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Development and Implementation of SSI-Based Module in Promoting Decision-Making Skills of STEM Strand Learners

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Abstract

In today's technology-driven society, STEM literacy plays a crucial role in preparing students for future work, yet Filipino students demonstrated low STEM literacy based on recent international assessments. Socio-scientific issues (SSI)-based instruction offers the potential to enhance STEM literacy by engaging students in a real-world context. Despite the positive remarks on its benefits, its implementation faces challenges including the lack of resources and teacher support. This study addresses these gaps by developing an SSI-based module in teaching evolution for Grade 11 STEM students that aims to improve STEM literacy, specifically, their decision-making skills. This study utilized a mixed-method, quasi-experimental research design involving five science teachers and 51 students. Results from the thematic analysis revealed diverse methods and strategies of teachers including problem-solving activities, experiments, and collaborative work. The decision-making skills of students were found to be at a developing stage, which suggests a targeted intervention for improvement. The developed SSI-based module obtained a rating of "Very Satisfactory" with an overall mean of 2.82 from the panel of experts. It had a student involvement index value of 1.21, indicating the clarity of the module. Fry Graph Readability result showed that the sentence length and word length of the module are at the average level and are appropriate to the intended readers. Hence, this study further suggested implementing this SSI-based module to determine the improvement in the decision-making skills of students and its effectiveness in terms of the learning experiences of the students.

Keywords: SSI-based instruction, module development, decision-making

1. Introduction

The economy in today's era requires workers who possess the knowledge and skills to compete with others, innovators and inventors, problem-solvers, and can think rationally. The key to the development of these skills can be achieved through Science, Technology, Engineering, and Mathematics (STEM) education. The term "STEM literacy" is often defined as an educational goal of STEM education that aims to prepare students for future work in a technology-driven society (Tang & Williams, 2019; Sutaphan and Yuenyong, 2019).

News reports from the Philippine Inquirer showed that Filipino students demonstrate STEM literacy through different innovations presented in several science competitions at both national and international levels (Leonen, 2017). However, international assessments like the PISA (2018) and the recently released PISA (2022) revealed that Filipino students received poor ranking and remained one of the lowest among other countries. This poor performance of Filipino students poses a challenge to the Department of Education (DepEd) to address the issues and gaps to attain quality basic education and improve students' STEM literacy skills.

Socio-scientific Issues (SSI) is one of the active strategies in teaching and promoting STEM literacy because of its potential to develop an awareness of the interdependent relationship of science, technology, and society and allow students to be involved in societal issues as active citizens (Talens, 2016). SSI is complex and contentious and involves topics in science that are controversial which requires students to participate in discussions and arrive at possible resolutions to the issues presented. Students are also expected to discuss the issue from different points of view (Sadler et al., 2016) and most of the time, conclusions and actions toward the issue are underdetermined by scientific evidence (Sadler et al., 2017). SSI encompasses social problems connected to science, such as biodiversity (Mandapat, 2018); biotechnology (Nurtamara & Prasetyanti, 2020; Cayci, 2020), global warming (Atabey & Topcu (2017), environmental pollution (Yenni et al., 2017), vaccination, nuclear power plants, indiscriminate use of medicines, waste recycling (Cayci, 2020), etc. that students will be confronted to use their STEM literacy.

The utilization of SSI-based instruction from different studies has identified several benefits to learners, such as an increase in students' scientific literacy (Yenni et al, 2017; Yuenyong and Narjaikaew, 2009); improvement in students' interest and behavior in science, as well as improvement in decision-making skills (Nurtamara and Prasetyanti, 2020); development in informal reasoning capabilities (Cayci, 2020); enable students to determine the moral and ethical implications of the issue; and apply their learning in their daily activities (Talens, 2016).

However, despite the multitude of studies on implementing SSI and the recognition of some teachers regarding the potential of SSI in science classroom contexts, research showed that teachers struggle to incorporate SSI in their classrooms for several reasons. Most classrooms in the Philippines lack SSI-based activities in dealing with contemporarys issues (Mandapat, 2018). Friedrichsen et al. (2016) identified two major reasons why this type of instruction is scarcely applied in classrooms: (1) the lack of instructional materials for teaching SSI and (2) teachers do not receive adequate support during the implementation of SSI. Therefore, there is a need for developing additional materials to teach SSI in the classroom. The development of an SSI-based module to address the problems related to STEM literacy will shed light on the current issues in the educational system. Other 21st century skills, like the 4Cs (critical thinking, creativity, collaboration, and communication) are sought to be improved upon the implementation of this strategy

Upon conducting a literature review, it was found that acceptance of biological evolution is still a major issue in high school. It is still considered one of the most

misunderstood concepts in science. To address this issue, the researcher will develop an SSI-based Module in teaching evolution for Grade 11 STEM students. The module will provide SSI-based instruction to determine the conceptual understanding of STEM learners and if there is an improvement in the decision-making of students towards issues related to evolution, thereby improving Filipino students' STEM literacy.

2. Methodology

2.1 Research Design

This study utilized a mixed method with a quasi-experimental research design. The baseline data consisted of qualitative data from the methods and strategies of teachers in promoting decision-making skills and the level of decision-making skills of learners. An open-ended questionnaire was used in gathering the data to support the study. A follow-up interview was also conducted with the science teacher for additional input from their responses to the survey to obtain rich data for this study.

2.2 Participants

Five (5) Science teachers handling Science subjects in Junior High School and fifty-one (51) Grade 9 students were involved during the conduct of the study. Since the topic evolution for Grade 11 STEM learners were already discussed in the previous grading period, and similar case with the Grade 10 learners, the researcher together with the approval of the thesis adviser and the panel members decided to implement the module to Grade 9 learners in order to avoid contamination of data. The developed module was intended for Grade 11 STEM students, but for implementation purposes, the main respondents of this study were the Grade 9 learners.

2.3 Data Collection

A consent formal letter to the students and parents has been presented to the ethics committee before the formal endorsement to the school principal before conducting the study. The endorsement of the principal was forwarded to the Division of Zamboanga Sibugay for approval to conduct the study. The researcher conducted a survey on the methods and strategies of teachers in promoting decision-making skills consisting of five (5) Science teachers (1 male and 4 females) and 51 students (15 males and 36 females). Both the teacher and student respondents were given ample time to answer the survey questionnaires. For the teachers, a one-on-one interview was conducted to gather additional information based on their responses to the survey. To maintain confidentiality, the respondents were given codes (e.g. SQ-T1 means Survey Questionnaire Teacher 1 and SQ-S1 means Survey Questionnaire Student 1) to observe anonymity. These codes were also used to identify potential themes relevant to this study.

2.4 Data Analysis

Thematic analysis was used to analyze the responses of science teachers on the survey regarding their methods and strategies in promoting decision-making skills as well as the follow-up interview. Data from the interview was carefully transcribed and combined with the data from the survey to obtain possible codes and common themes. The results from the survey on the level of decision-making skills of students were evaluated using a rubric crafted by the researcher and the teacher of the student respondents. This is to assess the current level of decision-making skills of the students.

3. Results and Discussion

3.1 Teachers' Methods and Strategies in Promoting Decision-Making Skills

Four (4) themes were determined from the answers of science teachers on the survey questionnaire regarding their methods and strategies in promoting decision-making skills (Table 1). Under the theme Integration of Real-World Applications, three (3) codes were determined. Two science teachers responded that they always integrate real-world applications, two (2) responded that they often apply, and one (1) responded that she occasionally applies real-world applications. For the theme Strategies in Promoting Decision-Making Skills, two codes were determined: two (2) teachers utilized problem-solving activities, and three (3) teachers conducted experiments and investigations. Under Collaborative Learning Strategies, five (5) teachers conducted collaborative work. Finally, the theme Assessment Methods had four (4) codes: Use of Rubrics (2 mentions), Observation and Feedback (2), Evaluation through discussions, and Assessment and Reflection (1).

Table 1. Summary of Responses on the Methods and Strategies of Teachers in Promoting Decision-Making Skills

Themes	Codes	Mentions	Sample Utterances
Integration of Real-World Applications	Always apply real-world applications	2	**SQ-T2** *"Yes, as a science teacher, I always integrate real-world applications."*
	Often apply real-world applications	2	**SQ-T4** *"Yes, in science class, we often use real-life examples to helps students understand concepts better."*
	Occasionally apply real-world applications	1	**SQ-T5** *"Yes, if the lesson is applicable to be applied to real-world issues."*
Strategies in Promoting Decision-Making Skills	Problem-solving	2	**SQ-T4 "***As a teacher, I use real-life applications like case studies, and problem-based learning activities."*
	Experiments and Investigations	4	**SQ-T2** *"I integrate through presenting real-world scenarios and through letting the learners conduct experiments or investigations."*
Collaborative Learning Strategies	Collaborative Works	5	**SQ-T3** *"I facilitate group works where students collaborate to solve difficult problems."*
Assessment Methods	Use of Rubrics	2	**SQ-T1** *"Using the rubric with collaboration as the key criterion, I allow the student to assess their own learning."*
	Observation and Feedback	2	**SQ-T2** *"I assess through reading their work and give feedback."*
	Evaluation through discussions	1	**SQ-T4** *"I assess and provide feedback on the decision-making skills of my students by evaluating their ability to analyze data,and justify their reasoning."*
	Assessment and Reflection	1	**SQ-T5** *"I also use peer assessment, reflection activities, and feedback loops in assessing and providing feedback on students' decision-making skills."*

The qualitative analysis of teachers' methods and strategies in promoting decision-making skills reveals varied practices. While some consistently integrate real-world applications and utilize active learning strategies like conducting experiments and problem-solving activities, others may benefit from greater consistency and exploration of other instructional approaches. The use of collaborative learning strategies emphasizes their value in enhancing decision-making skills through group interaction. This is supported by the study of Asha and Al Hawi (2016) which revealed a positive impact of interaction and cooperation in enhancing students' decision-making skills. They also discussed that decision-making skills are needed to help the students (1) adapt to the environment, (2) achieve their goals, and (3) be active participants in any task assigned to them. Additionally, the use of diverse assessment methods demonstrated a comprehensive approach to evaluating students' abilities. These findings revealed the importance of refining the methods and strategies in teaching to prepare the students for real-life contexts and decision-making.

In terms of the responses on the integration of an SSI-based approach in teaching, four themes were determined (Table 2). Under the theme Familiarity with SSI-Based Approach, there were two (2) codes which are Familiar with SSI-based approach (3 mentions) and Unfamiliar (2). For the theme use of the SSI-Based Approach, three (3) teachers incorporated the SSI-based approach and two (2) did not incorporate SSI. For the theme Challenges in Teaching SSI, three (3) teachers encountered challenges which included preparation, additional workload, time, and resources. Finally, the theme Benefits of Introducing SSI Lessons had two codes: Prepares the students to face the real world (2) and develops the different skills of students (3) indicating that science teachers have positive remarks on the integration of SSI-based approach in teaching.

While some teachers are familiar with SSI-based approach and utilized in their teaching, most of them faced challenges such as preparation time, additional workload, and resource constraints. Friedrichsen et al. (2021) discussed three reasons for teachers' omission of SSI activities in their classroom, one of which is the limited access to SSI-based resources (Sadler et al., 2006), and the other two are the teachers' unfamiliarity to this approach (Sadler et al., 2006; Saunders & Rennie, 2013) and the discrepancies between the teachers' philosophy in teaching and their perceptions of SSI (H. Lee et al., 2006; Sadler et al., 2006).

However, despite these challenges, there is a consensus among teachers regarding the benefits of introducing SSI lessons. These include preparing students for real-world scenarios and developing a diverse range of skills. Studies revealed that the SSI-based approach has several benefits to teaching including increased argumentation quality (Atabey and Topçu, 2017), developed critical thinking skills (Talens, 2016; Pauzi and Windiaryani,2021), improved decision-making skills (Gutierez, 2015; Nurtamara and Prasetyanti, 2020), and enhanced communication skills (Chung et al., 2016) and emotional competency (Gao et al., 2021). These studies revealed that SSI not only improved students' technical skills but also soft skills overall contributing to a wide range of benefits to teaching using this approach. These positive remarks on SSI integration suggest a potential avenue for enhancing students' decision-making skills. To further optimize the integration of the SSI-based approach in science education, addressing the challenges such as resource limitations by providing learning materials for teachers to utilize can benefit student learning outcomes.

Table 2. Summary of Responses on the Integration of SSI-Based Approach in Teaching

Themes	Codes	Mentions	Quotes
Familiarity with SSI-Based Approach	Familiar with SS-based approach	3	**SQ-T5** *"Yes, I am familiar with the SSI-based approach in teaching."*
	Unfamiliar with SS-based approach	2	**SQ-T1** *"No. I am NOT yet familiar with this approach."*
Use of SSI-Based Approach in Teaching	Incorporated SSI-based approach	3	**SQ-T4** *"Yes, I incorporate SSI in my teaching."*
	Did not incorporate SSI-based approach	2	**SQ-T2** *"No, I did not incorporate it because honestly it is the first time that I hear of this SSI-based approach."*
Challenges in Teaching SSI-Based Approach	Challenges Encountered	3	**SQ-T5** *"It also comes with challenges such as the preparation. The additional workload, time, and resources, and with its assessment which is quite challenging."*
Benefits of Introducing SSI Lessons	Prepares the students to face the real-world	2	**SQ-T4** *"Teaching SSI lessons can help improve students' decision-making skills by giving them chances to tackle real-world problems, analyze evidence, think from different viewpoints, and make informed choices, preparing them for future challenges."*
	Develops the different skills of students	3	**SQ-T5** *"It provides students with valuable opportunities to develop and enhance their skills in the context of real-world problems."*

3.2 Learners' Level of Decision-making Skills

Table 3. Mean Result on the Level of Decision-Making Skills of Students

Criteria	Mean	Description
Describing a recent decision-making situation	2.33	Developing
Factors considered before making the choice	2.12	Developing
Group decision-making process	2.06	Developing
Contribution to the decision-making process	2.18	Developing
Handling pressure in making quick decisions	2.08	Developing

Note: 3.50-4.00: Exemplary, 2.0-3.49: Proficient, 1.50-2.49: Developing, 0-1.49: Novice

The quantitative evaluation of students' decision-making skills reveals that they are currently at a developing stage (Table 3). While students were able to describe recent situations utilizing decision-making, there is evident room for growth, particularly in their ability to contribute effectively to group decision-making processes and handle pressure when making quick decisions. According to Genisa et al. (2021), decision-making is directly linked to the cognitive ability of students. Thus, students who have low levels of decision-making tend to have low cognitive abilities, and this affects their concept understanding (Jho et. al, 2014). These findings suggest the importance of implementing interventions to further develop students' decision-making skills. Incorporating discussions and activities that will foster collaborative decision-making skills and real-world scenarios may improve students' decision-making skills.

3.3 Developed SSI-based Module

Table 4 presents the student involvement index of the module using the procedure of Romney (1969). The computed student involvement index is $\frac{Total\ for\ Category\ II}{Total\ for\ Category\ I} = \frac{17}{14} = 1.21$. The result shows a ratio greater than 1 or a higher student involvement index. This means that the evaluation and clarity of the module make the developed material engaging and make their learning experiences relevant. According to Siniguian (2019), the involvement of the reader in the module makes the material interesting which involves the senses of sight, sound, and touch of the reader.

Table 4 Student Involvement Index of the Module in Evolution

Category	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	TOTAL
I.											
1. Facts			3								3
2. Stated conclusion		1			1			1			3
3. Definitions		1	2				2	3			8
4. Questions answered immediately											
Total for I											**14**
II.											
5. Questions requiring students to analyze data						1					1
6. Statement requiring student to formulate conclusions		2									2
7. Directions to students to perform and analyze some activity and solve problems				1	3				2	2	8
8. Questions to arouse student answer and not answered immediately	5		1								6
Total for II											**17**

To determine the readability of the module, a Fry Graph Readability method was employed (Table 5). The average number of sentences in the y-coordinate and the average number of syllables in the x-coordinate were plotted in Figure 1. The grade levels in the readability graph are based on norms in the United States at the time the data was collected. The Philippines norm is two grade levels lower.

Table 5 Number of Sentences and Syllables Per Hundred Words on the Module of Evolution

	No. of Sentences	No. of Syllables
First Page	6	156
Middle Page	5	162
Last Page	6	168
Average	**5.67**	**162**

Based on Figure 1, the average number of sentences and syllables per hundred words in the module lies on the Grade 11 level in the graph. Subtracting two grades lower falls on the Grade 9 level. Hence, it can be inferred that the sentence length and word length of the module are at the average level and are appropriate to the intended readers which are Grade 9 learners.

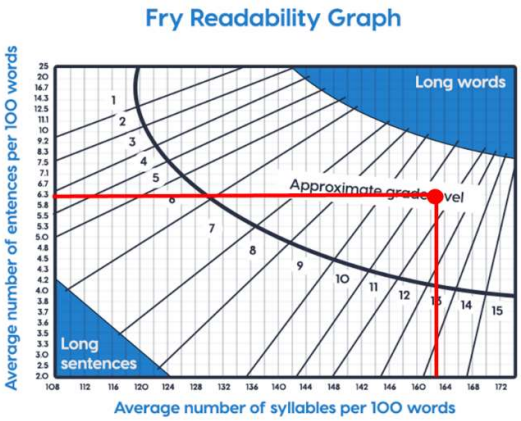

Figure 1 Fry Graph for Readability of the Module on Evolution

Prior to conducting a pilot study, the developed SSI-based module underwent content validation by a panel of experts. A scoring rubric adopted from the study of Foulks (2020) was utilized that contains the following components: Focal Issue, Learning Objectives, Science Content, Social Connections, Assessment, Information Communications Technology (ICT), and Closure.

The scoring rubric was composed of a 4-point scale, where 3 indicates exemplary, 2 indicates explicit, 1 indicates implied, and 0 indicates absent. Based on Table 6, all of the components of the scoring rubric were rated as Very Satisfactory by the entire panel of experts. Hence, the developed SSI-based module has an overall rating of Very Satisfactory. This result demonstrated that the developed learning material was ready to be implemented to the respondents of the study.

After gathering relevant data from the teachers and students, the researcher developed an SSI-based module that underwent content validation by a panel of experts. A scoring rubric adopted from the study of Foulks (2020) was utilized that contains the following components: Focal Issue, Learning Objectives, Science Content, Social Connections, Assessment, Information Communications Technology (ICT), and Closure.

Table 6 Panel of Experts Rating on the SSI-Based Module in Evolution

	SSIM-E1	SSIM-E2	SSIM-E3	SSIM-E4	SSIM-E5	MEAN	DESCRIPTION
A. Focal Issue	3	2.66	3	3	3	2.93	Very Satisfactory
B. Learning Objectives	2.66	2.33	3	3	3	2.80	Very Satisfactory
C. Science Content	3	2.66	3	3	3	2.93	Very Satisfactory
D. Social Connections	3	3	2	3	3	2.80	Very Satisfactory
E. Assessment	3	2.50	3	3	3	2.90	Very Satisfactory
F. ICT	3	2	2	3	2	2.40	Very Satisfactory
G. Closure	3	3	3	3	3	3.00	Very Satisfactory
Average	2.95	2.59	2.71	3	2.85	2.82	Very Satisfactory

Note: 2.01-3.00: Very Satisfactory 1.01-2.00: Satisfactory 0.00-1.00: Poor

The scoring rubric was composed of a 4-point scale, where 3 indicates exemplary, 2 indicates explicit, 1 indicates implied, and 0 indicates absent. Based on Table 6, all the components of the scoring rubric were rated as Very Satisfactory by the entire panel of experts. Hence, the developed SSI-based module has an overall rating of Very Satisfactory. This result demonstrated that the developed learning material was ready to be implemented to the respondents of the study.

5. Conclusion

This study demonstrated the importance of the integration of SSI-based instruction in promoting decision-making skills. Results revealed that teachers utilized varied methods and strategies in promoting decision-making skills, and the current level of decision-making skills of the students are at a developing stage suggesting a targeted intervention for its improvement. The developed SSI-based module had a high student involvement index and appropriate readability for Grade 9 learners. For its evaluation, the developed module received a Very Satisfactory rating from the panel of experts. Hence, this study further suggested implementing this SSI-based module to determine the improvement in the decision-making skills of students and its effectiveness in terms of the learning experiences of the students.

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