A Content Analysis of the Science and Engineering Practices (SEPs) in the Self-learning Modules (SLMs) of Batangas State University Integrated School

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Abstract: Textbooks serve as one of the materials that guide teachers in crafting a lesson. Not only is it used as a guide, but also, the extent of what teachers teach and what is learned by the students heavily rely on textbooks. However, with the surge of Covid-19 cases in the Philippines, the Department of Education (DepEd) adopted the distance learning modality in delivering instruction. With such modality, textbooks are substituted by Self-learning materials (SLMs). This qualitative relational content analysis used the Science and Engineering Analytic Rubric (SEPAR) formulated by Papakonstantinou and Skoumios (2021) to determine the occurrence and level of engagement of the Science and Engineering Practices (SEPs) in the SHS science SLMs of Batangas State University Integrated School. Results revealed that there is a low level of engagement of the SEPs in the science SLMs. This suggests that there are little to no opportunities were provided in the SLMs for the students to use and develop SEPs to better understand the science lessons.

Key Words: Next Generation Science Standards; Science and Engineering Practices; Self-learning Modules; Science education

1. INTRODUCTION

In preparing a lesson, one of the materials that guide teachers is the textbook. Not only is it used as a guide, but it also contains the contents of the lessons with which much of the classroom dynamics occur. The extent of what the teachers teach and what is learned by the students rely heavily on textbooks. In addition, in terms of proximity, textbooks are the closest tool students can easily use as a source of information. The quality of teaching and learning science is dependent on the quality of the textbook being used. Thus, it enables learners to achieve the expected learning outcomes (ELOs) specified in the curriculum, further developing scientific literacy – the main goal of science education.

In the school year 2019-2020, it was never expected that due to the surge of COVID-19 cases in the Philippines, the Department of Education (DepEd) adopted the distance learning modality in delivering instruction. This new mode of providing lessons required instruction to shift from classroom instruction to various means such as self-learning modules (SLMs) and other video conferencing platforms. With this shift, students cannot come to school and use the school-owned textbooks. However, it is not easy since this is the first time that Philippine education has undergone significant reform in the mode of education amidst the COVID-19 pandemic. It affected the majority, especially instructional challenges, and student proximity since they must study remotely. One factor contributing to distance learning problems maybe access to technology, the faculty-learners ratio, and teachers' preparedness for lesson delivery (Dubey & Pandey, 2020). Consequently, when these factors are not addressed, the student's 21st-century skills and developing literacy across subject matters will be compromised. Using SLMs in MDL, students are provided with teaching materials, a series of learning activities, lesson content, generalizations, and assessment. All of which are put together in SLMs for students to achieve the learning competencies, modified explicitly by the DepEd to be a compact version of the Enhanced Basic Education Curriculum (EBEC) known as the Most Essential Learning Competencies (MELCs). With this shift in education, where SLMs now substituted textbooks, assessing the SLMs is necessary to determine their quality. The study by Natividad (2021) found that the quality of content and usability of SLMs enhance the effectiveness of Modular Distance Learning (MDL). In connection with this, Yazon (2018) stated that for the SLMs to be considered good quality, they must contain learning competencies to be acquired by the students, supplementary activities to add up to the learning experience, vocabulary words, and its conceptual and operational definition., clearly stated instructions for each activity, and the provisions of self-assessments to assess learning. All of these determine SLM's effectiveness. These qualities must all be present in the SLMs and help students understand the subject matter, especially since they learn remotely and independently.

The SLMs might be subjected to an analysis based on several parameters as one of the ways to assure its quality. In research, qualitative content analysis is a study used to identify the meaning from a body of a text through classifying and organizing the content into categories and designate them into a predetermined themes or topics of a material or text. Although more predominantly used among texts, qualitative content analysis may also be used to any type of media – textual, verbal, or visual. (Williamson et al., 2018)

In this relation, this paper intends to answer the research question:

1. What is the level of engagement of SEPs in each of the science SLMs of Batangas State University Integrated School?

The Science and Engineering Practices

These set of practices are the behaviors by which scientists and engineers engage as they explore the natural world through investigation, theorization, designing, and building of mental and physical models. Rather than using the term "skills", the NRC used the term practices to emphasize that in scientific investigation, it requires not only the skill but also the knowledge that is particular to each SEP. Table 1 describes the eight SEPs provided by the NRC (2012) upon which the content analysis of the SLMs will be based on.

Table 1.
The Science and Engineering Practices

Asking Questions and Defining Problems	Science begins with a question about a phenomenon such as "Why is the sky blue?" or "What causes cancer?" A basic practice of the scientist is the ability to formulate empirically answerable questions about phenomena to establish what is already known, and to determine what questions have yet to be satisfactorily answered. Engineering on the other hand, begins with a problem that needs to be solved, such as "How can we reduce the nation's dependence on fossil fuels?" or "What can be done to reduce a particular disease?" or "How can we improve the fuel efficiency of automobiles?" A basic practice of engineers is to ask questions to clarify a problem, determine criteria for a successful

	solution, and identify constraints.
Developing and Using Models	Science often involves the construction and use of models and simulations to help develop explanations about natural phenomena. Models make it possible to go beyond observables and simulate a world not yet seen. Models enable predictions of the form “if … then… therefore” to be made to test hypothetical explanations. Engineering on the other hand, makes use of models and simulations to analyze extant systems to identify flaws that might occur, or to test possible solutions to a new problem. Engineers design and use models of various sorts to test proposed systems and to recognize the strengths and limitations of their design.
Planning and Carrying Out Investigations	Scientific Investigations may be conducted in the field or in the laboratory. A major practice if scientists is planning and carrying out systematic investigations that require clarifying what counts as data and experiments identifying variables. Moreover, investigations in engineering are conducted to gain data essential for specifying criteria or parameters and to test proposed designs. Like scientists, engineers must identify relevant variables, decide how they will be measured, and collect data for analysis. Their investigations help them to identify the effectiveness, efficiency, and durability of designs under different conditions.
Analyzing and Interpreting Data	Scientific investigations produce data that must be analyzed to derive meaning. Because data usually do not speak for themselves, scientists use a range of tools—including tabulation, graphical interpretation, visualization, and statistical analysis—to identify the significant features and patterns in the data. Sources of error are identified, and the degree of certainty calculated. Modern technology makes the collection of large data sets much easier providing secondary sources for analysis. Engineering investigations, on the other hand, include analysis of data collected in the tests of designs. This allows comparison of different solutions and determines how well each meets specific design criteria—that is, which design best solves the problem within given constraints. Like scientists, the engineers require a range of tools to identify the major patterns and interpret the results. Advances in science make analysis of proposed solutions more efficient and effective.
Using Mathematics and Computational Skills	In science, mathematics and computation are fundamental tools for representing physical variables and their relationships. They are used for a range of tasks such as constructing simulations; statistically analyzing data; and recognizing, expressing, and applying quantitative relationships. Mathematical and computational approaches enable prediction of the

	behavior of physical systems along with the testing of such predictions. Moreover, statistical techniques are also invaluable for identifying significant patterns and establishing correlational relationships. In engineering, mathematical and computational representations of established relationships and principles are an integral part of the design process. For ex- ample, structural engineers create mathematical-based analysis of designs to calculate whether they can stand up to expected stresses of use and if they can be completed within acceptable budgets. Moreover, simulations provide an effective test bed for the development of designs as proposed solutions to problems and their improvement, if required.
Constructing Explanations and Designing Solutions	The goal of science is the construction of theories that provide explanatory accounts of the material world. A theory becomes accepted when it has multiple independent lines of empirical evidence, greater explanatory power, a breadth of phenomena it accounts for, and has explanatory coherence and parsimony. The goal of engineering design is a systematic solution to problems that is based on scientific knowledge and models of the material world. Each proposed solution results from a process of balancing competing criteria of desired functions, technical feasibility, cost, safety, aesthetics, and compliance with legal requirements. Usually there is no one best solution, but rather a range of solutions. The optimal choice depends on how well the proposed solution meets criteria and constraints.
Engaging in Argument from Evidence	In science, reasoning and argument are essential for clarifying strengths and weaknesses of a line of evidence and for identifying the best explanation for a natural phenomenon. Scientists must defend their explanations, formulate evidence based on a solid foundation of data, examine their understanding in light of the evidence and comments by others, and collaborate with peers in searching for the best explanation for the phenomena being investigated. In engineering, reasoning and argument are essential for finding the best solution to a problem. Engineers collaborate with their peers throughout the design process. With a critical stage being the selection of the most promising solution among a field of competing ideas. Engineers use systematic methods to compare alternatives, formulate evidence based on test data, make arguments to defend their conclusions, critically evaluate the ideas of others, and revise their designs in order to identify the best solution.
Obtaining, Evaluating, and Communicating Information	Science cannot advance if scientists are unable to communicate their findings clearly and persuasively or learn about the findings of others. A major practice of science is thus to communicate ideas and the results of inquiry orally; in writing; with the use of tables, diagrams, graphs and equations; and by engaging in extended discussions with peers. Science requires the ability to derive meaning from scientific texts such as papers,

the inter- net, symposia, or lectures to evaluate the scientific validity of the information thus acquired and to integrate that information into proposed explanations. Engineering cannot produce new or improved technologies if the advantages of their designs are not communicated clearly and persuasively. Engineers need to be able to express their ideas orally and in writing; with the use of tables, graphs, drawings, or models; and by engaging in extended discussions with peers. Moreover, as with scientists, they need to be able to derive meaning from colleagues' texts, evaluate information, and apply it usefully.

2. METHODOLOGY

2.1 Sample

The content analysis primarily focuses on the Senior High School science modules of Batangas State University Integrated School. Each self-learning module includes the following, (1) the lesson objectives, (2) the content of each science lesson, (3) learning activities, (4) written works, and (5) performance tasks.

Table 2.
Number of Modules per Science Subject

SHS Science Subjects	Number of Modules
General Biology 1	8
General Biology 2	8
General Chemistry 1	8
General Chemistry 2	8
General Physics 1	8
General Physics 2	8
Disaster Readiness and Risk Reduction	7
Earth Science	8
	N = 63

Table 2 shows the number of modules in each subject. All the science subjects have eight modules except Disaster Readiness and Risk Reduction, which has seven modules.

2.2 Procedure

This study used qualitative conceptual content analysis in determining the presence, meanings, and relationships of certain words, themes, or concepts within a given qualitative data. We used this method in determining communication patterns through written contents of textbooks, essays, newspapers, novels, magazines, articles (Strijbos et al., 2006), and in the case of the research at hand, learning modules. The science and engineering practices were determined in the senior high school science modules of Batangas State University Integrated School.

After determining the objectives of this research, we proceeded to obtain copies of the science modules from the Batangas State University Integrated School. A letter that we signed was sent to the head of the school seeking permission to use the science modules as the subject of this research study. After receiving a favorable response, we continued the coding process to determine the presence of the science and engineering practices in the contents of the science modules.

2.3 Analysis Framework

We used the Science and Engineering Practices Analytic Rubric (SEPAR) developed by Papakonstantinou, M., & Skoumios, M. (2021) to determine the occurrence and evaluate at the same time which level do the contents fall under the science and engineering practice and its corresponding level at which each of the contents of the module falls under. The rubric has four levels for each SEP and differs depending on the extent to which a particular SEP is contained in the science modules. When the science module does not provide any learning opportunity for each SEP, the science module is classified at level 0. However, all other levels (1,2, and 3) represent an increasing degree of SEP opportunity. For example, in the SEP developing and using models, if the science module does not provide students with the opportunity to create or use models, it is at level 0. When the science module provides the students the opportunity to create or use models, but there is no clarification if the models should focus on describing, predicting, and explaining a natural phenomenon, it is classified under level 1.

Consequently, when the science module provides opportunities to create or use models but does not clarify its merits and limitations, then it is classified under level 2. Lastly, when the science module provides an opportunity to create or use models on predicting and explaining the natural world and at the same time clarify the merits and limitations of the model, then it is classified at level 3 – the highest degree of SEPAR. See Appendix A for the details of SEPAR.

2.4 Intercoder Agreement

Table 3.
Intercoder Agreement Calculations for Each SEP

Science and Engineering Practices	Intercoder Agreement
SEP 1: Asking Questions and Defining Problems	89%
SEP 2: Developing and Using Models	93%
SEP 3: Planning and Carrying Out Investigations	92%
SEP 4: Analyzing and Interpreting Data	93%
SEP 5: Using Mathematical and Computational Thinking	98%
SEP 6: Constructing Explanations and Designing Solutions	98%
SEP 7: Engaging in Argument from Evidence	97%
SEP 8: Obtaining, Evaluating, and Communicating Information	98%

After determining the rubrics for analysis, we analyzed the levels of engagement of each of the 63 modules to SEPAR using the Dedoose™ software. It is a web-based software that allows researchers to organize and analyze quantitative data such as surveys, tests, scores, ratings, spreadsheets, demographics, and qualitative data, including audio, images, videos, and texts Dedoose Version *9.0.17* (2021). To ensure the reliability and validity of the results, the analysis was done by two independently working researchers. Finally, we coded every science module by determining the degree to which the science module falls under the SEPAR.

The internal consistency of the two separate coding was identified for each SEP using Cronbach's Alpha. Cronbach's alpha measures how reliable or consistent a set of variables are (Goforth, 2015).

3. RESULTS AND DISCUSSION

Table 4 summarizes the frequency distribution and percentages of the levels of engagement of the eight SEPs in the SLMs. The result revealed the low level of engagement of the SEPs in the science modules could be attributed to various conditions that may be why incorporating SEPs in the SLMs is difficult. The current teaching and learning setup, specifically MDL, maybe the most influential since SEPs is what the scientists and engineers do to explore the natural world and design and systems, it is easier to think of learning experiences to develop SEPs among students when in a face-to-face setup since it is a practice that must be observed.

Creating opportunities for both practices in the SLMs may be difficult already. How much more if we consider eight SEPs. Furthermore, in the chances were SEPs could be incorporated into a science lesson, the problem would be in the assessment of students' learning. There is a limited way of assessing students learning concerning SEPs in an MDL setup. In addition, since the integration of the SEPs in the science modules is subjective to the lesson at hand, embedding the SEPs all at once may be impossible. However, increasing the level of engagement in the SEPs present may be considered. It is also vital that teachers are oriented to the SEPs before incorporating them into the SLMs. Lastly, although the Science curriculum framework for basic education in the Philippines and the NGSS K-12 Science education framework both mentioned developing inquiry skills among learners, NGSS emphasizes focusing on practices (SEPs) rather than inquiry skills, which is broad.

Table 4. *Frequencies and Percentages of the Levels of SEPs in the Science Modules*

Science and Engineering Practices N = 63	Level 0		Level 1		Level 2		Level 3	
	f	%	f	%	f	%	f	%
Asking questions and defining problems	51	81	11	17	1	2	0	0
Developing and using models	36	57	15	21	10	16	2	3
Planning and carrying out investigations	52	83	9	14	2	3	0	0
Analyzing and interpreting data	41	65	12	19	10	16	0	0
Using mathematics and computational thinking	35	56	24	38	3	5	1	2
Constructing explanations and designing solutions	48	76	8	13	6	10	1	2
Engaging in argument from evidence	48	73	7	11	10	16	0	0
Obtaining, evaluating, and communicating information	46	73	7	11	10	16	0	0

4. CONCLUSIONS

This study focused on analyzing at which level the SHS self-learning modules provide SEP learning opportunities. In this regard, the results show that each SEPs was provided with learning opportunities in the SLMs. However, the reported opportunities were at the lower level of SEPAR, meaning development in the students' SEPs was not significantly seen. The results also revealed that the least provided with SEP opportunities is the SEP of *asking questions and defining problems*. Thus, making it the only SEP with zero SLM lessons at level 3. On the other hand, the SEP for *developing and using models and mathematical and computational skills was* the SEPs with the greatest number of learning opportunities at the highest level of SEPAR (level 3). Therefore, the SEPAR may also help analyze the contents of SLMs in other grade levels to determine the engagement of the SEPs in the learning materials.

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