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Socio-Scientific Issues-Based Electronic Learning Material Design Framework Development for Flexible Learning

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Abstract

The study aims to design a socio-scientific issues (SSIs)-based electronic learning (e-LM) design framework. It is anchored to the SSI occurrences in teaching Science at a State University in Batangas province, Philippines. This SSI-based e-LM design framework will guide the e-LM development for teaching Science socio-contextually through flexible learning. The explanatory sequential mixed method design addressed the study's goal. Initially, the existing SSIs in the science course curriculum were analyzed. Significant insights into the occurrence of existing SSIs, such as the appropriate teaching approaches, suitable teaching strategies, assessments, and e-LM design structure, were identified. The resulting least occurring SSI identified and factors affecting their existence comprised the salient features of the proposed e-LM design framework. Findings showed that lifelong learning issues, ethical issues, and sustainability issues were almost "no occurrences at all" SSIs in the analysis. These identified SSIs became the priority SSIs in e-LM design framework. Significant insights showed that flexible learning and socio-contextualization are suitable teaching approaches. Meanwhile, the teaching strategies that were found appropriate in the SSI inclusion include brain-netting, discovering scientific ideas, e-collaboration, and reflective thinking evaluation. The e-LM design framework proposed is called Brain-DeCoR e-LM Framework. Applying the proposed e-LM design framework in teaching Science will encourage science facilitators to situate priority SSIs in teaching Science. This results in creating a balance in SSI inclusion. The least occurring SSIs, which are the priority SSIs, are given into focus. Furthermore, the proposed framework will aid students in learning science beyond the content, developing their skills, and enhancing their environmental concerns and social awareness.

Keywords: Socio-Scientific Issues (SSIs), Electronic Learning Material (e-LM), Socio-Scientific Issues (SSIs)-Based Electronic Learning Material (e-LM) Design Framework, Flexible Learning, Socio-Contextualization.

1. Introduction

As COVID-19 spread and became a pandemic, the academic landscape experienced a total overhaul. Pre-pandemic best practices demand modifications to suit the "new normal." United Nations (2020) described education as a progress catalyst for Sustainable Development Goals (SDGs). They further suggested that immediate action is necessary to avoid a learning crisis in the future.

scientific issues (SSIs) like this, and practicing mitigation measures. Toquero (2020) insisted that higher education institutions (HEIs) should welcome improvements in teaching methods and make them more sensitive to the learning needs of students. Science education should focus on critical reflections on global problems such as pandemics and climate change.

According to Levinson (2018), to solve a societal problem, socio-scientific issues (SSIs) use empirical knowledge as their basis. They are considered as "learning about science," which involves understanding science, nature, and its theories. SSIs in science teaching empower students to embrace the scientific habit of mind (Erduran, 2020; Genisa et al., 2020) and improve cognitive performance (Ma'rufah et al., 2020). It also creates social justice awareness and environmental concerns (Nurtamara, 2020) and makes comprehensive decisions when dealing with societal issues. Therefore, there is a need to establish a balanced situation of SSIs in the HEIs science teaching.

To better understand SSI-based learning, it must demonstrate a holistic approach to all factors in the educational setup. The current societal condition requires a differentiated approach. The academe is now considering flexible learning. An electronic learning material (e-LM) incorporated with a smart mobile learning strategy would be advantageous. Arizen and Suhartini (2020) shared that this approach will provide convenience and enthusiasm to learners. Meanwhile, El Shinta et al., (2020) mentioned that it will enhance learners' scientific literacy skills and assist self-sufficiency in learning. Academic institutions are implementing an in-person mode of learning. However, nobody can tell when an online learning mode will be again necessary. In this case, an e-LM that is flexible enough to respond to an inevitable scenario will comply with this requirement.

This study aimed to develop an electronic learning material (e-LM) based on a validated design framework. The inclusion of socio-scientific issues in teaching Science with socio-context through flexible learning is also given focus. Specifically, this study intended to address the following questions:

(1). What existing socio-scientific issues are on the curriculum of the selected Science courses in the aspects of the syllabi, instructional materials, and strategies in teaching, assessment tools, and learners' experiences?

(2) What electronic learning material (e-LM) framework can be designed based on the identified socio-scientific issues (SSIs)?

This study will significantly contribute to society. The learners exposed to the proposed e-LM will hopefully hone them to be socially, environmentally informed, and ethically concerned in their community. Getting them involved in the community will mold them to be proactive on societal issues affecting them and eventually benefit their community. Furthermore, the e-LM situated in the SSI with socio context would be helpful to Science course facilitators in aiding learners to hone socially and environmentally concerned learners. The features of the e-LM design framework would help them easily balance SSI inclusion in teaching Science courses. The specific goal of the topic/ issue will be clearly stated, giving learners enough time to accomplish each segment. The "electronic" (e) feature of the learning material will quickly get along with the learning style of the digital generation.

Based on the previously cited premises, the researcher aimed to identify the existing SSIs in the science curriculum. Furthermore, their occurrence level will be determined. This SSI occurrence will construct the proposed SSI-based e-LM framework, aiding in balancing the SSI situation. This proposal will guide the science facilitators in structuring the SSI-based e-LM. A socio-context approach employed in flexible learning will aid in its implementation. The researcher believes this endeavor will significantly contribute to teaching science, improving content knowledge, and developing skills. Moreover, it will enhance social concerns and environmental awareness.

2. Research Methodology

The mixed method exploratory sequential design (Walker & Baxter, 2019) was employed to address the study's goals. According to Walker & Baxter (2019), this design is applied when the quantitative analysis supports the qualitative analysis.

The study was conducted at a state university in Batangas province, Philippines. The fourteen (14) science facilitators are the respondents in the curriculum analysis. Three hundred eighty (380) science students participated in a survey for their learning experiences.

A guide checklist for analyzing existing SSIs was adapted from the Organizational Outline of an SSI-based instruction framework (Presley et al., 2013). Another instrument utilized in the study is guide questions in conducting open-ended interviews with the facilitator. A student survey for the occurrence of SSI in the learning experience further substantiated data gathering. All instruments utilized were validated to ensure "measuring what is intended to measure" (Taherdoost, 2016). To measure the reliability of the instruments, SPSS software was used to generate the Cronbach Alpha reliability coefficient. According to Taherdoost (2016), the Cronbach Alpha reliability coefficient is the most commonly used internal consistency measure. The student survey instrument was excerpted from the validated curriculum guide checklist (learning experiences aspect). It was pilot-tested with thirty (30) BIT Food Technology students before its administration to intended student respondents. Table 1 shows the result of the reliability test conducted:

Table 1. Reliability Test Results

Instruments	Cronbach Alpha Coefficient	Interpretation
Students' Survey for the Occurrence of SSI in the Learning Experiences	0.655	Moderate Reliability

Note: Reliability Cronbach Alpha Coefficient Interpretation was based on Taderhoost (2016)

The student survey for the occurrence of SSI in the learning experiences instrument was found to have moderate reliability. Kalpande (2022) shared that a Cronbach Alpha coefficient value of 0.6 above is considered acceptable for reliability analysis. This is supported by Taherdoost (2016), stating that for an exploratory study, it is recommended that the reliability coefficient should be equal to or above 0.60.

Thematic analysis (Braun &Clarke, 2006) identified the existing SSIs in the curriculum artifacts such as syllabi, instructional material, recorded class video conferences, assessment tools, and reflection journals. The identification of SSIs in the artifacts was coded manually. Manual coding was validated by field experts who specialized in thematic analysis and had a background in socio-scientific issues. Illustrative responses of teacher respondents in an open-ended interview further validated the identified SSIs. Verbal data from interviews were transcribed, codes were identified and then categorized. Using the Curriculum Guide Checklist, identified SSIs were quantified on each artifact analyzed. Student responses on the survey of the existing SSIs in their learning experiences further substantiated this artifact's results. Experts further validated the collected data before its analysis.

A summary of all SSI occurrences on the science curriculum encompassing various artifacts concludes the analysis. In identifying the occurrence level, color coding was assigned from 'high occurrence' to 'no occurrence at all.' Color coding, red for "high occurrence," green for "moderate occurrence," blue for "low occurrence," and yellow for "no occurrence at all" was given. Color coding facilitated a visible presentation of what SSI will be prioritized in designing the framework.

In the design phase, the least occurring SSIs were defined as the priority SSIs. These identified priority SSIs were situated into the Institution's IM design structure. Suitable teaching approaches were reviewed. The actual setup in the institution is well-thought-out. Its favorable aspects are considered in the designing stage of the e-LM. Lastly, as learning material structure was defined, appropriate teaching strategies were also identified. The proposed e-LM design framework underwent validation by experts. Revisions were made based on the comments and suggestions of the validators. Significant insights contributing to SSI occurrences were collected and comprised the salient features of the e-LM design framework.

A dichotomous Yes/No checklist guide instrument was used to quantify the occurrence level of the existing SSIs identified. The mean average percentage of occurrence was computed by dividing the frequency by the total number of samples analyzed multiplied by 100. A range set with its corresponding adjectival interpretation was utilized to interpret the computed mean percentage of the occurrence.

Table 2. SSI Occurrence Mean Average Percentage Range with its Adjectival Interpretation

SSI Occurrence Mean Average Percentage Range(%)	Adjectival Interpretation
67-100	High occurrence
34-66	Moderate occurrence
1-33	Low occurrence
0	No occurrence at all

Note: Adapted from: "Institutional Impressions through Economic Impact Studies" by French (2019), The Journal of Economic Development in Higher Education, (2), (www.universityeda.org)

Table 2 presents the mean average percentage of SSI occurrence scaling range with its adjectival interpretation. This set of mean ranges above was used to interpret SSI occurrences in the artifacts analyzed. Identifying the existing SSI occurrence level resulted in recognizing the priority SSIs.

3. Results and Discussion

3.1. Existing Socioscientific Issues (SSIs) on the Curriculum of Selected Science Courses

Fourteen (14) science facilitators in the six colleges of the state university were the teacher respondents (TRs) on the analysis of SSIs in the science curriculum. Existing SSIs in the science curriculum were identified in the aspects of the syllabi, instructional material, strategies in teaching, assessment tools, and learners' experiences. The following are the quantitative samples that were analyzed for each aspect of the science curriculum:

Table 3. Number of Samples Analyzed on Each Curriculum Aspect

Science Curriculum Aspects	Number of Samples
Syllabi	35
Instructional Materials	85
Class Video Conferences	9
Assessment Tools	26
Reflection journals	52

The artifacts were examined through thematic analysis to identify the various SSIs in the curriculum. The analysis also yielded valuable insights into the occurrence of SSIs, which were further reinforced by transcripts from TR interviews. These insights were further supported in designing the framework for SSIs. Moreover, using a guide checklist, SSIs were quantified to determine the level of occurrences. Those least occurring SSIs became the priority in the e-LM design framework.

Table 4 presents the thematic analysis result. This showed how the theme was generated from the codes and categories extracted from the analyzed samples.

Table 4. Thematic Analysis of Socio-Scientific Issues in the Science Curriculum

Codes	Category	Theme
Lifelong learning awareness Lifelong learning purpose	Recognition of Lifelong Learning	Lifelong learning issues
Professional Responsibility Learner Welfare and Community reintegration Responsible citizenship and stewardship	Lifelong Learning Social and Ethical Responsibility	
Personal guidelines and career significance	Personal and career development for lifelong learning	
Educational Technology for Quality Teaching	Quality teaching materials for lifelong learning	
Contemporary environmental problems, impact, and climate change Waste management and Energy efficiency Environmental engineering and protection	Environmental impact and management	Environmental issues
Environmental Initiatives and Projects Environmental education and analysis	Generating environmental solutions	
Pursuing the good life through ethical innovation Empowering ethical wisdom amidst scientific progress Ethical integrity in teaching	Ethical pathways in the pursuit of progress	Ethical issues
Fostering moral growth for understanding human behavior	Understanding moral issues	
Promoting sustainable development goals through education and awareness Empowering sustainable development goals through goal-oriented actions	Sustainable development goals (SDGs) and education	Sustainability issues
Exploring renewable energy considering its recompenses Sustainable energy generation and management	Advancing sustainable energy solutions	
Health and disease awareness Environmental and health impacts Nutrition and food safety	Promoting holistic health and wellness	
Towards environmental sustainability and social justice	Environmental sustainability and social justice	
Collaborative sustainability in the professional community	Collaborative sustainability	
Sustainable farming for environmental health	Sustainable Agriculture	

Enhancing food sustainability	Promoting a sustainable and safe food system

The study performed quantitative curriculum analysis considering the themes generated: lifelong learning, environmental, ethical, and sustainability issues. A validated curriculum guide checklist was used to gather data. Organizational Outline of an SSI-based framework (Presley et al., 2013) served as a basis for structuring the content of the curriculum guide checklist to analyze existing SSIs in the Institution. Peripheral influencers like the instructional material and student assessment tools were considered part of the modified instrument. The results of identified SSI occurrence levels in selected science courses are summarized in Table 3.

Table 5. Summary of Results of Identified SSI Occurrence Level in Selected Science Courses

SSIs	Various Aspects Across the Science Curriculum						
	Syllabi	Instructional material	Strategy in teaching (Video conferences)	Strategy in teaching (Interview)	Assessment tools	Learning experiences (Reflection journal)	Learning Experiences (Student survey)
Life-long learning issues							
Environmental issues							
Ethical issues							
Sustainability issues							

Note: High occurrence, moderate occurrence, low occurrences, no occurrence at all

Table 5 summarizes the SSI occurrence level in the science courses encompassing different artifacts analyzed. To recognize the level of occurrence, color coding of SSI is assigned. Red is for high occurrence, green is for moderate occurrence, blue is for low occurrence, and yellow is for no occurrence at all. The table generated multi-color highlights revealing inconsistencies in the SSI occurrences across artifacts. Interestingly, it shows that the least observed mark was a high occurrence, depicted by the red highlights. Upon analyzing the syllabi samples, it was noted that lifelong learning issues were the only SSI with high occurrence. However, this SSI did not occur across other aspects of the science curriculum except with learning experiences.

In contrast, there were few moderate occurrences, indicated by green highlights, in relation to environmental issues and lifelong learning issues. These situations were identified through syllabi and learning experiences (reflection journals and student surveys).

Blue highlights, which signify "low occurrence," were present in all identified SSIs. While environmental issues had some moderate occurrences (green mark), they were mostly marked with low occurrences (blue mark). Ethical issues and Sustainability issues had similar highlight patterns with low occurrences in syllabi, reflection journals, and student surveys.

Notably, yellow highlights were observed across all identified SSIs except with environmental issues, which are the most occurring SSIs. These yellow highlights were showcased on lifelong learning, ethical, and sustainability issues. On the other hand, this is evident in instructional materials and strategy in teaching- video conferences. It is also significantly apparent in strategy in teaching (Interview) and assessment tools.

The four occurring SSIs show varying occurrence levels in each analyzed aspect of the curriculum. Unfortunately, most learning materials analyzed tend to focus solely on science content, not considering the significance of SSI. While facilitators discuss SSIs during class conferences, the learning materials do not reflect these discussions. Furthermore, SSIs arise during reflection journal learning experiences. Assessment tools primarily focused on content, overlooking content applications. Teaching strategies assisted in SSI situations in the curriculum. These include brainstorming supported by technology, discovery learning, interactive learning, and collaboration supported by technology. Furthermore, implementing a flexible learning approach and socio-contextualization also aids in situating SSIs in the analyzed science courses.

To ensure that there is a balance in the SSI situation, it is recommended to develop an SSI-based electronic learning materials (e-LM) design framework. Genisa (2020) recommended designing SSI-based instructional material as it fosters social awareness and scientific thinking habits. Dalaila et al. (2022) further shared the advantage of digitally-inclined SSI-based e-LM as it aids 21st-century learning. Bigcas et al. (2022) also stated that incorporating SSIs into flexible learning instruction can improve student's performance and engagement (English, 2019).

3.2. The Proposed Electronic Learning Material (e-LM) Framework

The concept map joint display was illustrated to portray the quantitative and qualitative points of convergence.

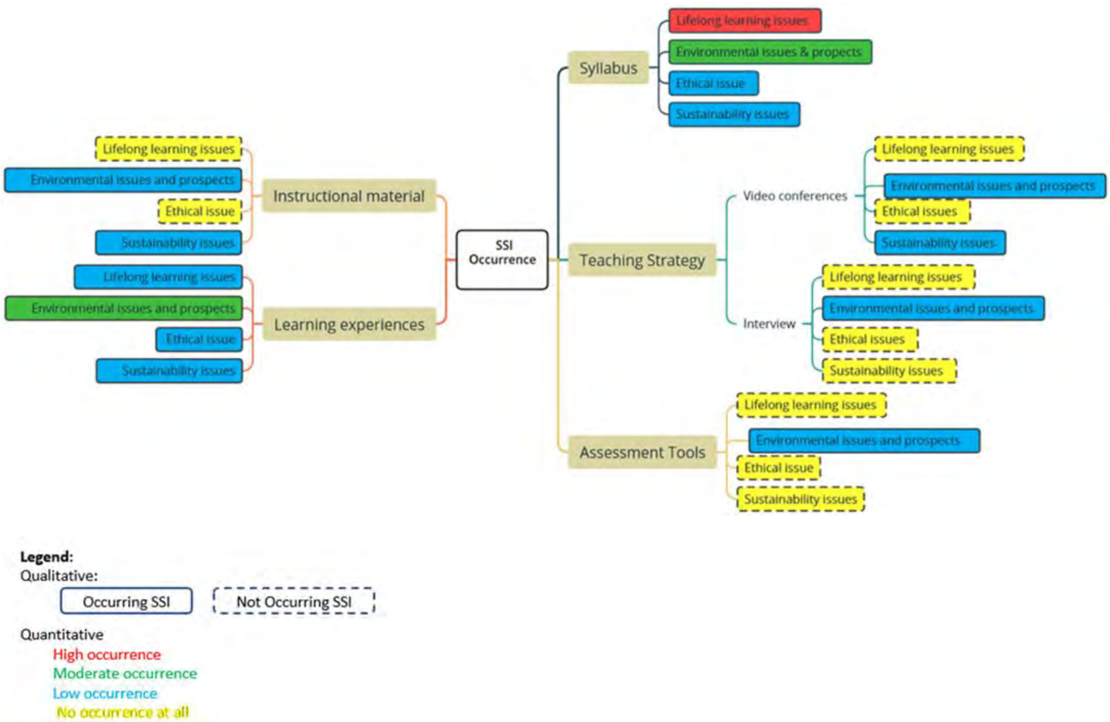

Figure 1. Concept Map Joint Display Portraying the Quantitative and Qualitative Points of Convergence

Figure 1 shows how the thematic analysis result converged with the guide checklist SSI analysis outcomes. The six artifacts analyzed were the syllabus, teaching strategy (video conference and recorded video interview), assessment tool, learning material, and learning experiences. The thematic analysis generated themes that represent the occurring SSIs. Rectangular blocks with solid borders represent these. However, these themes generated did not occur on all artifacts analyzed. A rectangular block with broken line borders represented those SSIs that did not occur on specific artifacts but occurred on other artifacts. This was done to portray the SSI non-occurrence on the specified artifact. On the other hand, a guide checklist SSI analysis determined the level of occurrences of each theme. Color coding was assigned on each level: red for high occurrence, green for moderate occurrence, blue for low occurrence, and yellow for no occurrence at all. Using the color-coding representation, those SSIs that had no occurrence at all (yellow code) on specific artifacts were identified. By examining Figure 3, it can be observed that there are yellow codes with broken line borders. This indication implies that the non-occurring SSIs identified in the thematic analysis were the same, with no occurrence in the guide checklist result. Those SSIs with yellow code in broken line borders, the non-occurring SSIs or SSIs with no occurrence at all, can be explained as the representation of least occurring SSIs in the science curriculum analysis and be given priority in the SSI situation in e-LM development.

Significant insights influencing the occurrences of SSIs were also analyzed. It is noticeable that environmental issues have remarkable insights and are the most occurring SSIs among the four identified. Meanwhile, the other three SSIs, namely ethical issues, sustainability issues, and lifelong learning issues, are the least occurring SSIs and are prioritized for e-LM development.

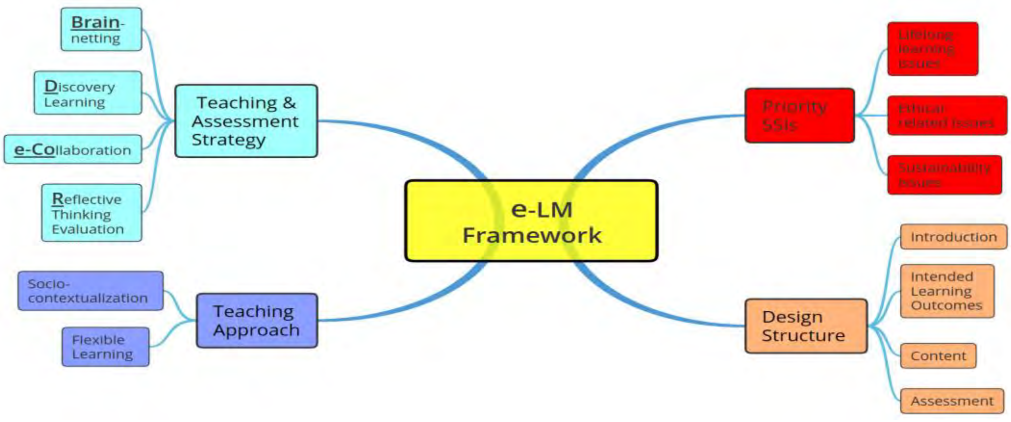

Figure 2. Concept Map Showing the Salient Features Generated from Identifying Occurring SSIs

Figure 2 illustrates the priority SSIs, the IM design structure, the teaching and assessment strategies, and the teaching approaches that construct the salient features of the proposed e-LM design framework.

3.2.1. The Inclusion of Priority SSIs

The priority SSIs identified in the curriculum analysis are the highlights of the proposed e-LM design framework.

(1) Lifelong learning issues delved into its recognition, social and professional responsibilities, personal and career development, and link with quality education. Realizing it occurred only on syllabi and learning experiences, it will be situated across the module structure.

(2) Ethics issues occurred in its path toward pursuing progress and understanding moral issues. This was almost observed as “no occurrence at all” in the curriculum, noted only on the Science Technology and Society (STS) course syllabi and learning experiences analyzed. This will be significantly emphasized in the proposed e-LM design framework. It is expected to be situated across the module structure to highlight its relevance in the learner’s decision-making.

(3) The curriculum analysis shows that sustainability issues are applied to Sustainable Development Goals (SDGs) and education, sustainable energy solutions, promoting health and wellness, collaborative sustainability, sustainable agriculture, and promoting a sustainable and safe food system. These issues did not occur in the facilitators’ interview and assessment tools. This will be given priority in the proposed e -LM design framework. Sustainability issues are expected to be situated across the e-LM structure considering SDG goals. As SDG link with other occurring SSIs is culled, other related SSIs may be correlated as applicable, such as lifelong learning issues with SDGs (English, 2019) and ethical issues with SDGs (Bertella, 2020).

3.2.2. The Institution’s IM Design Structure

The IM design structure utilized by the facilitator respondents in their submitted instructional materials is extracted from the HEI MO No. 359 Implementing Rules and Regulations of General Guidelines on the Conduct of Flexible Learning for Academic Year 2020-2021 Rule II S 7.8. It comes in a stepwise procedure, starting with the Introduction, followed by Intended Learning Outcomes, then Content, and ending at the Assessment.

(1) The introduction structure is placed at the start of learning material to motivate and interest the learners, intending to emphasize the significance of the science course. Talens (2016) described that as the introduction is situated with SSIs, it makes the learning progression more authentic. She added that SSIs make the introduction more engaging. Personal experiences were applied and contextualized to the science content.

(2) The Intended Learning Outcomes (ILO) part introduces the course content and presents the ILOs of the e-LM. SSIs in the ILOs create engagement to maintain professional, ethical, and social responsibilities to learners and focus on attitude and value formation. Controversial issues are expected to be explored, dealing with moral reasonings, which the learner will attempt to resolve. Furthermore, SSIs, such as sustainability issues, encourage learners to be abreast with a learning outcome that promotes sustainable development.

(3) Content component presents the course content of the e-LM. SSIs in the e-LM content capture the learners’ life experiences as part of the learning process, ramify their decisions, recognize their moral situations while relating to science, and promote sustainable practices linking to scientific ideas through procedural or processes.

(4) The Assessment aims to assess the learner’s performance in science in terms of content knowledge, skills, and attitude. In this part, SSIs aim to assess the practical learnings, encourage learners to enhance their moral reasoning, and propose a sustainable solution while dealing with societal development.

3.2.3. The Teaching and Assessment Strategy Component

Designing the proposed framework carefully considered suitable teaching and assessment strategies for the IM structure. A teaching strategy shows the plans of the teacher's technique to facilitate the teaching-learning process in the classroom.

(1)"Brain-netting" refers to using technology to support brainstorming with the learners. This strategy involves sharing ideas and linking their thoughts and experiences through the available technology resources. In the data gathered, the Padlet application assisted the learners in actively participating and sharing their responses. Learners can view their peers’ shared ideas. This activity allowed the facilitator to gain insight into the learners' prior understanding of the topic. Additionally, learners are aided in understanding content's relevance in their lives. Brain-netting fostered a sense of belongingness within the class and motivated them to continue their pursuit of learning. Maaravi et al. (2021) confirmed that this strategy boosts creativity and generates innovative ideas among learners, while Mauluddiyah et al. (2018) noted that it gives comfort, enabling them to be more expressive in sharing their ideas. Its construct aims to inspire and engage learners in the introduction part. This activity will provide the facilitator with the learner's socio-cultural background. additionally, this strategy will blend with the flexible learning approach of the e-LM.

(2) The Discovering Scientific Ideas strategy is learner-centered, encouraging learners to explore and discover knowledge. In the analyzed class video conferences, the learner understood how concepts such as distance, velocity, and projectile are related. They also claimed ownership of their newfound knowledge by actively participating in related practical activities. Discovering scientific ideas blends with the proposed e-LM design framework. The e-LM aims for learners to develop their knowledge for themselves and recognize the significance of the social environment in the process. Bruner (1961) explained that this strategy would not directly convey the content to the learners. The sequential query of the investigation will be done while relating the acquired knowledge with the new one. As SSI is situated in the lessons, learners investigate appropriate circumstances relating to the social environment and claim their knowledge of the discoveries.

(3) e-Learning is a learning practice that incorporates digital tools. Arizen & Suhartini (2020) cited that it encourages mobile learning to simplify the process, enabling one to study anywhere, anytime, at the learner's convenience. Collaboration with e-learning results in e-collaboration. It can occur by utilizing digital technologies suiting the digital lifestyle in the new normal. This strategy promoted interactive activities among learners. Teacher respondents (TRs) shared that they utilized technology applications like Padlet, Google Documents, Google Slides, and Jam board to integrate societal issues. This activity increased their engagement. The e-collaboration strategy is well-suited to the proposed e-LM design framework. It can be used to support other strategies to promote communication skills and build a collaborative workforce while using digital resources. Learners are encouraged to participate in learning by creating interactive activities focusing on societal issues.

(4) Reflection thinking involves a dynamic process of considering one's belief or supposed form of knowledge supported by evidence and arriving at a concluding decision. De Leon-Pineda and Prudente (2022) emphasized that reflective thinking evaluation is crucial for learners. They added that it helps them reflect on their thoughts, comprehend their experiences, and enhance their performance in science. In the reflection journals analyzed, SSIs enabled learners to enrich further their understanding of the lessons discussed. The e-LM assessment tool designed in the e-LM framework will evaluate the learners' gains in science concepts, the skills acquired, and as well as an appreciation of social concerns and environmental awareness. Science concepts are those presented and discussed in the class. The skills acquired may come from evidence-based activities requiring critical thinking in relating SSI to science content and e-collaboration skills through inquiry learning. Lastly, learners' recognition and appreciation may come from learner's experiences with social concerns and environmental awareness.

3.2.4. The Teaching Approach Component

Suitable teaching approaches are considered in the e-LM to ensure that the priority SSIs in the Institution's design structure are implemented accordingly. The actual setup in the Institution is well-thought-out, and its features are considered in the designing stage of the proposed e-LM design framework.

(1) Flexible learning, as defined by CHED (2020), is a pedagogical approach permitting flexibility of time, place, and learners that not only depends on digital resources. The teacher respondents (TRs) utilized the flexible learning approach as they situated SSI in teaching science. The availability of technological resources aided TRs in suitably applying this approach in teaching SSIs. The flexible learning approach in blended learning modality suitably works with the proposed e-LM design framework. e-LM, situated with SSI in the flexible learning approach, will simplify learning that gives convenience to the learners.

(2) The socio-contextualization approach considers the social environment when contextualizing content. It aims to acknowledge the learners' experiences and cultural background in learning science. Picardal & Sanchez (2022) revealed that as a teaching approach, contextualization uses the learners' previous knowledge and personal experiences to help them understand scientific concepts. Teacher respondents utilized the socio-contextualization approach as they situated SSI in teaching science. TR1 was able to relate in her class to the social issues that directly affect the learners' daily lives. The Socio-contextualization approach in the proposed e-LM design framework will allow them to relate their prior knowledge and personal experiences to the science concepts acquired in the class discussion. In the end, the socio-contextualization approach helps learners to claim the knowledge they discover and become a part of their learning. This approach in the e-LM makes the content practical to relate to and recognize its significance, affecting their daily life. Given in Figure 3 the proposed e-LM design framework:

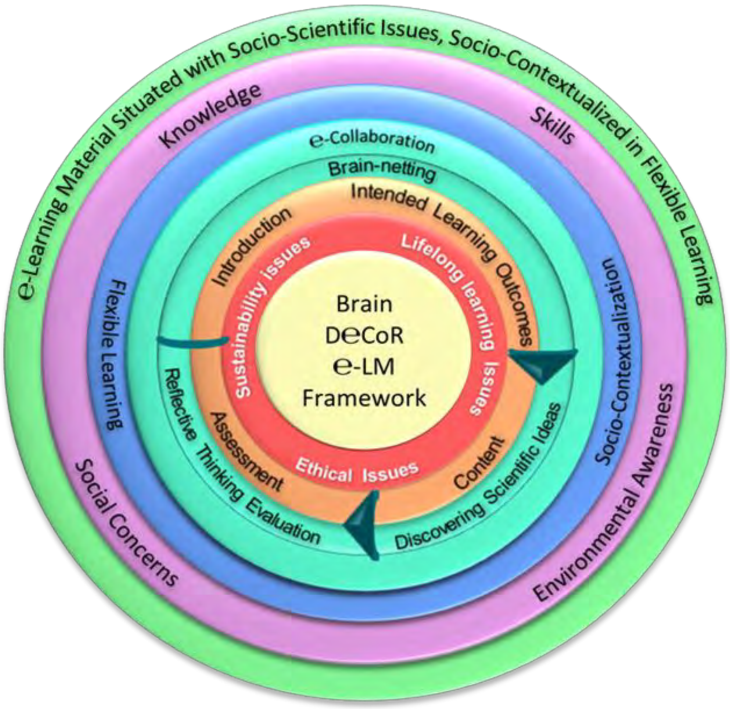

Figure 3. The Proposed Brain-DeCoR e-LM Framework Structure

The proposed e-LM design framework comes in a circular structure to symbolize a holistic presentation of its elements. It comprises layers of rings that begin at the innermost core (center) and extend outward to the outermost ring. The proposed e-LM design framework's name is located in the innermost core, Brain-DeCoR. This name was excerpted from the suitable teaching strategies presented in the proposed e-LM design framework, namely Brain-netting, Discovering scientific ideas, e-Collaboration, and Reflective thinking evaluation. The identified priority SSIs, namely lifelong learning issues, ethical issues, and sustainability issues, given in the next layer ring, will be situated across the proposed e-LM structure. This is followed by an IM design structure comprising the Introduction, Intended Learning Outcomes, Content, and Assessment. Guided by arrows and a straight bond, this will be performed stepwise. The specific IM design structure was bonded with the next layer ring, and the suitable teaching strategies include Brain-netting, Discovering Scientific Ideas, and Reflective thinking evaluation. This signifies that as the IM design structure is presented in a stepwise procedure, it is implemented with suitable teaching strategies. e-collaboration, the next layer ring of teaching strategies, then covers the initially given strategies to emphasize that they can be applied simultaneously. To ensure the situation of priority SSI was appropriately implemented, the next layer ring, the teaching approaches to flexible learning and socio-contextualization, will be considered. As the ring layers of salient features were all incorporated, it is expected to attain science achievement relating to content knowledge, developed skills, social concerns, and environmental awareness. Finally, an e-LM situated with SSI that is socio-contextualized in flexible learning is assumed to be effectively attained.

Table 6. The Structure of the Proposed Brain-DeCoR e-LM Framework

Layer	Description	Specific Description	Characteristics (Framework salient features)
1st Layer (core)	Resembles the name of the proposed SSI e-LM Framework	Brain-DeCoR SSI e-LM Framework	
2nd Layer*	Presents the Priority SSIs	● Lifelong Learning issues ● Ethical Issues ● Sustainability issues	To be situated across the e-LM structure
3rd Layer*	Recognizes the e-LM design structure	1. Introduction 2. Intended Learning Outcomes 3. Content 4. Assessment	To be performed in a step-wise procedure

4th Layer*	Identifies the e-LM teaching and assessment Strategy	1. Brain-netting 2. Discovering Scientific Ideas 3. Reflective Thinking Evaluation	To be incorporated into each design structure following its stepwise procedure.
5th Layer*	Illustrates another teaching strategy	e-Collaboration	This strategy can simultaneously be applied with other initially given strategies, considering the nature of the science course.
6th Layer*	Shows the appropriate e-LM teaching approaches	• Flexible Learning • Socio-Contextualization	To be practiced across the e-LM structure
7th Layer	Depicts the learning areas where the learner's science achievement is expected to be attained after utilizing the developed e-LM	• Knowledge • Skills • Social Concerns • Environmental awareness	
8th Layer (Outermost layer)	Demonstrates the outcome of the design framework	e-LM situated with SSIs, socio-contextualized in flexible instruction	

Note: Those with an asterisk (*) are the salient features of the proposed e-LM design framework

The elements of the proposed Brain-DeCoR e-LM framework are summarized in Table 6. These are defined based on their arrangement and relations in the proposed e-LM design framework.

The proposed Brain-DeCoR e-LM framework structure intends to map the development of e-LM that will respond to the current need for socio-contextualizing and flexible learning considering the least occurring SSIs. This is in contrast with the SSI-based framework designed by Presley et al. (2013), which was designed to map SSI-based instruction. The proposed framework structure is broader in scope, covering beyond design elements, learning experiences, teacher attributes, and classroom environment (Presley et al., 2013). It includes the curriculum aspects, teaching practices, instructional materials, and student assessment tools to respond to the current academic needs. The proposed framework structure became feasible by conducting the curriculum analysis initially to visualize what SSIs are situated and how these are included in the science curriculum implementation.

4. Conclusion and Recommendation

Analysis of existing socio-scientific issues in the aspects of the syllabus, instructional material, and strategies in teaching, assessment tools, and learners' experiences showed the occurrence of SSIs in selected science courses across the science curriculum. Environmental issues were the most occurring SSI identified in the science course curriculum. The identified SSIs were lifelong learning, ethical, and sustainability issues, which have almost "no occurrence at all." The inclusion of lifelong learning issues, ethical issues, and sustainability issues was considered in the design of the proposed e-LM framework.

SSI's significance in teaching science cannot be underestimated. It supports how the content knowledge will be effectively conveyed to learners through societal issues that may relate to their experiences. Least occurring SSIs, which may usually be challenging to include, must be given into focus to create a balance in SSI inclusion in science teaching.

The proposed design of the electronic learning material (e-LM) framework was based on the identified socio-scientific issues (SSIs). Lifelong learning, ethical, and sustainability issues were considered the priority SSIs. The designed and validated "Brain-DeCoR e-LM framework." is recommended to be used by science facilitators in structuring their e-LM that is situated with SSIs with socio-context implemented in flexible instruction.

The "Brain-DeCoR e-LM Framework, " which includes priority SSIs and the appropriate teaching strategies, assessments, and approaches, is deemed necessary in teaching science. This will give the opportunity to learn science beyond the content and encourage the inclusion of SSIs in teaching science. Science facilitators will be guided on how the priority SSIs will be situated in teaching science while providing appropriate teaching approaches, strategies, and assessments.

While the academe is still in the post-pandemic phase, this study recommends exploring the teaching methodology applied in developing e-LM. The changing circumstances would require a varying approach considering the availability of academic institutions' resources. e-learning features such as QR code scanning, brain-netting, and e-collaboration that substantially assist learners in utilizing the developed e-LM. It is recommended to be utilized in developing learning materials in science courses and other courses offered in the academe. As the academic world continuously progresses, the design framework could be improved in the near future. This is suggested to blend flexible learning innovations with upgrading technology. Lastly, this recommendation will ensure that science teaching is re-equipped with the evolving SSIs.

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