laboratory. The results can also be used to further improve the safety guidelines and policies of schools to ensure the effectiveness of the science laboratory learning environment and to ensure laboratory safety practices for students. In addition, they can also be the gauge for comparing the data from other schools should they wish to explore this area or research. This study was based on the proposition of Hinderson, Fischer, and Fraser (1998) that learning environment factors are particularly important influences on student outcomes, even when other factors are controlled.

Assessing the relationship between the science laboratory learning environment and students' safety practices is essential to understand how the environment influences behaviour, improves safety standards, informs policy development, enhances science education, and ensures student well-being. Researchers are encouraged to examine this study because no research has been conducted to determine the significant relationship and influence of the science laboratory learning environment on students' practices on laboratory safety at the University of Mindanao. As mentioned above, the incident also pushed the researchers to pursue the study since they discovered the necessity of conducting the study.

Furthermore, the findings of this study can be used as valuable information for expanding knowledge about the importance of science laboratory learning environments on the students' practices on laboratory safety. By placing a greater emphasis on hands-on experiences that foster problem-solving abilities and critical thinking, a science laboratory learning environment significantly promotes advanced learning at all levels of education. When supported by investments in hands-on experiences, this environment encourages students to pursue higher education and equips them with the skills that high-tech employers value (American Chemical Society, 2017).

This study has four aims: (1) To determine the level of science laboratory learning environment in terms of rule clarity, integration, indoor air quality, learning space, and material environment; (2) To describe the level of students' practices in laboratory safety in terms of work procedures, safety equipment, handling of experiments, chemical waste management, and emergency response plan; (3) To identify the relationship between the science laboratory learning environment and students' practices in laboratory safety as well as to determine which domain of science laboratory learning environment predicts the students' practices in laboratory safety of all education students who experienced laboratory classes at the university through multiple linear regression analysis; (4) The researchers hypothesise that there is a significant relationship between the science laboratory learning environment and students' practices on laboratory safety, and there is a domain in the science laboratory learning environment that predicts the students' practices on laboratory safety.

Methodology

Study Participants

The respondents of this study were second to fourth-year students from the College of Teacher Education (CTE) of the University of Mindanao–who took at least one subject or course with at least one laboratory unit in face-to-face classes. However, only 201 out of the 268 total population were qualified to take the survey. The study was conducted from September to November of the school year 2021-2022. Considering the current situation, some of the respondents could not take the online survey due to poor internet connectivity and their hectic academic priorities. According to Raosoft computation, based on the total population, the recommended sample size is 159; subsequently, the 201 participants were highly acceptable (corresponding to a 75% respondent rate) since it exceeded the recommended sample size. The researchers used a census approach where all members are enumerated (Surbhi, 2017).

Materials/Instruments

In congruence with the quantitative research design, the researchers adopted research questionnaires. To determine the Science Laboratory Learning Environment of CTE students, the adopted and merged questionnaires from the study of Fraser and Lee (2009) and Ahmad and Halim (2014) were used. This study focused on five indicators: rule clarity, integration, indoor air quality, learning space, and material environment. The rule clarity, integration, and material environment contained seven items, while the indoor air quality and learning space had four and five items.

On the other hand, the second part of the instrument was a 5-point statement scale corresponds to Very True (5); True (4); Somewhat True (3); Not True (2); and Not at All True (1). It focused on the students' practices on laboratory safety which was the dependent variable of the study. This part of the research tool was extracted from the study of Ali et al. (2018). The study contained five indicators that assessed the knowledge of the students in terms of their practices in laboratory safety, which included work procedures, safety equipment, handling experiments, chemical waste management, and emergency response plans. The first two indicators mentioned above contained seven statements each. The handling experiments and emergency response plan indicators included six statements, while the chemical waste management indicator had four statements. The standardised questionnaire did not undergo validation since it was adopted from a source. The researchers used this scale adopted from Alipio's (2020) study with the following interpretations: 1.00-1.79 as very low, 1.80-2.59 as low, 2.60-3.39 as moderate, 3.40-4.19 as high, and 4.20-5.0 as very high.

Design and Procedure

This paper employed the quantitative descriptive correlation design, collecting data from surveys using standardised questionnaires (Pal, 2017). The descriptive correlation research design was employed to describe the present and subsequent phenomena (Atmowardoyo, 2018). As stated by Creswell (2003), quantitative research uses strategies of inquiry using predetermined instruments to collect statistical data through experiments and surveys. The non-experimental quantitative research aligned with the present investigation, for it seeks to determine the influence of laboratory learning environment on students' practices on laboratory safety.

Furthermore, with the approval of the study conduction, the survey was done virtually using Google Forms. The researchers reached the respondents through social media, then sent the questionnaires privately to individuals, verified their email based on the generated data from Google Forms, and forwarded it to the statistician. The weighted mean was utilised to determine the level of the science laboratory learning environment and students' practices on laboratory safety. Pearson product-moment correlation was applied to determine the relationship between the science laboratory learning environment and students' practices on laboratory safety. Furthermore, linear regression analysis was employed to identify which science laboratory learning environment domain predicts students' laboratory safety practices at the University of Mindanao. In addition, SPSS 19.0 was used for all statistical tools.

Result and Discussion

Level of Science Laboratory Learning Environment

Table 1 shows the mean score for the scientific laboratory learning environment indicators. The highest rating given by the respondents, which indicated that the science laboratory learning environment was consistently observed, had an overall mean of 4.48. Rule clarity had the highest mean of 4.60 of all the factors categorised as very high, as presented below, showing that students always adhered to the teacher's rules and directives inside the lab. On the other hand, while indoor air quality received the lowest mean of 4.40; it is considered very high. In fact, the students always observed suitable-temperatures with adequate working fans and exhaust fans for efficient airflow, which allowed the learning process to take place comfortably.

The very high level of the science laboratory learning environment aligned with the viewpoint of Kwok (2015), that the science laboratory is specially designed and equipped for science experiments and investigations. It was also comparable to Sharma's (2014) idea, which evaluated the emphasis on creating and adhering to a clear set of rules and on learners' acknowledgement of how far the teacher will go when a student defies the rules. The set of rules is essential to ensure safety in the laboratory. As pointed out by Allanas (2021), the lack of rules might raise the danger of an accident, that is why teachers typically follow safety standards very strictly to prevent lab accidents. It is further justified that having clear regulations will prevent any administrative or physical accidents. Consequently, rules are used to establish safe conditions in laboratories.

Table 1. Science Laboratory Learning Environment

Indicators	Mean	Std. Deviation
Rule Clarity	4.60	0.502
Integration	4.50	0.557
Indoor Air Quality	4.40	0.624
Learning Space	4.41	0.564
Material Environment	4.46	0.571
Overall	**4.48**	**0.494**

Level of Students' Practices on Laboratory Safety

Table 2 shows the mean scores for the indicators of students' practices on laboratory safety. The highest rating given by respondents had a mean score of 4.48, indicating that students' practices on laboratory safety were consistently evident.

The emergency response plan obtained the highest mean score of 4.44 out of the six indications, showing that respondents consistently demonstrated the set of written procedures for handling emergencies.

Table 2. Students' Practices on Laboratory Safety

Indicators	Mean	Std. Deviation
Work Procedure	4.30	0.474
Safety Equipment	4.11	1.076
Handling Experiment	4.07	1.112
Chemical Waste Management	4.25	1.061
Emergency Response Plan	4.44	0.837
Overall	**4.48**	**0.484**

The very high level of students' practice on laboratory safety was affirmed by the notion of Duban, Aydogdu, and Yuksel (2019) saying that to bridge the gap between theory and practice, laboratory practices are crucial, and their applications have been shown to assist students in defining scientific concepts in a more thorough and relevant way. Furthermore, it agreed with the study of Muenz (2017) that the essential things to consider in developing an emergency plan are creating responses to various incidents, conducting drills, having equipment in the proper place, and having a clear leadership structure and sets of priorities. Ali et al., (2018) also emphasised that students must be aware of what to do during an incident.

The emergency response plan must be thorough and guarantee that everyone involved, including the students, is familiar with how to use it in an emergency.

Correlation Between Science Laboratory Learning Environment and Students' Practices on Laboratory Safety

Table 3 illustrates the significant relationship between the two variables, the science laboratory learning environment and students' practices on laboratory safety.

Additionally, the determined R-value for the association between the general standard of the scientific laboratory learning environment and the students' practices on laboratory safety was .863, with a p-value of .000 and a significance level significantly lower than 0.05. Consequently, the null hypothesis is rejected.

As a result, this study found a substantial link between the learning environment in scientific laboratories and students' safety procedures in the lab. While the survey by Hofstein and Naaman (2007) showed that school science labs aid students in gaining experience through interactions with various tools and materials and improving their ability to understand the natural world, Akinbobola (2015) pointed out that students should also be made aware of the safety guidelines and regulations governing laboratory activities and procedures.

Influence of Science Laboratory Learning Environment on the Students' Practices on Laboratory Safety

The linear regression analysis of the science laboratory learning environment and students' practices on laboratory safety are analysed and interpreted to determine which among the rule clarity, integration, indoor air quality, learning space and material environment significantly predicts the student's practices of laboratory safety. Reflected in Table 4 is the linear regression analysis of the science laboratory learning environment and with R^2 value of .772 and p-value of .000 lower than level of significance.

Table 3. Correlation between Science Laboratory Learning Environment and Students' Practices on Laboratory Safety

Science Laboratory Learning Environment	Students' Practices on Laboratory Safety					
	Work Procedure	Safety Equipment	Handling Experiment	Chemical Waste Management	Emergency Response Plan	**Overall**
Rule Clarity	.629** (.000)	.416** (.000)	.684** (.000)	.670** (.000)	.630** (.000)	**.696** (.000)**
Integration	.644** (.000)	.469** (.000)	.699** (.000)	.679** (.000)	.663** (.000)	**.719** (.000)**
Indoor Air Quality	.688** (.008)	.646** (.010)	.651** (.000)	.710** (.000)	.706** (.000)	**.785** (.000)**
Learning Space	.681 (.229)	.602 (.090)	.652** (.002)	.682** (.000)	.729** (.000)	**.770** (.000)**
Material Environment	.749** (.000)	.673** (.005)	.716** (.000)	.737** (.000)	.782** (.000)	**.843** (.000)**
Overall	**.767** (.000)**	**.639** (.000)**	**.767** (.000)**	**.786** (.000)**	**.802** (.000)**	**.863** (.000)**

*p < .05 is significant (two-tailed)

Table 4. Influence of Science Laboratory Learning Environment on the Students' Practices on Laboratory Safety

Study Behavior				
Indicators	***B***	**β**	***t***	***Sig.***
Rule Clarity	.069	.072	1.194	.234
Integration	.045	.052	.823	.412
Indoor Air Quality	.139	.180	2.813	.005
Learning Space	.176	.206	3.494	.001
Material Environment	.387	.457	6.993	.000
R	.878			
R^2	.772			
F	131.821			
ρ	.000			

Thus, it could be stated that the science laboratory learning environment influences students' practices on laboratory safety. Moreover, the science laboratory learning environment influences students' practices on laboratory safety by 77.2 per cent. Among the indicators, the material environment best predicts the students' practices on laboratory safety given its highest beta coefficient. The difference of 22.8 per cent is characterised by other components not included in the study. Furthermore, the science laboratory learning environment and students' practices on laboratory safety were reflected in the results of the study conducted by Ali (2018). This study indicated a medium-high to high level of students' awareness on laboratory safety, but with the lowest score on safety equipment, which can be attributed to low resource allocation for the purchase of safety equipment like laboratory coats and safety goggles. The results of this study reinforce the importance of providing the students who are conducting laboratory activities with a conducive science laboratory learning environment. Since the study suggests that there is a significant relationship between the two variables, this amplifies the idea that students' practices on laboratory safety are greatly influenced by their learning environment. The study might be limited to education students only who were able to experience laboratory activities, but this is an effective way of assessing the status of the university's laboratory environment and can be replicated by other courses to further improve both the science laboratory learning environment and student's practices laboratory safety.

Conclusion

Based on the results of the study, it is concluded that the learning environment in the scientific lab, as shown in the scores, was high on all fronts, including rule clarity, integration, indoor air quality, learning space, and learning environment. Second, the level of students' practices on laboratory safety is very high. In particular, the emergency response plan, the work procedure, and the chemical waste management were also very high; however, the work equipment and handling experiment obtained a descriptive level of high. Third, a significant relationship exists between the science laboratory learning environment and students' laboratory safety practices. Lastly, material environment significantly predicts the student's practices on laboratory safety. As a result, this study on science laboratory learning environment and students' practices on laboratory safety confirms the proposition of Hinderson, Fischer, and Fraser (1998) that learning environment factors were found to be particularly important influences on student outcomes, even when other factors were controlled.

Recommendation

It can be noted that two indicators in students' practices on laboratory safety gained only a high descriptive value; thus, it is recommended that more emphasis be placed on safety equipment and handling experiments. Nonetheless, this can be further explored since the findings of the study are only limited to a few laboratories in the institution where this study was conducted.

Other researchers can explore this study by looking into other types of laboratories, such as biology laboratory, physics laboratory, microbiology laboratory, or even laboratories in other courses, such as those in Hotel and Restaurant Management or Engineering courses. In addition, researchers can also use the data from this study to be able to compare it with other colleges or universities to determine the similarities and differences, thereby improving the conduct of laboratory activities through the refinement of the science laboratory learning environment and better improving the students' practices on laboratory safety. Lastly, to help future researchers that may find other factors that influence the students' practices on laboratory safety not involved in this study with a broader scope of participants.

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Research Paper

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Kiwari: Inquiry Smart Module (Investigation Fiction Case-Based) as an Approach to Integrative Science for Student's Analytical Thinking Competencies in Senior High School

Definda Putri Arisna[1*], Sakina Rizqiani[2], and Muhamad Fahreza Ramadhan[3]

[1]Islamic State School (MAN) 4 Jakarta, Pondok Pinang, Kebayoran Lama, Jakarta Selatan. Indonesia. 12310
[2]Biology Cambridge AS Level Curriculum Teacher, Islamic State School (MAN) 4 Jakarta, Pondok Pinang, Kebayoran Lama, Jakarta Selatan, Indonesia. 12310
[3]Student Science Major Cambridge AS Level Curriculum, Islamic State School (MAN) 4 Jakarta, Pondok Pinang, Kebayoran Lama, Jakarta Selatan, Indonesia. 12310
[*]Corresponding author, e-mail: sakinarizqiani@man4-jkt.sch.id

Abstract

The ability to think analytically and critically is one of the keys to carrying out education, which can make students understand comprehensive information and associate between components. However, to train the students' analytical and critical thinking skills, their interest and excitement towards the learning process must be approached. This research was conducted to attract and increase students' interest in learning Biology and Chemistry (Integrative Science), providing an alternative or inspiration for inquiry science learning media to train students' analytical thinking skills and creating a Learner-Centred class. The method used in this study is Research and Development (4D Model); the module design includes the Define, Design, and Development stages. Furthermore, the Two Group Randomised Experiment Method was used to test and measure the feasibility of the Kiwari Module. In this research, the parameters used to test the effectiveness of the module include the parameters to measure in terms of students' interest or excitement in learning, the use in terms of honing students' analytical thinking skills, and the use in studying Biology and Chemistry material, as well as student participation or contribution actively on learning. This study found that the module was said to be effective in increasing students' interest in learning Biology and Chemistry by up to 92%. The analytical uses of the module were scored 4.5 out of 5 by the material experts and suitable for use as a science inquiry learning media option up to 71%. The module was 70.6%, involving students participating actively in the class (Learner-Centred Class).

Keywords: *Analytical Thinking, Biology, Chemistry, Integrative Science, Inquiry Module, Learner-Centred Classroom, Science Learning Media, Student Interest*

Introduction

Technological development is one thing that cannot be avoided and will always happen on earth. With the development of technology, it is necessary to develop and improve human quality as well. A politician, Nelson Mandela, once said that education is the most powerful weapon you can use to change the world. Apart from being a teaching process, education is also said to be a process of transferring knowledge, transforming values, and forming personality with all the aspects it covers, this is necessary to get balance and perfection in the development of individuals and society (Nurkholis, 2013).

At this time, Indonesia and the world are in the Industrial Revolution 4.0 and the Era of Society 5.0. In facing the development of this era, it is essential to make efforts to increase and optimise human resources in terms of education so that they can contribute on a global scale and as provision in the future. The ability to think analytically and critically is one of the keys to undergoing education in this era because this will make students understand comprehensive information and associate between components (Brookhart, 2010; Yilmaz & Saribay, 2017; Dinni, 2018). Education in Indonesia itself has carried out the development of modern learning that is oriented towards HOTS (High-Order Thinking Skills) so that students become accustomed to thinking critically; hence, they can develop their creativity (Wena, 2020) as a form of quality improvement efforts to face Industry 4.0. High-Order Thinking Skills is the ability to connect, manipulate, and change the knowledge and experience the students already have critically and creatively in making decisions to solve problems in new situations (Dinni, 2018).

The analytical thinking skills of Indonesian students is known to be low. This is viewed by Indonesia’s participation in TIMSS (Trends in International Mathematics and Science Study) about five times, including in 1999, 2003, 2007, 2011, and 2015. This participation shows that Indonesian students' ranking results are always included in low-ranking countries. Furthermore, in one of the research studies conducted by Prawita et al. (2019) about measuring Kotabumi students’ analytical thinking skills on respiratory system material, it was found that 49% of the total students still have analytical thinking skills in a very poor category. 42% have analytical thinking skills in a poor category, and 9% in a fair category. This research does not obtain any students with a good or excellent category of analytical thinking skills.

Several factors support all the cases mentioned above, such as the learning strategy and monotonous learning material (repeating questions, multiple-choices, and long essays). The usage of routine questions causes low student curiosity (Sulistiani *et al*., 2018). Therefore, it will create a monotonous class and not catch students’ interest towards the material, which will end up not supporting them to have the capability to analyse the questions thoroughly. Moreover, not engaging students’ participation by having a one-way communication type of teaching could also be a factor. Developing logic, critical thinking, and analytical thinking skills will be challenging if learning is conducted with a strategy that includes students memorising materials (Kao, 2014). On the other hand, allowing students to observe, research, and discuss based on problems presented by the teacher can train students’ analytical thinking abilities (Widyaningsih *et al*., 2018).

Based on research studies have been done showing how previous learning strategies and materials have affected the opportunity for students to train their analytical thinking skills. This research study innovates an inquiry type of module to support students in preparing their analytical thinking ability. The inquiry-based models begin with a problem that can improve analytical thinking skills since it encourages students to discuss and investigate problems, sum up the results, and communicate them well (Ramadani *et al*., 2021). The whole Kiwari Module uses a unique concept which is compiled with the concept of case studies as well as illustrations with approaches to Biology and Chemistry. This emphasises students to investigate the cases and narratives (storylines). Learning with inquiry models prioritises students to not only provide the right solution but also can analyse the case (Ahaddin *et al*., 2020).

This module is an integrated science module because, in practice, literacy learning must be varied and all subjects should be integrated to see the diversity of students' potential integration (Budiono *et al*., 2021). In addition, according to Fogarty (Budiono *et al*., 2021), integrative learning is a learning process that integrates the curriculum of various topics across disciplines. The purpose of integrative literacy-based learning is to make students able to understand and analyse a text. Therefore, with the plan to create this module, it is hoped that later, it will be able to attract and arouse students' interest to be able to investigate cases in the module, as well as become a form or concept of a new variation in the application of High-Order Thinking Skills.

Methodology

3.1 Data Sources, Tools, and Materials

The research was conducted at MAN 4 Jakarta from July to September 2022. This analysis is a Research and Development study in which data acquisition is obtained by adapting one of the research and development methods, the 4D Model developed by Thiagarajan, Semmel, and Semmel 1974. The 4D itself consisted of Define, Design, Development, and Disseminate. However, the research carried out in this module will be limited to the Development stage.

Furthermore, the Two Group Randomised Experiment Method was used to test and measure the feasibility of the Kiwari Module in the class. There would be two different classes from MAN 4 Jakarta (XI IPA 1 and XI IPA 3), which would be subject to compare the study's final results. XI IPA 1 would be the Treatment Group that received the treatment being researched; in this case, XI IPA 1 was the one who tested the Kiwari Module in the class. Meanwhile, XI IPA 3 would be the Control Group that did not receive the treatment being researched; they were learning in the general Biology and Chemistry class without the Kiwari Module.

The parameters used to test the feasibility and effectiveness of the module include the parameters to measure in terms of students' interest or excitement in learning, the used of the module in terms of honing students' analytical thinking skills, and the used of the module in studying Biology and Chemistry material, as well as student participation or contribution actively on learning.

3.2 Data Collection Method

The first stage is the Define stage, which is carried out to identify and find out the facts behind the creation of this module through literature study activities. At this stage, it aims to determine and define the requirements needed in learning by analysing the objectives and limitations of the material developed by the device (Kristanti & Julia, 2017). The next stage is Design that includes the creation of instruments for the validator and the module framework according to the Module Design plan. This design is retrieved to determine that the modules are made according to learning needs. Meanwhile, the third stage is Development in order to maximise the modules' concept and produce revised module based on input from validators or experts in their fields and to test the feasibility of the module according to learning needs.

After the modules were validated, the next stage was the module trial for XI IPA 1 students. The method used in the module trial phase to test the modules' effectiveness is the Two Group Randomised Experiment method. In the end, XI IPA 1 and XI IPA 3 students will complete the same questionnaire to compare the difference between the class with and without the Kiwari Module in the Treatment and Control group.

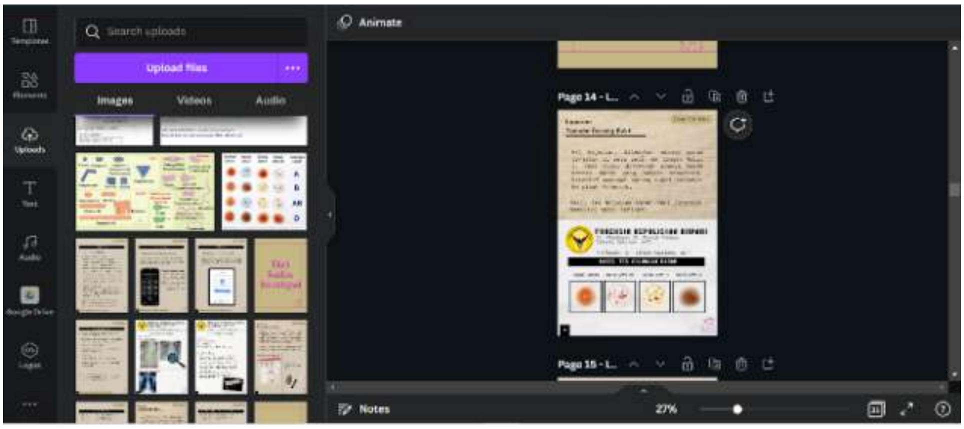
3.2 Data Analysis

The data analysis method used in this study is descriptive qualitative data analysis; the data will be analysed using two variables, namely, the product's characteristics and the module's quality. The instrument used to analyse the data comes from the results of a questionnaire that the respondents will fill out after working on the module to measure its impact and effectiveness. Data analysis includes aspects in the module such as whether the language is easy to understand, presentation systematics, implementation aspects, whether the module attracts students' interest, and so on as parameters which will later be accumulated to get a final result in the form of a percentage then the results are analysed according to the scale module eligibility.

Results and Discussion

This study aims to create an inquiry module that can be used as a variation of a new concept to attract students' interest and improve analytical thinking competence as well as create a student-centred learning class (Learner-Centred Class). Starting with the 4D Modelling stage in module design, the design of this inquiry module starts from the module concept, which is inspired by investigative and detective concepts. At the module design stage, starting from making narrative cases and determining material with literature and literature studies to find out what materials will be covered and linked in the module.

Furthermore, the preparation of module and the manufacture of designs or illustrations of module is carried out using the Canva software (Picture 1). Finally, the module validation stage was carried out by material experts.



Picture 1. Module Illustration and Design

The instrument validation stages in this module are carried out by means of experts' judgment in producing instruments, in this case, the Biology and Chemistry Teachers of MAN 4 Jakarta.

Table 1 presents the data from the expert assessment results of the questionnaire used for the validation.

The questionnaire consisted of 8 questions with a rating range of 1-5. Aspects of module assessment include Student Interest, Learner-Centred modules, and Analytical Uses of Modules. The comments, suggestions and input given by the material experts are contained in Table 2.

Table 1. Results from Material Experts

Scope Scoring	Experts Score		Total Average	Notes
	1	2		
Student Interest	5	4.5	4.75	Very value
Learner-Centred Module	4.6	4.6	4.6	Very value
Analytical Uses of Module	5	4	4.5	Value
Total Score Average			4.6	Very Value

Table 2. Suggestions and Advice from the Material Experts

No.	*Suggestions and Advice*	*Follow-up*
1.	The instructions and steps of the module are clear	-
2.	In the section on respiratory system disorders, additional information is needed about the bacteria that cause the disease	Adding information and modifications or revisions regarding the form of problems with respiratory system disorders
3.	Reflections are strengthened during the class	Making presentation slides for students' reflection after working on the module.
4.	Revision regarding the beginning of the paragraph to be indented	Revised

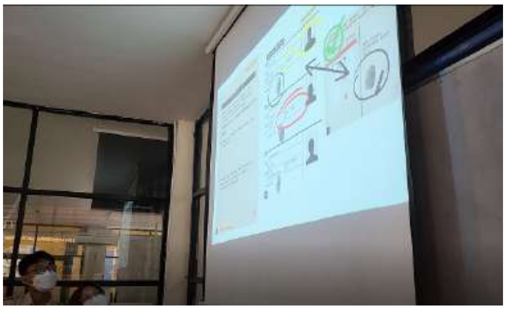
Table 2 shows the list of suggestions and advice, including the follow-up of the suggestions from the Material Experts (Validators). There are at least four main suggestions and advice from both experts, with all of them already being solved or revised as the experts suggest.

The subject of this research is class XI (11) IPA MAN 4 Jakarta. There are two classes, where one class (XI IPA 1) is the group that gets the trial (Treatment Group), and the other class (XI IPA 3) is the group that does not get the treatment (Control Group). The trial of the Kiwari Module was conducted on Wednesday, 5^{th} October 2022 (Picture 2). The research was conducted in the Treatment Group, class XI IPA 1 MAN 4 Jakarta. Before the module was tried out, the students read the instructions and were divided into groups. Furthermore, the trial began with the duration of working on the module for 1 hour and 30 minutes. After working on the module, each group prepares two people to present the results of their analysis of cases in the module in class (Picture 3). Next, a discussion of the modules is carried out, including the cases contained in the module (Picture 4). After the end of the trial, students were asked to fill out a questionnaire related to their experiences during the whole class, their interests, the content, form, or design of the Kiwari Module.

Picture 2A. Kiwari Module Trial

Picture 2B. Kiwari Module Trial

Picture 3. Presentation Post-Module Work



Picture 4. Module Discussion

The data used in this study were primary data based on a specialisation questionnaire in Biology and Chemistry which was given to students in both Treatment Group class XI IPA 1 and Control Group XI IPA 3 MAN 4 Jakarta. The trial of the Kiwari Module has been carried out and the group that received the treatment, namely class XI IPA 1, received and filled out the specialisation questionnaire as well as the Module Effectiveness Validation and Feasibility Validation questionnaires. Later, this data will be used as a benchmark for comparing the interests of students who received the module treatment (Kiwari Module) with students who did not receive the treatment.

Interest Measurement of Control Group

Class XI IPA 3, which also served as the control group in this study, filled out 16 questions in the questionnaire or interest questionnaire in Biology and Chemistry learning, where the questions were related to their experiences and interests during the Biology and Chemistry learning process in general classes (without Kiwari Module).

Table 3. Percentage of Control Group's Interest

Interest Ranges	*Interest Percentages*
Interested	52%
Average	26%
Not Interested	22%

Based on Table 3, it is known that 52% of students in class XI IPA 3 have an interest in learning Biology and Chemistry with general learning methods. While 26% are known to have an ordinary interest in learning Biology and Chemistry, 22% of students are not interested in learning Biology and Chemistry.

Interest Measurement of Treatment Group

Table 4. Percentage of Treatment Group's Interest

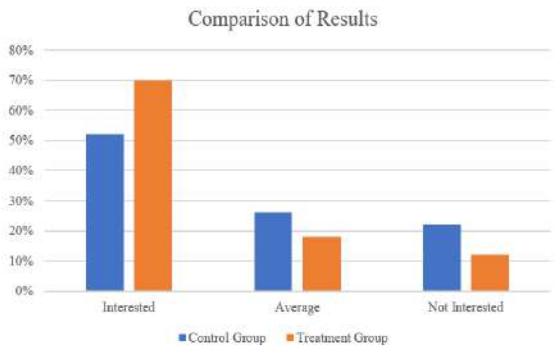
Interest Ranges	*Interest Percentages*
Interested	70%
Average	18%
Not Interested	12%

Based on the data shown in Table 4, as many as 70% of students in class XI IPA 1 felt interested in learning Biology and Chemistry with the Kiwari Module used during the class. Meanwhile, 18% are known to feel the same way (ordinary) during module trials and learning in general. Meanwhile, 12% or as many as two students felt not interested in learning Biology and Chemistry. Class XI IPA 1, which also served as the treatment group, had 17 students and had been divided into groups of 4-5 people when the module trial was carried out.

Comparison of Results

The results of the two studies were then measured and compared between the results from the Treatment Group (XI IPA 1) and the

Control Group (XI IPA 3). The purpose of the comparison is to record progress in research.



Picture 5. Comparison between Control and Treatment Group

The diagram above shows (Picture 5), a difference in the percentage of students' interest reaching approximately 20% in Biology and Chemistry learning using the Kiwari Module. Besides, there is a difference of up to 10% in students' disinterest in learning Biology and Chemistry without the Kiwari Module.

The last stage of this research is the validation of the Kiwari Module. After completing the Kiwari Module trial, class XI IPA 1 received and filled out the Module Effectiveness Validation and Feasibility Validation questionnaires. The questionnaire is a benchmark for respondents to determine whether the Kiwari Module is effective and feasible in attracting students' interest in learning Biology and Chemistry. Their responses to the Kiwari Module and the Biology and Chemistry Learning Process using Kiwari are listed in Table 5.

Table 5. Percentage of Responses on Respondents Questionnaire

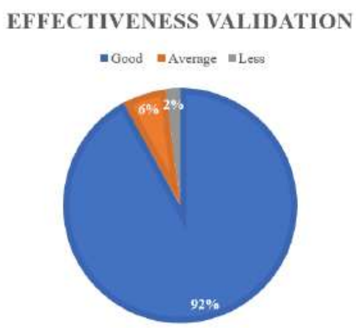
Benefits Aspects	Average Rating Scale			Notes
	5	4	3	
Use of Module to attract students' interest	80.4%	11.76%	7.84%	Very Agree
Use of Module to train Analytical Thinking Competency	70,6%	22.05%	7.35%	Very Agree
Use of Module to study Biology and Chemistry material	29.4%	52.9%	17.6%	Agree
Use of Module to involve students actively contributing to class (Learner-Centred Class)	70.6%	26.45%	2.95%	Very Agree

Notes:
5: Very Agree 4: Agree 3: Uncertain

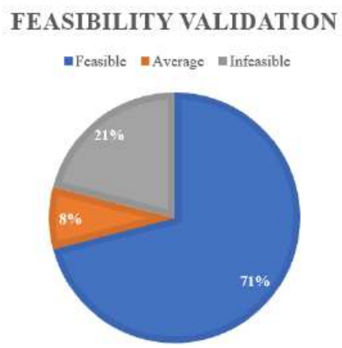
According to the data shown in Table 5, 80.4% of students very agreed that using the Kiwari Module could interest them in learning Biology and Chemistry because they were equipped with a unique concept and illustrations that match the material to attract students' interest in learning. This is in line with research by Septiani et al. (2013); Afridah et al. (2022), who stated that teaching which is attractively designed and equipped with pictures attracts students' interest.

The use of module can also train students' analytical thinking competencies which 70.6% of students agree that learning activities with Kiwari can hone their analytical skills in linking Biology and Chemistry learning in everyday life. The module is equipped with consecutive and further questions that encourage students to solve and investigate the case inside the module by connecting links between evidence that have a relation to the Biology and Chemistry materials to find appropriate conclusions and solutions. This is supported through research done by Kusdiastuti et al. (2016) that inquiry-based learning involves students actively seeking, finding, and investigating knowledge

Furthermore, 52.9% of students agreed they could study Biology and Chemistry while working on this module. In addition, 70.6% of students felt that they could actively contribute to discussions, express opinions, and convey the results of their analysis to fellow group members.



Picture 6A. Effectiveness Percentage



Picture 6B. Feasibility Percentage

According to the data obtained from the XI IPA 1 questionnaire (Pictures 6A and 6B), the Kiwari Module received positive results. Based on Pictures 6A and 6B, the Kiwari module gets a percentage of the effectiveness of using the module by 92%, and the percentage of the feasibility of the module is obtained by 71%. Based on assessment data for each aspect, the Kiwari Module received a good response in field trials because the effectiveness of this module reached a percentage above 90% of class XI IPA 1 students.

The results of the study show that the module is categorised as effective up to 92% for the Biology and Chemistry class because it caught students' interest and encouraged students' active participation to investigate, analyse, and solve the case inside the module. This is in line with Sartika et al. (2018), who stated that inquiry-based learning is one of the models that prioritise student activity in the learning process, such as building independent learning and analysing complex information. Moreover, it is also supported by the research conducted in 2019 by Qadariah et al. They conducted an inquiry-based module research on the Material of the Reproductive System. In the study, it is known that the value of the effectiveness or usefulness of the inquiry-based module has a percentage above 90%.

Conclusion

The Kiwari Inquiry Module received positive responses from both the validator and students who received this module treatment. The Kiwari Module can be used as an alternative learning medium for Biology and Chemistry, which is able to attract students' interest in honing their analytical thinking skills by implementing a learning process that involves active involvement and contribution of students in discussing and exchanging ideas.

Based on the analysis and discussion of the data, the conclusion that can be obtained from this study is that there is a difference in the percentage of students' interests reaching approximately 20% in the control group and treatment group. This fulfils the objective of the research, to create an inquiry module that can be used as a variation of a new concept to attract students' interests in improving analytical thinking competencies. In addition, according to the data listed, the Kiwari Module is able to help hone students' analytical thinking skills, reaching 70.6% improvement.

The Kiwari module can also be an alternative to inquiry learning that maximises student contribution and involvement during learning. It is in line with the aim of making this module, which is to maximise the contribution and activeness of students in the class (Learner-Centred Class) as an effort to improve analytical thinking competency.

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Research Paper

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Practices of Top Performing Science Secondary Schools in Baguio City

Philip Julius F. Nicer[1,2]

[1]*Saint Louis University, Baguio City 2600, Philippines*
[2]*Don Mariano Marcos Memorial State University, 2504 La Union, Philippines*
[*]*Corresponding author, e-mail: pjfnicer@slu.edu.ph*

Abstract

The progress of any nation has been associated with its scientific and technological expansion. This suggests that science plays a momentous part in the economic, technological, administrative, and ecological improvement of any nation-state because science has saturated all aspects of human existence. The study sought to identify science practices of the school participants that led to their high performance in various science-related activities. This study identified the profile of the school and its stakeholders, including their material resources and practices/methods for achieving high levels of success in science-related activities. Mixed method research was employed in processing the gathered data. It has been found that: (1) positive atmosphere; (2) learner-centred activities; (3) professional development; and (4) strong linkages generally contributed to the high performance of the schools in science-related activities. As a recommendation, a more contrived and intricate manner of assessing learning among student participants leaning towards their high performance in science-related activities and competition should be made.

Keywords: *Science education, Science practices, Top-performing schools*

Introduction

According to the Philippines' Department of Education (2017), schools are appraised based on some listed criteria to be tagged as the nation's best school. To qualify, schools must be guided by the following criteria, namely (1) performance indicators, including cohort, drop-out, and Mean Percentage Score (MPS); (2) financial management, including budget utilisation, the preparation and approval of a Work and Financial Plan (WFP), and monthly transparency board updates; (3) personnel development, including monthly In-Service Training (INSET)/Learning Action Cell (LAC) sessions (all employees having a properly completed Individual Professional Development Plan (IPDP)). and the approval of the School Head/Principal's Office Performance and Commitment Review (OPCR); (4) school environment that is comprised of school site ownership, clean and green program, health nutrition, and child protection policy; (5) partnership that is made up of school community projects/activities within or outside donations received and dissemination of DepEd programs during PTA meeting ; (6) strategic plan; (7) school awards won in municipal/district, division, region, and national levels, respectively.

Students' performance greatly influences the quality of the kind of education offered in a school. Students' ability to assimilate information directly correlates with their ability to process information and infer relationships and connections between and among facts. Hoffenberg and Saxton (2015) even claimed that if students understand how scientific knowledge is built, they can become more sophisticated consumers of scientific knowledge. At the high school level, several countries with high student performance use board examination systems.

As from National Centre on Education and the Economy (NCEE), the "Excellence for All" executed by United States schools is a program that differs from systems in other countries in that students are "tracked" less aggressively; if students do not achieve criteria by the end of sophomore year, their high school will be compelled to examine their results and develop a customised program to bring them up to standard the following year.

For emphasis, the problem-solving approach to learning is something to be considered of great importance. It involves asking the learners, "So what? How are you going to apply it?" in a biology class, rather than simply learning terms; students are presented with real-world situation and asked, "Here's a situation that might emerge in the real world. What would you do if you knew how to apply what you know to the problem?" rather than being investigated separately. These issues are investigated in a collaborative and interactive manner.

As general as it may sound, educational practices in a school also nurture great learners. The implementation of well-planned work plans and identification of the needs and assessments of the school may help school administrators in improving NAT (National Achievement Test) performance. As a result, in addition to the NAT, school procedures in general should be considered, accounted for, reviewed, and most importantly, examined to determine their effectiveness and impact on education. Besides the front runner (the principal), the roles of other stakeholders also make an impact on upgrading school undertakings.

A high-performing learning institution must investigate several factors, such as the organisational goals, teachers' performance, students' performance, and its own practices in keeping up with the set standards (Eslabra, 2019). Apart from that, another important factor contributing to students' high performance is the support from other stakeholders. Stakeholders are people or groups who have an interest or concern for the school. They are made up of parents, school administrators, board members, local government officials, alumni, and socio-civic organisations who all contribute to the school's success. As a result, a positive relationship between teachers and stakeholders is critical because it allows everyone to work together amicably, which will benefit the students. Hence, being "best" in science education means that it is the intertwinement of not only a single factor but also a vast array of educational dynamics.

Other factors for being identified as the best include the kind of teachers, the curriculum applied, availability of up-to-date facilities, and the like. However, Finkel (2012) felt that state-of-the-art facilities, new textbooks, and central administrations should be prioritised over teacher training and salary. Furthermore, Eslabra (2019) elaborated that high educational expenditures do not necessarily lead to high performance. NCEE recognises that education systems that sort pupils and only provide some of them challenging curricula will fail to generate suitably educated citizens for the 21st century. This is evident in high-wage countries like Singapore and Finland, as well as those seeking to be high-wage countries such as China, who understand that education systems that segregate pupils and provide some of them with difficult curricula would not generate suitably educated people for the 21st century (Finkel, 2012). This only suggests that curriculum on its own cannot mould "smart" citizens of the future. However, most importantly, routines and practices in school make one successful. It is the reason why schools put much effort to develop routines that can improve and maximise learning. In addition, the evaluation and assessment of these matters are also carried out continuously.

For the past three school years (2015 to 2016, 2016 to 2017, and 2017 to 2018), the following schools topped different science festival competitions in Baguio City: Baguio City National High School-Main, Pines City National High School-Main, and the

University of the Cordilleras-Senior High School. It is unclear how and why they won science competitions, which is why this study was done to educate others about their science education approaches.

There is a dire need to identify practices in science education. According to March and Peters et al. (2008), best practices help teachers separate instruction (including curriculum) and provide active learning opportunities for students to internalise material by allowing them to set expectations for completing activities/lessons/projects/units. Stone (2014), as cited by Brown et al. (2017), claimed that other best practices include managing the classroom, providing cooperative learning opportunities, setting consistent course standards, enhancing students' transferability skills, increasing learner engagement, and creating sustainable learning for students. To identify and emphasise successful schools, science practices need to be accounted for, assessed, and evaluated. As reasoned by Theall (2017), "Evaluation without development is punitive, and development without evaluation is guesswork." This encourages educational institutions to gear themselves towards constant improvement. The goal of evaluation is the same—to improve student learning (Benton *et al*., 2018).

What qualities/characteristics set performing schools from the rest? What strategies should be implemented to become the "school to beat" as well? What practices should be derived to develop scientific literacy and proficiency? These are only a few of the numerous questions the researcher wishes to explore as a teacher and a learner. Case in point, with all this said and done, this study would likely be of benefit to schools trying to perform well not only in science but also to improve their educational processes in general. This research would not only form the foundation of programme development and policies, but also can be translated into effective educational programmes, specifically that of science. The strength of this study stems from the fact that it is empirical rather than simply speculating on what could be useful or effective. The researcher went out into the field and conducted a study that will offer policymakers with hard data on which to base future decisions.

Bridging the gap between what works in research and what works in the field is one of the major issues in education. This shows that there might be a disconnect between the methods used in the best secondary scientific schools and what is known about the most efficient teaching techniques. Therefore, it is crucial to pinpoint the elements that make these schools successful and investigate how they might be incorporated into other educational environments to close this gap.

This study sought to reveal the science procedures of Baguio City's best performing schools. Particularly, this study investigated the profile of the science teachers along their educational attainment, specialisation, length of service, achievements, seminars attended, affiliations in organisations, and expert services related to science. Furthermore, the students' profiles were also investigated along their General Percentage Average (GPA), science-related awards received, and National Achievement Test (NAT) performance in science. Lastly, this study investigated the material resources, extent of support from the schools' internal and external stakeholders, and practices of science secondary schools in the city of Baguio.

Methodology

The study employed a mixed method; particularly, qualitative and quantitative research. The quantitative approach consists of a survey about the respondent's profile, namely, the science teachers and students. This survey was focused on gathering numerical data and generalising it across groups of people to explain a specific phenomenon. The presence of specific phenomena was determined by the frequency of certain parameters, which were then correlated to the statements of the problem stated above. Regarding the experience of the unprecedented COVID-19, quota sampling was utilised to identify the participating population of teachers and students from the respective schools. At this point, the population was defined as school heads, science teachers, and students. Furthermore, the sample size was identified as one school head, five teachers, and 15 students per school. After that, the data was acquired, and samples were collected.

Considering the quantitative approach, the descriptive method of research was utilised. Because the study is focused on existing teaching approaches that are demonstrated to be effective in teaching science, this form of research is a fact-finding study that emphasises what exists. Moreover, such a method was also used to secure responses to honest questions and practices of which the respondents are supposed to have information. The responses were then processed using the Warm Analysis Method, which resulted in the generation of encompassing phrases (generic) and several responses. The data, transcribed interviews, sorting, categorisations (cool analysis), and thematised categories (warm analysis) on a repertory grid or a dendrogram paved the way for a better understanding of the value of participants' lived experiences. The descriptive method also includes analysis and is concerned with the effects of the topics discussed, such as school profile, laboratory and library materials, to name a few, as well as emerging trends and existing relationships-particularly the status of the practices in teaching science of Baguio City's top performing secondary schools for the school year 2019 to 2020.

Research Questions:

This study determined the practices of top-performing science secondary schools in Baguio City. Specifically, it sought responses to the following questions:

1. What is the profile of the science teachers along:

1.1 Highest educational attainment and specialisation

1.2 Length of service

1.3 Science-related achievements/awards/innovations

1.4 Science-related seminars attended

1.5 Science club organisation membership/position held

1.6 Expert services related to science

2. What is the profile of the students along:

2.1 Academic Performance (GPA) for the past two years

2.2 Science-related awards received

2.3 NAT performance in science for the past two years

3. What are the material resources along:

3.1 Library holdings

3.2 Laboratory facilities

4. What is the extent of support of the administration and parents along the following parameters:

4.1. Financial

4.2. Moral

4.3. Administrative

5. What are the practices of science secondary schools in Baguio City?

The study's respondents came from the following schools: Pines City National High School (PCNHS), Baguio City National High School (BCNHS), and University of the Cordilleras-Senior High School (UC-SHS). The schools were selected based on the number of first places counted in different Baguio City Division Science Competitions from the three previous school years (2015-2016, 2016-2017, and 2017-2018).

There are 15 students from each school who invited to participate, for a total of 45 participants, consisting of 11 students from 10 graders (NAT results were also acquired), 22 from 11 graders, and 12 students from 12 graders.

Every school, survey sheets/Google Forms were provided to:

School/ Participant- respondents	School Head	Teachers	Students
A	1	5	15
B	1	5	15
C	1	5	15

Description:
A - Baguio City National High School
B - National High School of Pines City
C - University of the Cordilleras- Senior High School

Instrumentation and Data Collection

A letter advising the Schools Division Superintendent of the Education Department of Baguio was produced for the data collection of this study. A basic background on the study was included in the letter, as well as the process for gathering data. The participants were also assured that all information/data gathered from the participant would be kept confidential. Besides, since the study was conducted when the COVID-19 pandemic hit, the data from two school participants were gathered virtually via Google Forms and online interviews upon the approval of the dean and the researcher's adviser.

Two sets of tools were utilised by the researcher. One is a survey form for the profiles of the science teachers and students, and the other is a set of questions planned for the focused group discussion.

A survey was distributed to gather quantitative data on the profiles of the participants. The questionnaire was used to collect data for the study, such as human resources data, which included teachers and students, material resources data that include the library holdings (print & non-print), laboratory facilities (vis-à-vis standards of DepEd), and NAT performance in science for the past two years; and two schools' science practices.

The second set of tools is the interview questions on practices in the science of the top-performing secondary schools in preparation for various science-related events. This was administered during the key informant interview.

Several qualitative instruments were used to gather the data. Key informant interviews that facilitated with semi-structured interview questions were administered to teachers from their respective schools to gather detailed and comparable activities from teachers from each participating school. This method is a form of informal conversation while gathering information from the participants.

Open-format questionnaires were also utilised to further collect individualised responses from the participants. This questionnaire allowed participants to provide free-flowing responses of their views, experiences, and perceptions. It is like a follow-up question to the structured questions beforehand.

In the end, the Interpretative Phenomenological Study (IPS) was utilised. A phenomenological study is a study that attempts to understand people's perceptions, perspectives, and understandings of a particular situation or phenomenon (Leedy & Ormrod, 2001). This method was used to analyse responses to interview questions to determine how participants (interviewees) made sense of a particular phenomenon in a specific setting.

It is also important to note that since data were gathered on various platforms, triangulation was conducted to confirm the correctness of the data collected.

Analysis of Data

The data for the first statement of the problem (SOP) was analysed using frequency counts and percentages. Moreover, SOP 2 was analysed using central tendencies median. In evaluating the data acquired from the key informant interview and survey questionnaire for SOP 3, enumeration was also used.

Transcripts of the focus group discussions were coded using emergent coding for codebook development to classify the responses into meaning units. Similar meaning units were grouped, and a code or sub-code label was assigned. In order to sort the differences and similarities within the meaning units, sub-themes were created, compared and sorted into emerging themes. The questionnaire responses were treated with the same method and synthesised with from the key informant interview findings.

A four-point Likert Scale allowed respondents to express frequency with a particular statement for statistical analysis. The strength/intensity of an attitude is supposed to be linear: for instance, on a scale extending from always to never. The options for the Likert Scale were always, often, seldom, and never.

Results and Discussion

Profile of Science Teachers for Top Performing Schools

Contributory to science practices, there is a dire need to identify the profiles of the primary school stakeholders to correlate their background on the practices in science. The first table shows the summarised science teachers' profile regarding their highest educational attainment, specialisation, length ofservice,science-relatedachievements/awards/innovations,membership in science-related associations/institutions, training/seminars attended related to science, and rendered expert services. Table 1. Science Teachers' Profile .

Of the participating science teachers, 11 or 73 per cent finished their bachelor's degree, three or 20 per cent their master's, and one or seven per cent finished their Doctorate. Additionally, 14 or 93 per cent specialised in science and one or seven per cent in Chemical Engineering.

As to the length of service, seven or 47 per cent of the respondents have served for 5 years and below; three or 20 per cent between 6 and 10 years; two or 13 per cent between 11 and 15 years and 16 and 20 years; and one or seven per cent between 21 and 25 years, correspondingly.

In terms of science-related achievements/awards/innovations, the schoolteachers had four or 27 per cent at the school and division levels; two or 13 per cent at the regional level; and one or six per cent at the nationals. The remaining four, or 27 per cent, also had awards but not science related.

Memberships to science-related organisations are as follows: four or 27 per cent were division-based such as Baguio City Association of Science Teachers (BCAST); three or 20 per cent were school-based such as the Prime Movers Club (PMC); one or six per cent is national-based. The remaining seven or 47 per cent also were members of an organisation, but unrelated to science.

Attending science-related seminars/training might have also oriented and equipped personnel participants with the required and appropriate knowledge, techniques, and practices (Panganiban, 2017). There were four or 27 per cent who attended schoolwide and national level training; three or 20 per cent in the division; and one or six per cent at the regional level. The remaining three or 20 per cent also attended training/seminars but were not science related.

Lastly, the school personnel who participated in this research rendered science-related expert services. Ten or 38 per cent served as coaches; nine or 34 per cent as advisers, two or eight per cent as judges, speakers, and trainers; and one or four per cent as a lecturer, in varied science-affiliated activities. All the teachers are active members, and they play varied roles in the scientific community.

Table 1. Science Teachers' Profile

Variable	Frequency (n=15)	%
Highest Educational Attainment		
Bachelor's Degree	11	73
MA/ MS Graduate	3	20
PhD/EdD	1	7
Specialisation		
Chemical Engineering	1	7
English		
Mathematics		
Science	14	93
Length of Service in the Institution as an Administrator/teacher		
5 and below	7	47
6-10	3	20
11-15	2	13
16-20	2	13
21-25	1	7
26 and above	0	
Science-related achievements/awards/innovations		
National	1	6
Regional	2	13
Division	4	27
School	4	27
With award/ innovation unrelated to science	4	27
Membership in science-related associations/institutions		
National	1	6
Division	4	27
School	3	20
With membership unrelated to science	7	47
Trainings/seminars attended related to science		
National	4	27
Regional	1	6
Division	3	20
School	4	27
With trainings unrelated to science	3	20
Expert Services		
Adviser	9	34
Coach	10	38
Judge	2	8
Lecturer	1	4
Speaker	2	8
Trainer	2	8

Students' Profile of Top Performing Schools

From the three participating schools in Baguio City, 15 student participants per school were selected in this study. The 11 graders dominated the population comprising 49 per cent, followed by the 12 graders with 27 per cent, and the 10 graders with 24 per cent.

The following are the percentages of students with their corresponding GPAs: Two or four per cent comprise an average of between 80-85 and 96-100; nine or 20 per cent between 86-90; and 32 or 72 per cent of the population had a GPA of 91-95. Given that, the majority of the students had an average of 91-95, it is apparent that they are among the top students in their class.

Table 2. Students' Personal Profile

Variable	Frequency (n=45)	%
School		
A	15	33.33
B	15	33.33
C	15	33.33
Grade Level		
10	11	24
11	22	49
12	12	27
Academic Performance in Science for the past two (2) years (General Point Average, GPA)		
80-85	2	4
86-90	9	20
91-95	32	72
96-100	2	4
Science-related awards		
National	2	4
Regional	5	11
Division	4	9
School	5	11
With awards unrelated to science	29	64

The DepEd's current target is a mean percentage score (MPS) of 75 per cent. From the study conducted, it is evident that such a goal is far from being achieved or is still very elusive.

Table 3. NAT Performance of Grade 10 Students in Science for the past Two (2) Years

NAT results in science SY 2016- 2017		NAT results in science SY 2017- 2018	
M	SD	M	SD
39.15	22.42	34.59	19.01

Participation to Competitions & Seminars, Workshops & Training

Exposure to seminars, workshops, and training are considered as one good tactic contributory to the high performance of learners in science-related activities. Being equipped with strategies in competitions becomes an advantage in competitions.

Table 4. Students' Responses on their Practices in Science

Codes	Frequency	Percentage	Themes
Joining competitions and supplementary activities (seminars and training) in the field of science.	27	60	Participation to competitions & seminars, workshops & training
The presence of laboratory activities and experimentations Varied teaching strategies Cooperative and collaborative activities	33	73	Interactive learning activities

Interactive Learning Activities

The inclusion of experimentation hand in hand with the presence of laboratory activities serves as avenues for exploration, inference, and hands-on learning among learners. Students tend to get uninterested in lectures, but interactive activities involving their participation can pique their interest, resulting in a learner-centred class. When students are engaged in cooperative and collaborative activities, it tends to bring about good results in the student learning process. Besides the conduct of scientific experiments, students also find it effective if teachers employ varied teaching strategies. Altogether, if students are made to be engrossed with exploratory/interactive activities, it affected high performance in science-related activities.

Material Resources in Top Performing Schools

Library Holdings: Print and non-print

A vast array of library resources brings about better opportunities to expand and broaden learners' knowledge in science. In support to this, the availability of resources partnered with their maximised utility have been proven to yield high performance in science. School respondents from this study exceeded the standards set by DepEd for both print and non-print library holdings.

Libraries are viewed as social institutions dedicated to increasing knowledge, preserving cultural heritage, and providing information to a variety of consumers (Benard *et al*, 2014). According to Salman et al. (2014), the availability of books and other non-books enhances children's academic advancement in classrooms. Providing effective and successful library services in the classroom requires the utilisation of school library information resources.

Table 5. Inventory of Library Holdings (Print and Non- print)

Library Holdings	Quantity	DepEd Standards (DepEd Order No. 56, s 2011)	Remarks
Printed science-related library holdings *(Books, General References, Research, etc.)*	19,438	5,000	Exceeded the standard
Non- print science- related library holdings *(Audio- visual materials and electronic resources)*	2,155,287	390	Exceeded the standard.

Science laboratories

A total of 1641 items were listed as the number of equipment required in a laboratory for secondary schools. From these numbers, it can be inferred that the school participants exceeded the expectations and requirements of the Education Department. With the abundance of lab equipment and their maximized utility, laboratory facilities can be attributed and contributed to the participants' best practices in science.

Extent of Support from the Administration and Parents

Stakeholders' involvement in different school activities also contributes to student performance in certain areas, especially competitions.

It can be inferred that parental and administrative involvement is highly evident and apparently contributes to the high performance of learners in science-related activities. Based on the identified parameters, both stakeholders showed their support more in financial form than in moral support. To sum it up, the close ties and communication between stakeholders and the school, along with their support in different areas and active involvement, contribute to the school's practices regarding their high performance in science-related activities.

Practices of Schools

Science teacher and student profiles, library holdings, and laboratory facilities contribute to science practices. Table 8 shows the codes, frequency, percentage, and corresponding themes of the teacher-participants' responses. Transcripts were coded using emergent coding to classify the responses into meaning units.

Positive Learning Atmosphere

Classrooms were efficiently handled and tidy with minimum student misconduct, and students had sufficient assignments. Successful classroom administrators are more experienced in avoiding disturbances (Kounin, 1970, as cited by Dunbar, 2004). Proverbially, one of the most crucial aspects of good teaching is to create a joyful classroom environment. Teachers have the potential for improved classroom discipline and management by developing conducive classroom environments. In keeping behaviour issues to a minimum, a positive classroom atmosphere is essential. It also offers students an opportunity to think and act constructively. In all academic settings, positive classroom environments help to reinforce, support, and promote students' learning. The shared perspectives of students and teachers in the classroom setting may be used to characterise the environment (Fraser & Pickett, 2010, as cited by Fleming and Younger, 2012). Therefore, it is critical to provide an engaging and positive learning environment for learners to improve their knowledge and abilities.

Learner- Centred Type Approach

As to the teaching approach, the teachers usually follow a structured class routine. The class jumpstarts through a motivation/review and is followed by the lesson, then formative assessment and generalisation. This structure is a learner-centred and constructivist approach to teaching. Students in student-centred sections performed significantly better than students in teacher-directed sections in terms of process skill comprehension and application, creativity skill application, development of more constructive behaviours, and the ability to apply science principles in new ways (Akcay and Yager, 2010). This implies that a learner-centred section and a smooth flow of the teaching-learning process contribute to better achievement among learners.

Professional Development

Training sessions and attendance to science-related seminars and workshops are the common opportunities teachers involve themselves in order to achieve high performance in science. As reiterated by a teacher-respondent, "I attend training/workshops where I find applicable to my field. I also attended several webinars during the lockdown to enhance my knowledge and abilities."

Support System

Support from other school stakeholders also contributes to the sustenance of the science practices because of the financial, moral, and even administrative upkeep provided to the whole school community. As an old cliché goes, "A child is not raised by parents alone but a whole community," implying that other stakeholders outside the school also contribute to the high performance of learners in science-related activities in their respective ways.

The close ties and communication between stakeholders and the school, along with their support in different areas and active involvement, contribute to the schools' practices regarding their high performance in science-related activities.

Conclusion

This research on science practices took among the top three (3) schools in Baguio City in science-related contests, namely, Baguio City National High School-Main, Pines City National High School-Main, and University of the Cordilleras-Senior High School. As a result, the following conclusions are:

1. The science teachers have finished their bachelor's degrees. Some pursued their master's degrees, and only one of the whole populations finished their doctorate. Correspondingly, the same trend is true for the length of service. The majority are novices in the field. As to their science-related achievements/awards/innovations, few made such initiatives. In contrast, they assumed positions in science-related clubs/organizations, attended science-related seminars, training, and workshops, and provided science-related expert services (e.g., coach, adviser, speaker, trainer, etc.) in some way.
2. The 45 student participants, an average number in the population had a GPA of 91-95 per cent, of which few of them earned science-related awards. Notably, the schools' NAT results for the past two years were far from the set goal of DepEd, which is about 75 per percent. For students, their deemed science practices include (1) opportunities for example exposure to varied activities and competitions in the field of science and (2) the conduct of seminars and training in science-related topics.
3. The schools' material resources were also considered. All the school participants possess library holdings and laboratory facilities at par with the DepEd set standards.
4. The extent of support provided by the administration, parents, and other stakeholders was set at a high point in relation to the following parameters: financial, moral, and administrative. They converge to come up with the finest practices in science based on all the data.
5. For teachers, practices in science in general include (1) creating a positive learning environment; (2) using a learner-centred approach; (3) professional development such as immersion in training, seminars, workshops, and competitions; and (4) establishing strong community linkages.

Table 6. Laboratory Facilities

Laboratory Materials	Quantity	DepEd Prescribed Figures	Remarks
A. Glass wares	3,286	239	Exceeded the standard
B. Disposable Lab Wares	897	313	Exceeded the standard
C. Storage Apparatus/ Facilities	3,422	93	Exceeded the standard
D. Experimental Apparatus	13,910	964	Exceeded the standard
E. Analytical Apparatus	475	32	Exceeded the standard
Grand Total	20,050	1,641	

Table 7. Extent of Support from the Administration and Parents

Variable	M (Administrators)	DR	M (Parents)	DR
Financial				
a. There is a provision for pocket money.	3	*O*	4	*A*
b. There is a provision for material needs, registration fees, and transportation.	4	*A*	4	*A*
			4	*A*
c. There is a provision for “extra needs.	3.5	*A*	4	*A*
Moral				
a. Physical presence is sensed during training.	4	*A*	4	*A*
b. Attendance during the competition proper is felt.	4	*A*	3	*O*
c. There is a provision for words of encouragement.	4	*A*	3.5	*A*
	4	*A*	3.5	*A*
Administrative				
a. There is a provision for the training schedule.	4	*A*		
b. There is a provision for incentives.	3	*O*		
	3.5	*A*		

Legend:

3.25- 4.00	=	Always	(A)
2.50- 3.24	=	Often	(O)
1.75- 2.49	=	Seldom	(SE)
1.00- 1.74	=	Never	(N)

Table 8. Teachers' Responses on their Practices in Science

Codes	Frequency	Percentage	Themes
A positive atmosphere where students engage; Fun; Learners are attentive & engaged; Interactive	10	67	*Positive Learning Atmosphere*
Lecture & Laboratory; Student involvement; Classroom management; Hands-on activities; Learning through exploration; Experimentation & demonstration; Helping low performing learners; Student improvement	14	93	*Learner-centered type approach*
Participating in Science fairs & other science- related competitions; Attending training, seminars, & workshops Monthly Professional Development Meetings/ Programs Mentoring and teacher collaborations; Learning Action Cells;	15	100	*Professional Development*
Support system; Provision of needs; Donations; Sponsorships/ Funding; Rewards	15	100	*Establishing Strong Community Linkages (Support System)*

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Kompleks Balai Besar Guru Penggerak Provinsi Jawa Barat,
Gedung B, Jl. Dr. Cipto No. 9, Bandung, West Java 40171, Indonesia

+62 22 421 8739
secretariat@qitepinscience.org
+62 22 421 8749
www.qitepinscience.org

+62 821 2345 0630
qitep_in_science
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