2024

SciEd
SEAQIS Journal of Science Education

SEAQIS Journal of Science Education (SciEd)
ISSN: 2987-8101 | E-ISSN: 2964-7533
Vol: 4, No: 1, PP:14-29
www.journal.qitepinscience.org

Research Paper Open Accsess

Learning Materials Utilising Sustainability Pedagogy in Grade 8 Ecology

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Abstract

Science education in the Philippines is anchored on the United Nations (UN) goals on sustainability education, as provided in K to 12 Science Curriculum, which envisions learners to be environmentally literate, critical problem solvers, and responsible stewards of nature. However, K to 12 implementations in the Philippines faced several challenges that resulted in student's poor awareness and knowledge about Philippine wildlife and conservation, as well as low proficiency in science. In order to enhance the proficiency and competence of students in ecology, learning materials utilising sustainability pedagogy were developed. A Descriptive-developmental research method was used to evaluate the developed learning materials (DLMs) and describe the experiences of students in the DLMs. A Four-Point Likert Scale technique was employed to evaluate the DLMs. structured journaling and thematic analysis were used to determine the experiences of students in using the DLMs in ecology. The experts' evaluation showed that the five DLMs utilising sustainability pedagogy in grade 8 ecology passed the criteria of DepEd (Department of Education) as stipulated in the Learning Resources Management and Development System (LRMDS). Introduced features, sustainability-themed, issue-based, contextualised, and reflective likewise obtained very satisfactory result. Students found the DLMs interesting, comprehensible, promote awareness, relevant to the community's environmental issues, and helped them to express their opinions. The study recommended that the valid and modified DLMs utilising sustainability pedagogy may be used by biology teachers in their lessons, can still be improved and further contextualised as well as used in other topics in ecology and environmental science.

Keywords: Science education; Sustainability pedagogy; DLMs; Thematic analysis; Ecology

Introduction

Science education in the Philippines is anchored on the UN goals on sustainability education, as provided in K to 12 Science Curriculum Guide (DepEd, 2016; SEI-DOST & UP NISMED, 2011), which envisions learners to be environmentally literate, to the extent as critical problem solvers and responsible stewards of nature. The UN Sustainable Development Goals (SDGs) related to environmental literacy include clean water and sanitation, climate action, life below water, and life on land. These goals are incorporated in one of the core topics in the science curriculum, particularly in ecology, making environmental and ecological literacy significant variables to measure proficiency in science. Environmental conservation and ecological balance are also enshrined in Republic Act 9512, known as National Environmental Awareness and Education Act of 2008, which directs the Department of Education to integrate environmental education into the curricula at all levels. Additionally, Republic Act 9729, or the Climate Change Act of 2009, was also designed to fulfil human needs while preserving the quality of the natural

environment for current and future generations.

However, challenges in science education resulted in student's insufficient understanding and awareness of environmental science and ecology (Panjaitan et al., 2021). One of these is the insufficiency of teaching materials and resources that will help to facilitate and promote the teaching and learning process (Visconde, 2015; Penalba & Janer, 2019). Sufficient teaching materials and resources need to be coupled with the quality and appropriateness of teaching and learning materials. Dizon et al. (2019) argued that instructional materials must be enhanced to make sure that the learning process is supported among students in the current curriculum.

Filipino students have poor awareness and knowledge about Philippine wildlife and conservation (Gamalo et al., 2018). Knowledge about species conservation is one of the important concepts in ecology and environmental literacy, and one of the predictors in measuring scientific literacy. The Programme for International Student Assessment (PISA) measures scientific literacy based on the use of scientific knowledge to identify questions, acquire new knowledge, explain scientific phenomena, and draw evidence-based conclusions about science-related issues. These science-related issues include ecological issues such as species extinction. According to the PISA results in 2018, almost no student in the Philippines attained level five or six proficiency in science, who can creatively and autonomously apply their knowledge of and about science to a wide variety of situations. This lack of proficiency is also reflected in the results of the National Achievement Test administered to secondary learners in 2015, which revealed a mean percentage score of 57.11% in science, far below the target passing rate of 75% (Logmao, 2019). In the context of the study locale, as reflected in students' written works on ecology modules, grade 8 students got an average rating of 67.45%, which indicates poor understanding and appreciation of ecological concepts.

Hence, improving student's awareness, attitudes, beliefs, and behaviours is significant and necessary through the further integration of environmental and ecological education (Reyes, 2014; Schleicher, 1989; Howard, 2000). Ecological and environmental education should be holistic through learning activities that are reflective and integrative to hone students to be responsible stewards of nature (Ardoin and Heimlich, 2021). Thus, this study focused on developing supplementary learning materials in ecology, as according to Arga and Rahayu (2019), environment-based learning resources improved the eco-literacy of students. The study utilised sustainability pedagogy in developed learning materials in ecology, specifically covering (1) species, (2) species diversity, (3) energy in an ecosystem, (4) matter in an ecosystem, and (5) ecological footprint.

Sustainability pedagogy incorporates issue-based learning, sustainability-themed approach, contextualized, and reflective learning. Issue-based learning was used in this study as Ke et al. (2020) found out that issue-based learning work to be relevant, interesting, promoting agency, and beneficial for their science learning. Issue-based learning also has been found to improve students' learning outcomes both in the aspect of mastery of concepts and problem-solving skills (Kamaludin et al., 2018). Sustainability-themed approach was based on the study Burns (2013) that increases learners' systemic/thematic understanding of the relationships between complex sustainability issues. Contextualized feature was used as it caters to reflection and relational understanding of sustainability issues in different areas, thus, students find personal meaning and relevance in learning locally (Singleton, 2015). Lastly, reflective learning was used as it has been showed that conceptual understanding, critical thinking,

and problem-solving skills significantly improved with its use.

The study developed learning materials using sustainability pedagogy, an approach that incorporates sustainability themes, real-world ecological issues, local settings, and reflective activities, to enhance the competence of students in ecology. Specifically, it sought to answer the following research questions:

1. How can sustainability pedagogy be applied to develop learning materials in ecology with the following features: (a) issue-based, (b) sustainability-based, (c) contextualized, and (d) reflective?
2. What are the expert's evaluations on the developed learning materials in ecology in terms of: (a) content, (b) format, (c) presentation and organisation, (d) accuracy and up-to-date information, and (e) features of the developed learning materials?
3. What are the student's experiences in using the developed learning materials on ecology utilising sustainability pedagogy? and

What modifications may be done to improve the learning materials based on: (a) students' experiences, (b) expert's evaluations?

Methodology

Developmental research design was used in this study. Developmental research is a systematic study of designing, developing, and evaluating instructional products that meets internal consistency and effectiveness criteria (Richey, 1994). This approach offers researchers the chance to answer the research questions.

Instrument

The study used an Evaluation Tool on the Developed Learning Materials, an adapted four-point Likert scale evaluation tool aimed to determine the validity and presence of features of sustainability pedagogy in the developed learning materials. This tool was adopted to the DepEd's LRMDS for the evaluation of print resources (DepEd, 2016), and added researcher-made criteria and indicators to evaluate the validity and presence of features of the developed learning materials. Experts evaluated the developed learning activities based on content, format, presentation and organisation, accuracy and up-to-date information, and features of the developed learning materials. The reliability of the instrument gained a Cronbach's alpha of 0.99.

Researcher-made Journal Guide Questions were used to determine the experiences of students when performing each of the developed learning activities. The journal determined the interests, realisations, clarifications, and proposed modifications of students in the developed learning activities. The reliability of the instrument obtained a Cronbach's alpha of 0.94.

Sample

Thirty-eight (38) purposively selected Grade 8 students of Sorsogon National High School were the respondents in this study. Sorsogon National High School was chosen as the ecological issues that will be used in the learning materials is contextualized in Sorsogon and it represented the various characteristics of different public schools in the country, especially in terms of curricular offerings. Grade 8 students were selected because Biology subjects, especially ecology competencies, are offered in the fourth quarter. In addition, students were already grouped into sections prior to its implementation that made the conduct of the study more natural and less obtrusive since the students' groupings will remain the same. Furthermore, the study needs heterogeneously grouped students with interest in learning biology to gather more responses in the pilot test of the developed learning materials as it will include reflective activities.

Ten (10) purposively selected pool of experts evaluated the developed learning materials. Teacher respondents assessed the

content, format, presentation and organisation, accuracy and up-to-date information, and features of the developed learning materials. Teacher respondents were selected based on two qualifications: (a) preferably holding master's degree in biology, science education, educational management, or any related fields, and (b) possessing three or more years of professional experience in teaching Biology or Science or working as an instructional or educational developer.

Data Collection

Phase 1 – Design and Development.

The researcher reviewed the grade 8 science module, specifically the topics of ecology located in the last part of the module to determine where to integrate the features, issues that were used related to the topic, and to identify other opportunities to enhance the module. DepEd orders and regional memorandum orders were also reviewed and utilised to support the integration of the features. Likewise, the most essential learning competencies adopted, considering the pandemic were reviewed and incorporated into the learning materials. The learning materials in ecology that were developed utilised sustainability pedagogy with features including sustainability-themed, issue-based, contextualized, and reflective. Specifically, the learning activity have parts such as: (a) core ecological issue, (b) learning objectives, (c) list of terminologies, (d) sustainability focus (e) contextualized ecological issue (f) practice task 1, (g) practice task 2, (h) practice task 3, (i) reflection (j) rubric (if necessary), (k) references.

Phase 2 – Evaluation.

The Experts' evaluation sheet was used to evaluate the developed learning materials utilising sustainability pedagogy. The experts evaluated the developed learning materials based on content, format, presentation and organisation, accuracy and up-to-date information, and features.

Phase 3 – Implementation.

The aim of the pilot testing was to gather the response and experiences of students in performing the activity which served as the basis for the modifications of the introduced learning materials. Each learning material was answered by students in a span of one week due to the current educational system, it was collected and analysed every week until all learning materials were done. After that, journal guide questions were distributed to capture the experiences of students in answering and performing the developed learning activities in ecology utilising sustainability pedagogy. Finally, focus group discussion was administered for a post implementation interview of the study to student-respondents through Google meet calling.

Phase 4 – Modification.

Learning materials were modified based on the responses of students in journal and experts' comments and suggestions. Further, learning materials were modified, which may be replacement, removal, or addition of concepts or any parts in the learning materials.

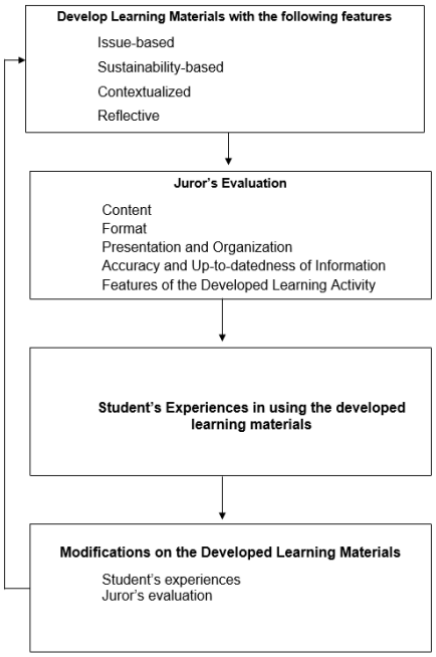
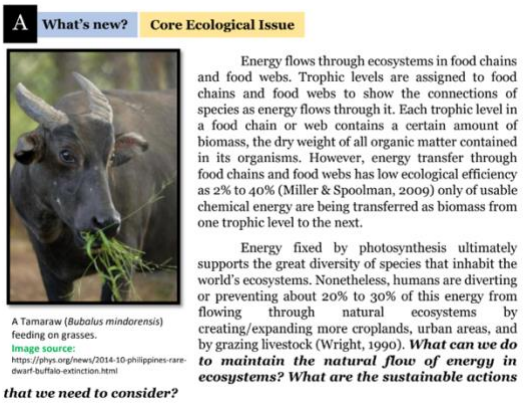


Figure 1. Summary of data collection procedure.

Results and Discussion

Learning Materials Utilising Sustainability Pedagogy

Learning materials utilising sustainability pedagogy were developed based on the DepEd Regional Memorandum No. 51, Series of 2020, which includes a learning activity sheet sample and suggested template. However, a notable difference between the DepEd format and the format of the developed learning materials in ecology is the inclusion of the introduced features, that is, the core ecological issue, suggested sustainable actions, contextualised ecological issue, and reflection.


A What's new? Core Ecological Issue

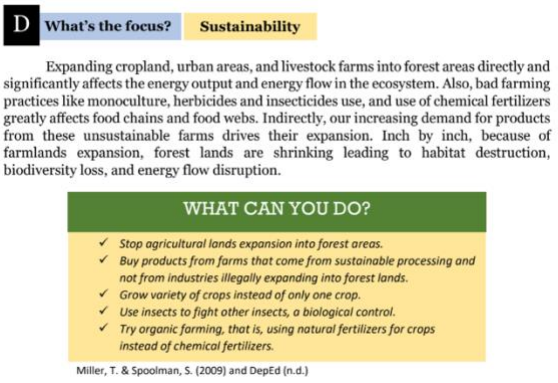
A Tamaraw (*Bubalus mindorensis*) feeding on grasses.
Image source:
https://phys.org/news/2014-10-philippines-rare-dwarf-buffalo-extinction.html

Energy flows through ecosystems in food chains and food webs. Trophic levels are assigned to food chains and food webs to show the connections of species as energy flows through it. Each trophic level in a food chain or web contains a certain amount of biomass, the dry weight of all organic matter contained in its organisms. However, energy transfer through food chains and food webs has low ecological efficiency as 2% to 40% (Miller & Spoolman, 2009) only of usable chemical energy are being transferred as biomass from one trophic level to the next.

Energy fixed by photosynthesis ultimately supports the great diversity of species that inhabit the world's ecosystems. Nonetheless, humans are diverting or preventing about 20% to 30% of this energy from flowing through natural ecosystems by creating/expanding more croplands, urban areas, and by grazing livestock (Wright, 1990). ***What can we do to maintain the natural flow of energy in ecosystems? What are the sustainable actions that we need to consider?***

Figure 2. Excerpt from the developed learning material 1, showing the issue-based feature.

Figure 2 shows the first feature that was utilised in the developed learning materials. It was issuing based learning where it uses ecological issues to stress out the need to study ecology, to justify the importance of protecting species, biodiversity, ecosystems, and personal behaviours relative to the environment and to get students' interests in the learning materials. The inclusion of this feature to the developed learning material is based on the study that problems in the environment have a correlation to the biological concepts, especially, ecology, conservation, and extinction issues (Presley et al., 2013). According to the result of the study of Kamaludin et al. (2018), issue-based teaching materials has been proven to improve students' learning outcomes. Improved students' learning outcomes happens as students will be engaged to learn if the source of learning is a phenomenon or issue in their environment (Elder, 2015).


D What's the focus? Sustainability

Expanding cropland, urban areas, and livestock farms into forest areas directly and significantly affects the energy output and energy flow in the ecosystem. Also, bad farming practices like monoculture, herbicides and insecticides use, and use of chemical fertilizers greatly affects food chains and food webs. Indirectly, our increasing demand for products from these unsustainable farms drives their expansion. Inch by inch, because of farmlands expansion, forest lands are shrinking leading to habitat destruction, biodiversity loss, and energy flow disruption.

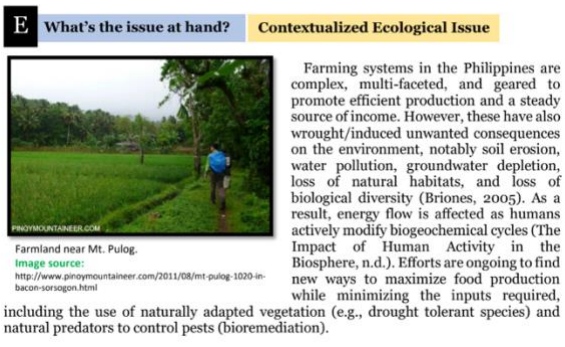
WHAT CAN YOU DO?

- ✓ *Stop agricultural lands expansion into forest areas.*
- ✓ *Buy products from farms that come from sustainable processing and not from industries illegally expanding into forest lands.*
- ✓ *Grow variety of crops instead of only one crop.*
- ✓ *Use insects to fight other insects, a biological control.*
- ✓ *Try organic farming, that is, using natural fertilizers for crops instead of chemical fertilizers.*

Miller, T. & Spoolman, S. (2009) and DepEd (n.d.)

Figure 3. Excerpt from the developed learning material 1, showing the sustainability-themed feature.

The sustainability-themed feature show in figure 3, provided students with ideas on what they can do to change their practices towards sustainability that aims to protect the ecosystem and the biodiversity. It encourages students to conserve and protect biodiversity through simple changes in actions, such as buying products from farms that employ sustainable processing, which could have a great impact in the environment. Buying and consuming sustainably produced products shows care for the environment (Wojciechowska-Solis & Barska, 2021). A Sustainability-themed approach promotes the development of the knowledge, skills, understanding, values, and actions needed to make a sustainable community (Laurie et al., 2016). Similarly, it increases a learner's systemic understanding, enhances civic responsibility, and creates transformative learning experiences (Burns, 2011).


E What's the issue at hand? Contextualized Ecological Issue

Farmland near Mt. Pulog.
Image source:
http://www.pinoymountaineer.com/2011/08/mt-pulog-1020-in-bacon-sorsogon.html

Farming systems in the Philippines are complex, multi-faceted, and geared to promote efficient production and a steady source of income. However, these have also wrought/induced unwanted consequences on the environment, notably soil erosion, water pollution, groundwater depletion, loss of natural habitats, and loss of biological diversity (Briones, 2005). As a result, energy flow is affected as humans actively modify biogeochemical cycles (The Impact of Human Activity in the Biosphere, n.d.). Efforts are ongoing to find new ways to maximize food production while minimizing the inputs required, including the use of naturally adapted vegetation (e.g., drought tolerant species) and natural predators to control pests (bioremediation).

Figure 4. Excerpt from the developed learning material 1, showing the contextualized ecological issue feature.

The developed learning materials presented ecological issues that have occurred or reported locally, presented issues in the community that induce social and environmental engagement among students, as well as use illustrations/images that are taken or can be observed locally which makes competencies meaningful, relevant, and useful to all learners. The appearance of this feature is displayed in figure 4. Contextualized learning caters meaningful learning in such a way that the content makes sense to student on their own frames of reference, encouraging deeper reflection and a sense of belonging to create a holistic understanding of sustainability (Singleton, 2015; Woodhouse & Knapp, 2000).

The last feature introduced is reflective which enables students to reflect on their own current actions, practice self-assessment, provide them the opportunity to change their actions and values towards sustainability, and encourage them to speak up on the ecological issues presented, as shown in Figure 5. The five developed learning materials include questions on students' realisation after answering the learning activities. Reflective learning was proved to be an effective means of developing student's environmental sensitivity and decision-making skills (Guerrero, 2017).

Expert's Evaluation on the Developed Learning Materials

The five developed learning materials obtained passing rates in all criteria, including content, format, presentation and organisation, and accuracy and up-to-date information, as stipulated in the DepEd Guidelines and Processes for LRMDS Assessment and Evaluation (DepEd, 2016).

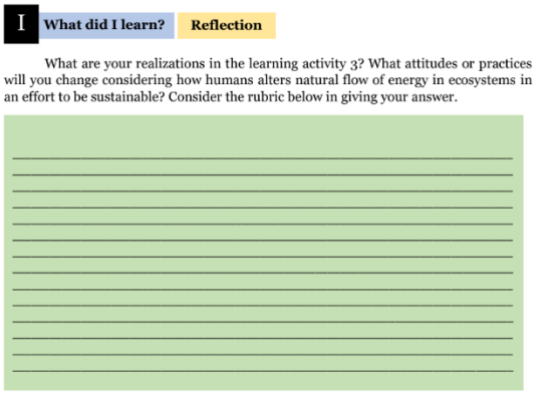


Figure 5. Excerpt from the developed learning material 1, showing the reflective feature.

Table 1. Summary of Experts' Evaluation on the Developed Learning Materials Utilising Sustainability Pedagogy

Criteria	Points to pass (DepEd, 2009)	LM1[a]	LM2	LM3	LM4	LM5	Over-all Rating
Content	At least 21 of 28	26.5	27.5	27.3	27.4	27.4	27.22
Format	At least 54 of 72	68.4	70.7	70	67.8	71.9	69.76
Presentation and Organisation	At least 15 of 20	18.5	19.1	19.4	19.2	20	19.24
Accuracy and Up-to-date Information	At least 18 of 24	23	23.4	23.2	23.4	23.7	23.34

Note: [a]Learning Materials

Content. Notably, in terms of content, LM1 to LM5 are excellent in terms of materials having free from ideological, cultural, racial, religious, and gender biases as well as prejudices (mean = 3.96). The findings suggests that the content of the developed learning materials is fairly presented relative to social and cultural norms, resulting in the students to have a positive outlook towards the developed learning materials and gaining learners' interest (DepEd, 2016). As noted by the Council of Europe (2022), educators should recognize the need to develop in every person a tolerant, non-discriminatory attitude, and create a learning environment that acknowledges and benefits from diversity through the incorporation of intercultural learning into the learning materials. However, the relatively low rating on the suitability for students' level of development is transparent with the comments of the experts, which suggests a need, *define and distinguish the terms used in the learning materials (5), provide adequate and suitable discussion of concepts to properly scaffold the students (7), provide examples and further discussion of concepts (7).* These comments were used to clearly point out the concepts, guide students for better understanding, and be able to thoroughly discuss the concepts for students to learn meaningfully in the learning materials and to equip students with adequate concepts before they perform the activities.

Format. Regarding the format of the developed learning materials, the data suggests that the size of letters of the developed learning materials is appropriate to the intended user, spaces between letters and words facilitate readability, fonts are easy to read, and print quality is high (cumulative mean = 15.5). The data imply that the developed learning materials are attractive, simple, with adequate illustration in relation to text, and there is a harmonious blending of elements. As underlined by Marinelli et al. (2013), well-written and well-designed learning materials are an important predictor of student learning. As what Shanahan (2020) pointed out, reading instruction should intentionally place students in situations in which their understanding of a text will depend upon their ability to surmount some particular conceptual or linguistic barriers. Despite these findings, there is still a need to improve the format of the developed learning materials based on the comments of the experts. Experts suggested *bold and italicize appropriate words and phrases (8), indent sentences (4), and contextualize images used (7).*

Presentation and Organisation. As to the presentation and organisation, the learning materials are very satisfactory in terms of length of sentences that are suited to the comprehension level of the target reader (mean = 3.9). The data indicates that the complexity of sentence patterns typically used is considered and simplified by omitting connections between ideas, which may reduce the user's ability to make meaning (DepEd, 2016). Similarly, the result of the study of Duncan et al. (2021) demonstrated that students use their understanding of sentences, for which they have gained a strong foundation through oral language to springboard into reading for understanding. Based on the comments of the jurors, there is still a need to *provide a brief introduction in all of the developed learning materials (2), sentences/concepts should be presented in a more positive* approach *(2), Give clear directions in the activity (8)*. These comments entail modifications of the developed learning materials to better present the concepts and activities.

Accuracy and up to date of Information. Finally, the accuracy and up-to-date information notably depict that the developed learning materials have no obsolete information (mean = 3.94). The rating on the accuracy and up-to-date information also indicates that the developed learning materials require slight improvements in the grammatical usage, as the jurors observe *minor grammatical errors (7).*

Table 2 Summary of Experts' Evaluation Relative to the Features of the Developed Learning Materials

Criteria	LM1	VI[a]	LM2	VI	LM3	VI	LM4	VI	LM5	VI	Overall mean	VI
Features of the Developed Learning Activity												
Sustainability-themed	3.85	VS[b]	3.98	VS	3.9	VS	4	VS	3.95	VS	3.94	VS
Issue-based	3.98	VS	3.95	VS	3.88	VS	3.9	VS	3.98	VS	3.94	VS
Contextualized	3.78	VS	3.93	VS	3.85	VS	3.78	VS	3.98	VS	3.86	VS
Reflective	3.9	VS	3.83	VS	3.95	VS	3.8	VS	3.95	VS	3.88	VS

Note: [a]Verbal Interpretation
[b]Very Satisfactory

Relative to *sustainability-themed*, a very satisfactory rating was obtained by the indicator, which states that the suggested sustainable actions are simple, doable, and relevant to the ecological issues (mean = 3.92). Suggested sustainable actions present what students can do to preserve and conserve biodiversity and their interactions. Similarly, according to UNESCO as reported by Leicht, A., Heiss, J., and Byun, W. J., (2018), the concept of teaching and learning must be transformed to enable individuals to lead sustainable development as agents of change. The inclusion of sustainability-themed is also convergent with the vision of the K to 12 curriculums to develop students to be environmentally literate and responsible stewards of nature (DepEd, 2016).

Regarding *issue-based* features, it can be inferred that the indicator, ecological issues/problems are evident in developed learning activities, obtained a very satisfactory rating (mean = 4). This means that the learning activity uses ecological issues that stimulate student's interest and promote critical thinking skills through questions. The ecological issue questions are clear and relevant to the ecological issue presented. Problem-based learning promotes critical thinking skills and creative thinking skills (Orozco and Yangco, 2016). In support of this, it could improve students' learning outcomes, both in the aspect of mastery of the concepts and problem-solving skills (Kamaludin, 2018). Hence, developing learning materials based on issues in students' environment will encourage them to explore ecological concepts.

Concerning to the *contextualisation* of the developed learning materials, ecological issues used in the learning activity that have occurred or reported locally are very satisfactory (mean = 3.88). The contextualised ecological issue makes competencies relevant, meaningful, and useful to all learners. According to the DepEd Order No. 32, s. 2015, the educational process should relate to a particular setting, situation, or application area to make the competencies relevant, meaningful, and useful to the learners. Contextualised learning (Singleton, 2015; & Woodhouse & Knapp, 2000), caters meaningful learning in such a way that it makes sense to them on their frames of reference, encourages deeper reflection and sense of belonging to create a holistic understanding of sustainability.

Finally, the developed learning materials are very satisfactory result relative to the *reflective* nature of the learning materials. The learning activity enables the students to reflect on their current actions. The learning activity allows learners to practice metacognition or self-assessment through reflection. This is supported by Guerrero (2017) who points out that reflective learning has proved to be an effective means of developing student's environmental sensitivity and decision-making skills. Furthermore, this is consistent with the conclusion of Oates (2014) that learning materials should guide learners to reflect on what they are learning.

Aside from the validity of the developed learning materials as evaluated by experts, the *inter-rater reliability of ratings*

by the experts was also established. The experts on the five developed learning materials are very reliable with a mean Cronbach alpha of 0.91. This data suggests that the ratings the experts are in consonance to each other, consistent, and they agree on their assessment on different points, specifically, relative to the content, format, presentation and organisation, accuracy and up-to-date information, and features of the developed learning materials. The inter-rater reliability index of ratings by the experts further established the quality of the lessons, validity and fitness for classroom integration and implementation (Cajurao, 2019).

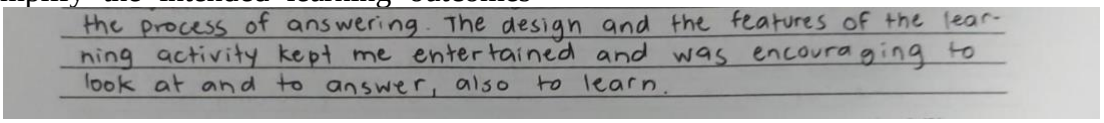
Student's Experiences on the Developed Learning Materials

The students found the DLMs interesting, comprehensible, promote awareness, relevant to community's environmental issues, and promote critical thinking.

Table 3. Summary of Students Experiences in the Developed Learning Materials.

Theme	Experiences
Interesting	● Students were entertained and encouraged to answer the developed learning materials. ● Interested in the topic and the activities. ● Become interested in the ecological issues introduced.
Comprehensible	● Made their mind expand. ● Helped to understand species concepts. ● Don't need other devices to search for answers. ● Understood the basics of ecology and sustainability. ● Enabled the students to think critically.
Awareness	● Become aware of the issues in the environment. ● Gained knowledge on how to maintain and care for the environment.
Relevance	● Helped the students to connect with the present environmental condition in the community. ● Relate with what the students previously knew.
Express opinion	● Analysed environmental issues in the community. ● Expressed opinions on different ecological issues presented.

Interesting/Encouraging. Students showed positive responses in the learning activities suggesting their interest in the concepts and the design and features of the learning activities of the developed learning materials in ecology (Figure 6). Encouraging and interesting design of the learning activity enables the students to be engaged in and motivates them to demonstrate the objectives and competencies of the learning activity. When developing learning activities, it is important to consider the kinds of activities that students will need to engage in to exemplify the intended learning outcomes which would enable the students to practice the specific outcomes (The University of Queensland, 2022). In addition, the issue-based feature prompted and challenged the students to perform the learning activities in the developed learning materials. Issues presented in the developed learning materials keeps the students to ponder the causes, effects, and solutions of ecological issues.



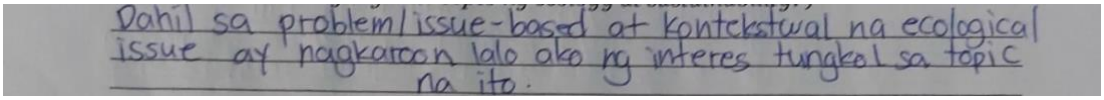


Figure 6. Sample students' journal entry saying learning activity was encouraging and interesting. (Translation: Because of the issue-based and contextualized ecological issue, I became in this topic.)

Comprehensible. The developed learning materials provided sufficient information per topic and comprehensively discussed the presented concepts, guiding the learners to understand the concepts well. Based on the journal entries, students say that *the learning materials helped me to understand species, ecology, and sustainability (10)*. Since the developed learning materials are designed to guide students in independent learning, with adequate discussion of concepts and issues, illustrations, and instructions, students easily understand and learn from the learning activities. This conforms with the idea of Kapur (2019) which explains that the availability of proper learning materials that educational institutions can render an effective contribution in achieving the desired educational objectives and promoting effective growth and development of students.

Awareness. Sustainability themed features of the developed learning materials made the students aware of their actions which are unsustainable and have an indirect negative effect on biodiversity and ecosystems (Figure 7). Learners' understanding and appreciation of the topic contributed to their awareness. Cheng, Yeh, Chao, Lin, and Chang (2020), concluded also that issue-based learning promotes students' knowledge and responsibility regarding environmental conservation.

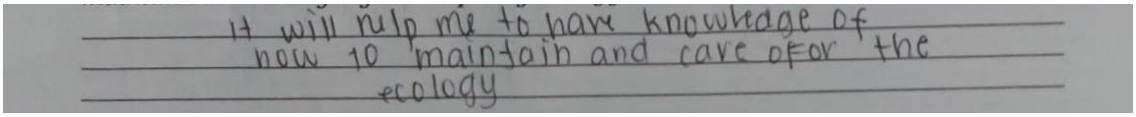


Figure 7. Sample student's journal entry showing that the learning activity helped the students to have knowledge on how to maintain and care for the environment. (*for the environment*)

Relevance. Students can relate and connect to the ecological issue presented and therefore learn meaningfully (Figure 8). In accordance with Sadler (2009), relevant issues help students increase their motivation to learn science and relate scientific content to their everyday lives. Similarly, the result of the study of González -Espada et al. (2014) showed that the contextualized activities improved the perception about science in many children.

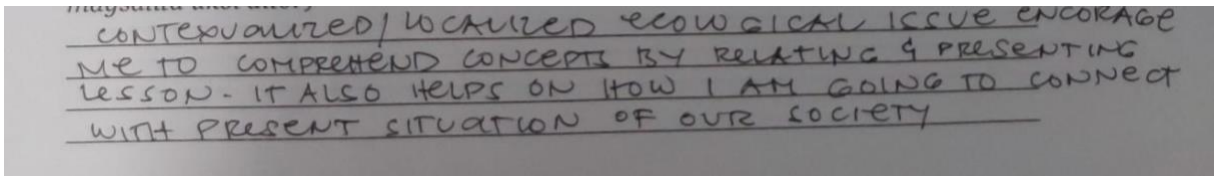


Figure 8. Sample student's journal entry showing that the learning material helped the students to connect with the present environmental condition in the community.

Express opinion. Through the reflective activity, students were able to express their opinion about ecological issues and address the challenge on how to protect and conserve biodiversity (Figure 9). The experiences of students are apparent in the findings of

Ashley et al. (2006) which suggested that reflection, on both process and content of learning, could help students move toward a deeper approach to learning. Similarly,

Colomer et al. (2020) found that reflective learning is likely to transform students' preconceived perspectives and social preferences to foster new reasoned action plans for decision-making and modify the students' beliefs, attitudes, and daily behaviour to develop competences that will ultimately result in promoting sustainability.

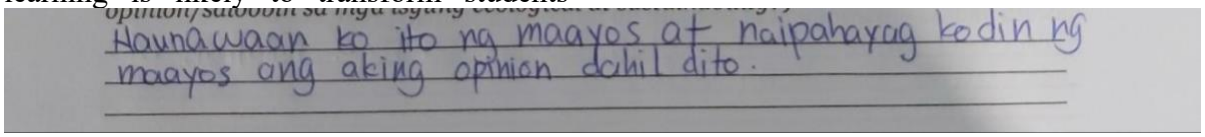


Figure 9. Sample student's journal entry showing that reflective activity helped to express learner's opinion on the issues. (*Translation: I understand it well and I expressed my opinions because of this.*)

Modifications Based on Experts' Evaluation and Student's Experiences

Comments, suggestions, and proposed modifications of the experts and the students were considered modifying of the developed learning materials. The developed learning materials need to be modified per area, i.e., introduction, objective, definition of terms, sustainability-themed, activity, and reflection. In developed learning activity 2, one of the suggestions of the experts, in terms of content, was to distinguish species diversity and biodiversity because they are used in the discussion. Distinguishing these two concepts would provide a more concrete understanding to students and limit conceptual errors. Gustiani, Widodo, and Suwarma (2017), similarly found that content and technical appropriateness are important for the students to comprehend technical terms and explain the concepts easily.

One of the experts' comments suggests changing the sentences/statements in the sustainability actions in part D to an affirmative or a more positive approach. According to Nucaro (2017), using positive words and encouraging students to meet expectations (the suggested sustainability actions) allows students to fulfil those expectations, or even surpass them. Therefore, it is important to modify the suggested sustainability actions from negative sentences to a more positive statement.

Varying comments were drawn from the journal of the students, positive and negative. Negative comments were used to modify and improve the developed learning materials to make it more relevant, appropriate, and understandable to students. Modifying and improving the developed learning materials would help to attain the objectives of the learning material, that is to enable the students to embody sustainable thinking (Kapur, 2019). Findings showed that there is a need to discuss the concepts in the developed learning materials briefly and in a way that is adapted to their level of understanding and grade level. Convergent to the study of Bar-Yam et al. (2002), the goal of education is to transmit knowledge with the goal that emphasises the development of the individual student, especially adapting the lessons or materials to students' ability levels. Students also suggested presenting more examples and more explanations in the developed learning materials. As reported by Rawson, Thomas, and Jacoby (2015), abstract concepts can be instantiated in real-world situations by presenting students with concrete examples, a common pedagogical approach for supporting learning of declarative concepts.

Conclusion

Learning materials were developed utilising sustainability pedagogy, with introduced features such as issue-based, sustainability-themed, contextualised, and reflective. The five developed learning materials are valid and passed the criteria of DepEd (Department Education) according to

LRMDS (The Learning Resources Management and Development System). Students found the developed learning materials interesting, comprehensible, promote awareness, relevant to community's environmental issues, and helped students to express their opinions. Additionally, the developed learning materials need to be modified per area, introduction, objective, definition of terms, sustainability-themed, activity, and reflection. The study recommended that the valid and modified DLMs utilising sustainability pedagogy may be used by Biology Teachers in their lessons and can still be improved and further contextualised. Sustainability pedagogy may be employed in other topics in ecology and environmental science to explore its validity and effectiveness.

Acknowledgements

Thanks to the Department of Science and Technology – Capacity Building Program for Science and Mathematics Education (DOST-CBPSME) for the funding support. Immense thanks also to Bicol University Graduate School for the guidance throughout the study. To Sorsogon National High School Science Department, especially to Mrs. Jardiolin, thank you for the cooperation and participation during the conduct of the study.

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