



The Use of Primary Literature in Teaching Science as a Strategy in Addressing Surface Learning: A Synthesis

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ABSTRACT

The Goals of Science Education in the Philippines have always been centred on the development of scientific process and inquiry skills, values, and attitudes that can be of help for every individual, the community, and the country through the provision of high-quality Science Education. However, the teacher's conceptual and memory-based rather than procedural and inquiry-based approaches to teaching science led the students to resort to surface approach to learning (absorption and regurgitation of facts) rather than deep approach to learning (applying, analysing, creating, and demonstrating) leading to their inability to develop science process and inquiry skills. This paper reviews some of the studies that focus on the use of primary literature in teaching science that helps the students transition from surface approach (performance goal oriented) to deep approach (mastery goal oriented) to learning in order to develop science process skills and inquiry skills. It specifically seeks to identify the factors that contribute to this problem and the effects it will have to the present education landscape. This study made use of systematic review methods to analyse a total of thirteen (13) journals which were all published between the years 2013 to 2023 and reported outcomes consistent with the purpose of the study. Results revealed that there are three major factors that contribute to the student's lack of motivation to learn science and inability to develop science process skills and inquiry skills. These include teacher's ineffective and inefficient teaching of science, poorly written textbooks and instructional materials, and heavy reliance on conventional teaching-learning activities and assessment methods. Hence, the student's low motivation and under-performance in science result from problems in our education system (ineffective and inefficient approaches, materials, and assessments). It is recommended that primary literature be integrated in Science Education curriculum in order to expose the students to the processes and mechanisms of science.

Keywords: Science Education, Primary Literature, Science Process Skills, Inquiry Skills, Surface Learning, Deep Learning

1. Introduction

The teaching and learning of science have always been considered challenging by most teachers and learners in the Philippines. This is based on the premise that the teaching of science highly demands mastery of the subject matter and competence in the use of appropriate pedagogical approaches and strategies on the part of the teacher and the learning of science strictly requires the development and use of critical, analytical, and logical thinking, and science process skills on the part of the students. The demanding nature of the scientific discipline makes the teaching and learning of science difficult and laborious (Sarabi, 2018). Consequently, the students may consider the learning of science unrewarding or demotivating.

Surface learning is one of the various forms of motivational problems. It is an approach based on rote memorization, an alternating process of absorption and regurgitation of facts, rather than understanding them. This approach is associated with mere learning of facts in order to pass a course of study or comply with the academic requirements (Prosser and Trigwell, 1998; Biggs and Tang, 2007; Spada and Moneta, 2012), extrinsic or low motivation to study (Kyndt et al. 2011), low interest in the study of subject matter (Coertjens et al. 2016), low self-efficacy (Lindblom-Ylänne et al. 2015), lack of self-regulation as well as organized way of studying and the formation of fragmented knowledge (Meyer, 1991). All these result in the student's fixation to the memorization of scientific facts rather than understanding them and failure to develop procedural and inquiry skills and apply higher order thinking functions (Rogers, 2022).

A science teacher plays a critically essential role in cultivating the student's complex mental abilities that will help them succeed academically and professionally. It is the responsibility of the teacher to set the classroom context so as to facilitate maximum student's engagement with the content, with the other students, and with the teacher. As engagement is seen as a prerequisite for subsequent learning to take place, the teacher then has to ensure that every student in the class is actively engaged with the material, teaching-learning activities, and assessment tasks one provides. The teacher's knowledge of the subject matter and the national standards of teaching Science and skills in facilitating learner-centered, constructive, and meaningful learning experience go hand in hand as one assists the learners in achieving the desired or intended learning outcomes (Ambag, 2018). Teacher's failure in performing these vital functions lead the students to fall short in achieving what are expected of them.

Filipino students have been consistently performing low in science in the National Achievement Tests. They also have low scientific literacy levels as revealed by the results of an examination administered by OECD Program for International Student Assessment (PISA) in 2018 (PISA, 2019). These can

be attributed to poor Science Education in the country which can be well understood from a reductionist view of the situations occurring in many Philippine classrooms.

Traditional classroom teaching has long been established as the most commonly used teaching method in the Philippines. Despite the implementation of the Outcomes-based Education and other progressive educational approaches, some teachers still resort to focusing to memorization rather than application, analysis, creation, and demonstration (Balansag, 2019). Textbooks and other learning materials are written in form and structure that facilitate lower order thinking skills rather than higher order thinking skills. Lastly, the teaching and learning activities and assessment tasks heavily focus on conventional and objective methodology rather than authentic and performance-based approaches. All these result to student's adoption of surface approach instead of deep approach to learning (Ambag, 2018).

In order to do away with surface learning, the teaching of science must be made relevant, connected, and meaningful to students. The use of primary literature exposes the students to the process of science and its implications to their daily lives. It aids them in the development of scientific literacy (Litowitz, 2013) and scientific process skills and helps them increase their motivation, student's engagement, and achievement (Howard et al., 2021).

This paper reviews some of the studies that focus on the use of primary literature in teaching science that helps the students transition from surface approach (performance goal oriented) to deep approach (mastery goal oriented) to learning in order to develop science process skills and inquiry skills. It specifically seeks to identify the factors that contributed to this problem and the effects it will have to the present education landscape. Pedagogical recommendations are drawn from this examination.

2. Methods

This study reviewed 13 articles on the use of primary literature in teaching science to address the contemporary issue on students' lack of motivation as evidenced by their adoption of surface approach (performance goal oriented) rather than deep approach (mastery goal oriented) to learning resulting in the inability to develop science process and inquiry skills.

Criteria of inclusion in selecting studies to be reviewed were the date, type of publication, and reported outcomes. All selected studies covered the year 2013 – 2023, all were published in reputable journal publications, and reported outcomes of interest consistent with the purpose of the study.

This study is qualitative in nature. It specifically utilized the systematic review approach which is based on the scientific method. It started with clear formulation of objectives followed by identification of works relevant to the objectives, assessment of the quality of works, summarizing the evidence, and interpretation of findings.

The study also made use of qualitative content analysis to develop a central theme extracted from the selected literature. Identification of relevant data was the first step. It was followed by examination of each study's content and context. The results were presented using thematic approach. Objectives of the study at hand were addressed through these themes.

3. Results and Discussion

3.1 *Teacher's Ineffective and Inefficient Teaching of Science*

One of the major factors for the student's low motivation that leads to his adoption of surface approach to learning and consequently poor academic performance is the teacher's inappropriate use of teaching methods and strategies in the delivery of science lessons. This factor specifically focuses on the effectiveness and efficiency of the teacher as a curriculum implementor. Effectiveness of a teacher refers to one's ability to achieve what one is expected to achieve such as helping the students reach the intended learning outcomes. On the other hand, efficiency of a teacher pertains to one's ability to satisfactorily achieve what one intends to achieve through the use of minimal resources, effort, and time (Burns, 2018).

Most teachers in the Philippines still adopt the traditional method of teaching despite the constant effort of the system to transition to progressive and modern education (Balansag, 2019). The traditional or deductive approach of lecture and direct instruction in teaching the various concepts of science, and requiring the students to absorb these concepts for an oral recitation or a pen-and-paper-test at the end of the lesson are reflective of teacher's inappropriate teaching of the science lessons. These lead the students to only develop their lower order thinking skills such as memorization skills without meaningful understanding of these facts, concepts, theories, and principles. The conventional teaching of science does not provide the students the avenue to ask questions, predict outcomes, make inferences, and engage into laboratory experiments and investigations.

This approach has been proven to limit student's exploration of the connections and implications of the science concepts to their daily lives. The low level of engagement, lack of scientific literacy and science process skills, and inability to achieve the essential learning outcomes are the results of the ineffectiveness and inefficiency of teaching.

These perennial problems in student's low motivation and poor performance in science continuously plague the present education landscape both in the basic education and higher education creating a ripple effect to the wider society. High school students lack the necessary knowledge, values, and skills in the sciences which may pose a significant hindrance as they proceed with their university education. As a result, many students will tend to avoid science as their major field of specialization or many will decide to just drop out. Most college students are likewise observed to lack the relevant competencies to be a part of the science and technology workforce which pose a significant threat to nation-building and development.

3.2 Poorly Written Textbooks and Instructional Materials

Another condition that forces students to resort to surface approach to learning is the quality of the learning materials they read. This factor implies student-to-content engagement. Content engagement refers to the student's interaction with the material with consideration of the level of difficulty of the subject being considered, student's physiological readiness, occasion for processing, and motivation (McLaughlin et al., 2015). This is an important prerequisite for subsequent learning to occur.

The curriculum in the Philippines is congested with too many competencies to be addressed and voluminous facts and concepts to learn (DepEd, 2023). Science curriculum in the country possesses these evident features making it difficult for the students to see the connections of the concepts and the implications of these to their lives. The bland and unengaging feature of many science textbooks lead the students to just memorize the contents for the sake of passing the subject and eventually become disinterested, bored, and disengaged in the learning as they fail to see the relevance of these pieces of information to their daily lives.

At the heights of the pandemic in 2020 when online learning was implemented, student-to-teacher and student-to-student contact were restricted. This made fostering of content engagement in a virtual learning environment more challenging on the part of the teacher. The ultimate goal is to continuously engage the students to content even in the absence of face-to-face interaction with classmates and teachers.

Gutierrez (2022) pointed out two important factors that make the content relevant to the students. First is the alignment of the course with their long-term personal or professional goals. A student who wants to become a scientist normally sees various scientific literature relevant and interesting making him more engaged to the content and learning experience. Second is the perceived level of control. Students assert authority and control in learning the material. They do not want to be controlled or directed by the structure and instructions set by the teacher. The structure they impose to themselves provide them freedom and therefore provide avenue for self-directed learning and increase engagement and achievement.

The poorly written learning materials that lack the elements of appropriateness, relevance, and connections of the contents to the lives of the students are among the many unresolved issues in the Philippine education system that have continuously negatively affected student's learning. This, in turn, detrimentally affects the student's theoretical and practical knowledge which may be seen lacking as a result of insufficient training or erroneous as a result of incorrect and inappropriate training. Such instance renders the future vulnerable to social immobility and stagnation as workforce cannot meet the demands and needs of the contemporary industries.

3.3 Heavy Reliance on Conventional Teaching-Learning Activities and Assessment Methods

The last factor that significantly contributes to the surface learning of the students is the teacher's concentration on the use of conventional teaching and learning activities and assessment methods in teaching science. Despite the paradigm shift to a more progressive curriculum, many still employ purely traditional and objective tests as ultimate measurement of student's success, setting aside a more relevant and authentic performance approach that closely resembles daily and real-life events. According to Abah (2020), the use of traditional teaching and learning activities only encourage the students to study for the test where students are generally required to regurgitate facts in written and / or oral presentation as a display of proficiency. The lack of inquiry and problem-solving approaches in the conventional teaching and learning activities make these means ineffective to scaffold the students in achieving the intended learning outcomes.

Many teachers in the Philippines apply traditional teaching and learning activities such as chorale reading, oral recitation, drills and practice, among others which only facilitate surface learning. These strategies emphasized the use of repetitive, mechanical, routinary, and sometimes rehearsed teaching and learning dynamics, disregarding problem solving, analytical thinking, critical thinking, and metacognitive thinking skills. As a result, students lack the relevant skills required in daily works and life as they are only able to memorize verbatim what is in the book and fail to demonstrate competence and mastery of skills necessary for them to become productive and contributing members of the society (Balansag, 2019).

Assessment practices in the country heavily focus on objective testing. Much of the effort in the teaching and learning processes are devoted to the student's taking and successfully passing the written examination. Teacher's disregard of performance-based and authentic assessment tasks results to student's lack of competence and underachievement (Johnson, 2022).

3.4 The Use of Primary Literature in Increasing Student's Motivation, Engagement, and Achievement

Several studies elucidated that the use of primary literature in teaching science encourages the students to be more engaged to the learning process, elevates motivation encouraging them to proceed from surface (performance-oriented) to deep (mastery-oriented) approach to learning, thereby increasing students' academic achievement.

The study of Howard, et al. (2021) demonstrated that students have difficulty in grasping the big picture of the article, difficulty in understanding the technically sophisticated experimental setups and data interpretations, and lack of knowledge of jargons and other technical terms and techniques. They were observed to manifest mastery and performance approach goal orientations indicating positive learning outcomes achievement, show appreciation on the usefulness of reading primary literature, and engage in reading primary literature within their locus of interest. These findings bear implications to the use of primary research literature as a pedagogical practice as this is seen as helpful and relevant to learning by the students.

On the study of Abdullah, et.al. (2015), they revealed that students find the learning of science using primary literature useful and essential to their understanding of the subject matter and engaging into practical science tasks. The results showed that primary literature increase student's self-efficacy and ability to design experiment. An increase in student's self-efficacy in the performance of science process skills such as drawing conclusions, evaluating author's conclusions, and designing an experiment was observed. The use of quantitative terms in data analysis, understanding of controls, and designing an experiment appropriate to the goal of investigation were also observed among the students. This means that the use of primary literature in delivering science lessons improves student's motivation and practical skills. This implies that teachers must strategize means to effectively integrate the use of primary literature in the teaching of science as it is proven to positively influence student's scientific skills.

Kararo (2019) utilized annotated primary literature as a pedagogical tool in teaching science. This study demonstrated that the use of annotated primary literature makes the students become more comfortable in reading scientific journals and engaged to learn scientific concepts. This specifically highlights that reading and analysing primary literature helps improve vocabulary and graph interpretation skills. The students were given the avenue to explore the connections of the various scientific concepts under study by reading the definitions on the glossary and deeply understanding the connections of these in a bigger picture through the graph. This calls for the teacher's incorporation of annotated scientific bibliography in teaching science as students find the tool meaningful and engaging.

On the other hand, an adapted primary literature is also seen to improve student's argumentation and reasoning skills (Lemus, 2020). This collaborative project aims to develop guidelines in making adapted primary literature as a tool in teaching science lessons and placing these articles in a storyline that will be of use by the teacher and the students. The teacher dissects that article and collates the most relevant information for students to learn the fundamental concepts in science and the writer adds context, graphics, and other elements that make the content more interesting and engaging. The implementation of the project was successful and the students demonstrated a significant modification in their use of argumentative and reasoning skills when the adapted primary literature was used compared to when the said tool was not used.

Another important endeavour that focuses on the use of primary literature that helped in increasing student's learning gains is that of Smith, et.al. (2022). In this project, primary literature was integrated in the teaching of science with the use of the so-called CREATE (Consider, Read, Elucidate the hypothesis, Analyse and interpret data, Think of the next Experiment) Pedagogy. Such approach focuses on the introduction of the process of science through the development and use of science practical skills (process / inquiry approach) rather than mere content delivery of the lesson (conceptual approach).

In another study using the same approach, Stevens (2014) used the so-called CREATE (Consider, Read, Elucidate the hypothesis, Analyse and interpret data, Think of the next Experiment) Pedagogy and trained a group of faculty on its development and implementation to a science classroom to help enhance student's critical thinking, analytical thinking, and scientific attitudes. Results show that the faculty demonstrated positive attitude towards teaching and learning science through the rigorous CREATE training and workshop that led to their effectiveness and efficiency in designing and implementing CREATE courses. Students under the tutelage of these teachers also demonstrated significant changes both cognitively and affectively.

POGIL or Process Oriented Guided Inquiry Learning is another important innovative strategy that is used in integrating primary literature in teaching science. In the study of Murray (2014), he reported that students learn scientific contents from the reading and analysis of the primary literature without using separate activities. Students also demonstrated increase in comfort and confidence in reading the literature after the process oriented guided inquiry learning was facilitated by the teacher as compared to when the POGIL activities were not administered. Such modification in the behaviour of the students lies in the assumption that the POGIL activities are student-centred, guided, collaborative that make these as an appropriate tool in teaching scientific knowledge and skills. This calls for a repeated integration of these activities in teaching science so as to increase gains in comfort and confidence in learning.

With the primary literature's contribution to the development of scientific practical skills, the students become a community of scientifically literate individuals. Scientific literacy among the educated constituency is indeed a prerequisite for a particular society to progress. The primary literature is also seen as an effective tool in teaching the students with basic scientific literacy. Lower-order literacy skills such as remembering, understanding, and applying were generally observed while the higher-order literacy skills such as analysing, synthesizing, and evaluating were modestly observed to have developed. Despite the modest number of students to demonstrate higher-order literacy skills, the use of primary literature still contributed to the significant learning gains of the students in science (Litowitz, 2013).

Another study that supports the use of primary literature in teaching scientific literacy is that of Eslinger (2018). In this investigation, a structured primary literature was employed in teaching science concepts through a student-led practical science activity. Results showed that students incurred significant increase in their scientific literacy skills and critical thinking skills. The activity provided the students the avenue to explore the process of science and how this relates to their daily lives not limited to classroom discussions and lectures leading to the development of a more hands-on approach to learning thereby improving science literacy and critical thinking skills. This calls for the incorporation of structured primary literature as a material in conducting student-led and teacher-supervised experiments in order for the students to transition from lower-order thinking skills to higher-order thinking skills.

In conclusion, teaching science demands so much from the teacher in terms of his content knowledge and pedagogy. The teacher's lack of competence leads to his adoption of ineffective and inefficient methods, approaches, and strategies in teaching science, use of poorly written, unengaging and uninteresting materials, and reliance on conventional teaching and learning activities and assessment methods. These, in turn, contribute to student's low level of motivation such as adoption of surface approach to learning, low academic achievement, inability to develop and use scientific literacies and competencies (knowledge, values, and skills). Filipino students' underperformance and lack of competence in the sciences make them incapable of joining the S&T workforce which is considered a primary driving force of social mobility, human capital development, and nation-building. The use of

pedagogical approaches that increase student's motivation, engagement, and achievement such as the integration of primary literature in teaching science must be implemented.

Thus, the following recommendations are provided:

1. **Using primary literature in teaching science.** The teacher may consider utilizing primary literature in teaching science to expose the students to both the contents and processes of science. This is anchored on the goals of Science Education to develop among the learners the scientific inquiry skills, values and attitudes, such as objectivity, curiosity, and honesty and habits of mind including critical thinking necessitate appropriate pedagogical approach that immerses the students to the scientific method that facilitates the development of these scientific knowledge, values, and skills. It is from this approach that the students are facilitated to shift from surface approach to deep approach to learning.
2. **Providing the students with the appropriate and relevant support in exploring primary literature in learning science.** In helping the students maximize the use of primary literature for their advantage, teachers may provide the students a variety of reading materials which are engaging and thought provoking, consistent with a given lesson in a unit, as their assignment. The teacher then provides the students the liberty to choose among these alternatives on the material that interests them the most. The actual classroom encounter is then devoted to the understanding and analysis of the chosen primary literature. It is suggested that the teachers carefully frame the analysis of this literature, provide avenue for reflection, and evaluating the implications and relevance of this literature to one's daily lives so as to ensure that the students will achieve what the goals of Science Education want them to achieve – to become scientifically, technologically, and environmentally literate individuals.
3. **Providing faculty training and support system for the effective and efficient use of primary literature in teaching science.** School administrators are expected to provide the necessary support system for the teachers to develop their content knowledge and pedagogical competence in teaching science as well as to reinforce their scientific research skills. A system of constant monitoring and evaluation must be implemented to ensure that the teachers deliver the lesson using effective and efficient teaching methods and approaches, use of well-written instructional materials, and employ authentic and performance-based teaching-learning activities and assessment by conducting peer mentoring and coaching, principal's observation, and teacher's performance evaluation.
4. **Integrating primary literature with secondary literature in science textbooks/instructional materials.** In order to make the science textbooks more engaging and interesting, curriculum developers and science textbook writers may consider incorporating primary literature in the science lessons. While most of the contents of science textbooks heavily focus on secondary literature, incorporating primary literature that emphasizes the actual process of scientific experimentation, the results of the investigation, and the implications of these results to daily lives significantly helps the students develop and use scientific literacy and science process skills.
5. **Intensifying research activities exploring the use of primary literature in teaching science in the Junior High School and Senior High School in the Philippines.** Most of the existing literature on the use of primary literature in teaching science are foreign. This is the reason why the use of primary literature in Philippine schools is an underexplored and under-investigated practice. Thus, it is highly suggested that future researchers will endeavour on studying the influence of the use of primary literature in teaching science to the effectiveness and efficiency, the implication it will have on the selection and utilization of instructional materials, and effect it will have on the use of teaching and learning and assessment methodologies on the part of the teacher and the development of scientific literacy and science process skills among the students in Philippine schools. The results of these investigations will significantly aid legislation and reforms in the country's education system.
6. **Developing exemplars that integrate primary literature in teaching and learning science.** As a concrete intervention and future direction of this study, it is recommended that science educators may look into developing exemplars that display the effective integration of primary literature (in its adapted, modified, or contextualized form) to science teaching and learning with emphasis on the assessment, utilization, and development of science process and inquiry skills. These exemplars will then be presented to the education community for peer critiquing, replication, and adaption of this as a schoolwide practice to improve student's motivation (deep approach to learning) and learning achievement in science (successful development of process and inquiry skills).

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