Development and Validation of Lessons in Ecology Integrating Concepts of Sustainable Development

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Abstract - *This study aimed to develop and validate lessons on Grade 11 ecology integrating concepts of Sustainable Development. Specifically, it aimed to develop lessons on Grade 11 ecology and subject them to experts' validation under the following criteria: a) consistency of the learning outcomes with the subject matter, b) appropriateness and relevance of integrated Sustainable Development concept, and c) congruency of objectives, activities, and evaluation. The five lessons that were developed focused on the fundamental ecological concepts such as the principles of ecosystem; biodiversity; biotic potential and environmental resistance; terrestrial and aquatic ecosystems and human ecological footprint. On the other hand, principles of Sustainable Development that were integrated into the five lessons were water conservation, biodiversity conservation; interdependency and environmental justice; ecological footprint and environmental stewardship. The developed lessons obtained an overall excellent rating from the expert jurors who evaluated them. This means that the lessons have satisfactorily met the standard and quality set forth by the Department of Education (DepEd). Meanwhile, the reliability of the rating provided by the jurors goes beyond the required standard (Gwet's AC2 = 0.942) which indicates that the jurors are in congruence regarding the consistency, appropriateness and acceptability of the developed instructional materials. The developed lessons can be utilized in teaching Grade 11 ecology and to foster awareness and positive attitudes toward sustainable development.*

Keywords: *developed lessons, grade 11 ecology, education for sustainable development*

INTRODUCTION

Unsustainable development is accelerating at the global scale and even getting worse in many countries characterized by inefficient use of energy, water scarcity, increased pollution, human rights abuses, overuse of personal transportation, unsustainable consumerism and changing climate all causing irreversible changes to our planet and our well-being [1]-[7]. The current situation is primarily driven by the people's lack of understanding and awareness to the real state of our planet diminishing ecological resources [8]. The current economic trends show that people's ways of living are not sustainable and public awareness, education and training are therefore necessary to move society towards sustainability [9]-[10].

In 2015, the United Nations (UN) adopted a new resolution entitled "Transforming our world: the 2030 Agenda for Sustainable Development" to address the continuing challenges in the implementation of Sustainable Development [11]. It can be noted from the said agenda that education is given more significant emphasis which can be read from the Goal 4.7, to wit:

"By 2030, ensure that all learners acquire the knowledge and skills needed to promote sustainable development, including, among others, through education for sustainable development and sustainable lifestyles, human rights, gender equality, promotion of a culture of peace and non-violence, global citizenship and appreciation of cultural diversity and of culture's contribution to sustainable development" (p. 17).

Hence, Education for Sustainable Development (ESD) is indeed a global agenda to promote sustainability in all learning spaces. This includes the crucial role of basic education program as knowledge and skills generators which will empower individuals to become future catalysts and critical decision makers with strong sense of promoting sustainable living practices [12]-[14].

With the advent of K to 12 Curriculum implementations in the Philippines, educators are confronted with unprecedented challenges. Among

these, is the unavailability of ready-to-use reading and teaching materials that will help facilitate the teaching and learning process in the classroom. To address such problem, the Department of Education (DepEd) urged teachers in the ground to develop and validate localized teaching and learning materials that can further enhance the learning achievement of the learners [15].

Meanwhile, the province of Masbate in the heart of the Philippines is currently affected by a myriad of environmental problems and concerns such as water scarcity and contamination, wild-life hunting driving loss to biodiversity, massive deforestation, and habitat destruction brought about clearly by lack of environmental awareness and other human activities such as irresponsible mining, kaingin and unsustainable fishing practices [16]-[21].

On the other hand, Kellert [22] and Unal and Dimiski [23] have found that secondary students particularly 8th to 11th grade students, appear to be the most appropriate targets for fostering ethical and environmental appreciation and stewardship.

Parallel to the SEAMEO INNOTECH [24] recommendation in structuring lessons for ESD, the researcher developed lessons exemplars for Grade 11 ecology integrating concepts of sustainable development such as water conservation, biodiversity conservation, carrying capacity and family planning, environmental justice and Ecological Footprint in an effort to reorient the current education and learning ecosystem so that students will be given the opportunity to acquire the knowledge, skills, values and attitudes that will empower them to contribute to sustainable community development in the province.

OBJECTIVES OF THE STUDY

Generally, the study aimed to develop and validate lessons on ecology integrating concepts of sustainable development in Grade 11 Earth and Life Science subject. Specifically, this study sought to answer the following objectives: 1) To determine the lessons in ecology that maybe developed integrating concepts of sustainable development 2) To determine the jurors' evaluation of the developed lessons in terms of: a) consistency of the learning outcomes with the subject matter; b) appropriateness and relevance of integrated sustainable development concept; c) congruency of objectives, activities, and evaluation; and 3) To examine how reliable are the ratings provided by the jurors for the developed lessons.

MATERIALS AND METHODS

Research Method

The researcher utilized a descriptive-developmental research design [25] in the development and validation of lessons in ecology integrating sustainable development concepts for Grade 11 Earth and Life Science Course. A quantitative format in data gathering was employed using a 5-point Likert Scaling Technique to examine the expert jurors' evaluation of the developed lessons.

Sources of Data

A pool of experts was selected and qualified based on their field of specialization (with masters or doctorate degree in science education and related fields), length of teaching experience (science teachers and instructors who have been teaching for five years up) and expertise on the subject matter (biology majors, environmental science majors and subject specialists). Their primary task was to determine the validity of the developed lessons integrated with concepts of sustainable development with respect to its content and pedagogy.

A total of ten (10) jurors participated in the evaluation process. The pool is composed of college professors from private and public universities as well as science teachers and subject specialists from DepEd.

Jurors were assigned into two groups; five members each group. One group composed of five jurors looked into the content validity and the other group of five jurors who scrutinized on the area of pedagogy. The content jurors are composed of four College professors, the two have Masters in Environmental Science, one has Doctorate degree in Educational Foundation, and the other one has Master's degree in Biology and the last one from DepEd who has earned a Master's Degree in Teaching Biology.

On the area of pedagogy, there were two College Professors, one has Doctorate Degree in Education and the other one has Master's in Educational Management; two Senior High School Science teachers, both have Master's degree in Educational Management and have taught Biology for more than five years. The last juror was a DepEd subject specialist who has a Doctorate Degree in Educational Management and has also been teaching science for more than five years.

Instrument

To determine the assessment of expert jurors of the developed lessons, the researcher developed a measurement tool called the Juror's Evaluation Sheet (*see Appendix A*) anchored on DepEd standards and guidelines for lesson development and evaluation. The assessment tool was developed using a 5-point Likert Scale and contains three main criteria and twelve sub-criteria. The criteria in the said assessment tool include: a) consistency of the learning outcomes with the subject matter, b) appropriateness and relevance of integrated Sustainable Development concept, and c) congruency of objectives, activities, and evaluation.

The 5-point Likert scale that was used in the evaluation process and their verbal interpretation is shown below: 4.50 – 5.00: Excellent (shows the criterion/item is extremely evident); 3.50 – 4.49: Very good (shows the criterion/item is very evident); 2.50 – 3.49: Good (shows the criterion/item is evident); 1.50 – 2.49: Fair (shows the criterion/item is slightly evident); 1.00 – 1.49: Poor (shows the criterion/item is not evident)

Lesson development integrating sustainable development concepts

In the development of the lessons, the researcher followed the ADDIE Model [26]-[28] in designing and developing the lessons. The ADDIE model is a systematic instructional design model consisting of five phases: (1) Analysis, (2) Design, (3) Development, (4) Implementation, and (5) Evaluation. It is a strategic plan for course design and may serve as a road map to design course assignments and various other instructional activities. One advantage of this model is the use of rapid prototyping, the idea of receiving continual or formative feedback while instructional materials are being created.

Data Gathering Procedure

During the actual conduct of the study, a series of events were carefully planned and were followed accordingly. First, a letter request was sent to the identified expert jurors to ask assistance in the validation of the developed lessons. Those who agreed to participate were provided with the copies of developed lessons and the Juror's Evaluation Sheet (JES) which contains the criteria for evaluation.

After the jurors' evaluation of the developed lessons, the copies of the lessons were retrieved and revisions were immediately carried out to incorporate all the substantial comments, suggestions and recommendations from the expert jurors. Ratings provided by the experts were recorded and analyzed in Excel. The degree of agreement among the jurors' ratings relative to the developed lessons was examined using the Gwet's Agreement Coefficient (AC2) [29].

The names, affiliations and individual ratings provided by the expert jurors were treated with outmost confidentiality.

Statistical Treatment

Weighted means were calculated to justify the jurors' overall evaluation of the developed lessons. A 5-point Likert Scaling technique was employed to quantify the jurors' rating. Gwet's Agreement Coefficient (AC2) was calculated to determine the degree of agreement on the ratings provided by the jurors.

RESULTS AND DISCUSSION

Developed lessons on interaction and interdependence integrating concepts of sustainable development

The K to 12 Basic Education Curriculum Guide for Earth and Life Science Course designed for Grade 11 learners was the basis for developing lessons in ecology integrated with sustainable development concepts.

The five lessons developed were: Lesson 1) Ecosystem: The Principles Within; Lesson 2) Biodiversity: Stability in the Diversity of Life; Lesson 3) Biotic Potential and Environmental Resistance: Limiting Population Growth; Lesson 4) Terrestrial and Aquatic Ecosystems: Interconnectivity in the Biosphere; and Lesson 5) The Ecological Footprint: Assessing Human Environmental Impact.

The learning competencies as well as the content and performance standards for the said unit of the course curriculum served as the guiding principles in crafting each of the five lessons. Lesson 1 and Lesson 2 were founded on the content standard no. 1 which intended to develop learners' understanding of the principles of ecosystem. Lesson 3 was constructed based on the content standard no. 2 aimed to develop students' understanding of biotic potential and environmental resistance. Lesson 4 was grounded on content standard no. 3 meant to cultivate the students understanding of the interconnectivity between terrestrial and aquatic ecosystems. Lastly, Lesson 5 was aligned on the content standard no. 4 of the unit which is aimed to develop students understanding of how human activities affect the natural ecosystem.

Each lesson exemplar was designed according to the lesson plan structure recommended by SEAMEO INNOTECH (2010) with the addition of extension part which will allow learners to extend learned concepts and ideas beyond the classroom. The said structure is composed of five salient parts: 1) Lesson objectives; 2) Starter activity; 3) Main lesson content; 4) Suggested class activities; and 5) Plenary. The starter activity was designed to elicit prior knowledge, identify misconceptions and at the same time to draw interest and curiosity of the students towards the lesson. It is also during this part that the lesson objectives are to be shared with the students. The main lesson content is where the subject matter is delivered and discussed with the students. It was delivered in a participatory manner where the teacher was not the center of the discussion and the only one who talked throughout the duration of the class. Students interacted by asking questions and shared important ideas and valuable insights relevant to the topic. For the suggested class activity, students were given the opportunity to apply what they have learned into various situations and tasks that required them to deal with real-life ecology and sustainability issues. They were also given the chance to showcase their outputs and findings in front of the class. Extension activities were given as homework to further enhance students' retention and conceptual understanding.

Finally, before the class ends, students were allotted a time for reflection (plenary) on the day's lesson and how it was carried out. This was done by allowing the students to answer open-ended questions in the student's journal. At the same time, students during this time assessed the level of their understanding on the lesson presented and for teachers to evaluate their performance in class using scoring rubrics. The plenary also gave the teacher valuable insights into the state of his or her lesson delivery and enable the students to recall and retain a greater part of the lesson tackled.

Likewise, the developed lessons were fortified with varied instructional activities such as small-group discussions; video presentations using multi-media; inquiry-driven activity worksheets, outdoor activities, and research works as extension activities. Authentic assessment strategies using scoring rubrics and students' written journals were also employed in evaluating students' performance and academic achievement during the conduct the five lessons.

Jurors' evaluation of the developed lessons

The validity of the five lessons was confirmed by the expert jurors (n=10) as shown in Table 1 which obtained an over-all rating of 4.69 which can be verbally interpreted as Excellent. This implies that the five developed lessons have excellently meet the criteria specified in the evaluation sheet and they were found to be extremely evident all throughout. Hence, the result supported the validity and appropriateness of the developed lessons for implementation.

Accordingly, the result conforms to the recommendations of [25] which argued that developed instructional materials must meet the criteria of internal consistency and content validity prior to implementation to ensure that the material passed the required standard and quality.

Table 1. Summary of jurors' evaluation of the five developed lessons on interaction and interdependence integrated with sustainable development concepts (n=10)

Lesson	Consistency of the learning outcomes with the subject matter		Appropriateness and relevance of integrated Sustainable Development concept		Congruency of objectives, activities, and evaluation		Over-all Rating	
	WM	VI	WM	VI	WM	VI	WM	VI
1. Ecosystem: The Principles Within	4.63	EX	4.55	EX	4.73	EX	**4.64**	**EX**
2. Biodiversity: Stability in the Diversity of Life	4.73	EX	4.63	EX	4.68	EX	**4.68**	**EX**
3. Biotic Potential and Environmental Resistance: Limiting Population Growth	4.73	EX	4.63	EX	4.68	EX	**4.68**	**EX**
4. Terrestrial and Aquatic Ecosystems: Interconnectivity in the Biosphere	4.78	EX	4.65	EX	4.70	EX	**4.71**	**EX**
5. The Ecological Footprint: Assessing Human Environmental Impact	4.78	EX	4.78	EX	4.70	EX	**4.75**	**EX**
Average	**4.73**	**EX**	**4.65**	**EX**	**4.70**	**EX**	**4.69**	**EX**

WM: Weighted Mean; VI: Verbal Interpretation; EX: Excellent

Table 2. Summary of jurors' evaluation on the consistency of the learning outcomes with the subject matter (n=10)

Criteria	Lessons					WM	VI
1. Consistency of the Learning Outcomes with the Subject Matter	L1	L2	L3	L4	L5		
1.1. The learning outcomes are specific, clearly stated, obtainable and measurable.	4.70	4.80	4.80	4.80	4.80	4.78	EX
1.2. The learning outcomes build on one another in a developmental continuum.	4.60	4.80	4.70	4.80	4.80	4.74	EX
1.3. The learning outcomes are anchored in the course curricular context and content of the lesson.	4.60	4.70	4.70	4.80	4.70	4.70	EX
1.4. The learning outcomes depict the element of sustainable development it is focusing with.	4.60	4.60	4.70	4.70	4.80	4.68	EX
Average Weighted Mean	**4.63**	**4.73**	**4.73**	**4.78**	**4.78**	**4.73**	**EX**

L1-L5: Lesson 1 to Lesson 5; WM: Weighted Mean; VI: Verbal Interpretation; EX: Excellent

Consistency of the learning outcomes with the subject matter. One good feature of an excellent lesson exemplar is the consistency of the learning outcomes with the subject matter [30]-[31]. As shown in Table 2, an overall rating of 4.73 from the expert jurors for the developed lessons was obtained which can be interpreted as Excellent rating. This shows that the learning goals and objectives are extremely evident in each of the five lessons and are consistent with the subject matter being discussed.

Specifically, an excellent rating (4.78) on the attainability, measurability and the clarity of the learning outcomes was obtained. This only shows that the stated learning outcomes in each of the five lessons were attainable, realistic, clear and measurable by both the teachers and the students. Similarly, the increasing complexity of the learning outcomes was also extremely evident (4.74). This means that the learning outcomes build upon each other in an increasing difficulty that challenge the learners' higher order thinking skills or HOTS. The jurors likewise found that the learning outcomes of each of the five lessons are grounded in its curricular context and content which was rated excellently with 4.70 rating. The rating only shows that the learning outcomes is in consonance with the learning standards and competencies as stipulated in the curriculum guide the DedEd provides. Additionally, these results are vital, since it is important that the learning outcomes must not deviate or move away from the context of the lesson to make it relevant and meaningful in evaluating student's achievement after the lesson delivery [30].

Similarly, the jurors attested that the learning outcomes depicted the element of sustainable development it is focusing on which obtained an overall rating of 4.68 from the jurors, which can be verbally interpreted as excellent. This only shows that the integrated concepts of sustainable development are extremely evident throughout the five lessons and were given emphasis in the learning outcomes of the lesson. Svanström, Lozano-Garcia and Rowe [32] clarified that it is important that the students understand, appreciate and shall be able to demonstrate the acquired concepts thoroughly.

Table 3. Summary of jurors' evaluation on the appropriateness and relevance of integrated sustainable development concept (n=10)

Criteria	Lessons					WM	VI
2. Appropriateness and relevance of integrated Sustainable Development concept	L1	L2	L3	L4	L5		
2.1. The integrated Sustainable Development (SD) concept is appropriate, recent, clear, and locally relevant.	4.50	4.60	4.70	4.70	4.80	4.66	EX
2.2. The integrated SD concept is suited to the subject matter/topic being implemented.	4.70	4.60	4.70	4.70	4.80	4.70	EX
2.3. The lesson allows the students to deal with real-life sustainability issues and challenges.	4.50	4.70	4.60	4.60	4.70	4.62	EX
2.4. The lesson provides opportunities for students to explore possible solutions to address sustainability issues.	4.50	4.60	4.50	4.60	4.80	4.60	EX
Average Weighted Mean	**4.55**	**4.63**	**4.63**	**4.65**	**4.78**	**4.65**	**EX**

L1-L5: Lesson 1 to Lesson 5; WM: Weighted Mean; VI: Verbal Interpretation; EX: Excellent

Appropriateness and relevance of integrated sustainable development concept. As shown in Table 3, the expert jurors confirm that the importance and appropriateness of integrated sustainable development concept/s in the five lessons were extremely evident and were generally rated 4.65, which can be interpreted as Excellent.

Hence, the result implies that the integrated sustainable development concepts in the developed lessons were all treated as locally relevant and essential not only to the subject matter but more especially to the current trends in the society wherein the environmental issues and concerns are very alarming and environmental education is therefore necessary. This is in consonance with findings of Hopkins and McKeown [8] which stressed the importance of the appropriateness and relevance of principles, skills, perspectives, and values related to sustainability are vital in the effective integration of ESD in the curriculum and often results to desirable outcomes.

Therefore, integrated concepts such us water conservation, conservation of local biodiversity, family planning, environmental stewardship and ecological footprint were all practically relevant to the learners and essentially observed the need of the society to counteract environmental problems and concerns. Having found to be extremely evident, the jurors gave an over-all rating of 4.66, which is interpreted as Excellent rating. This only shows that the integrated concepts were all necessary, relevant, recent and generally known to the learners. It is also worthy to note that most of these expert jurors were natives of Masbate, hence they are practically aware of the issues being raised.

Moreover, the excellent rating of 4.70 obtained from the jurors also shows that the information was presented clearly and there is a strong connection between concepts of ecology and principles of sustainable development as revealed in each of the five lessons.

Arguably, the results confirm that the lessons were developed in such a way that they allow students to deal with real life sustainability issues and concerns for them to acquire first-hand information about those issues and the problems surrounding them and be able to think critically of possible long-term solutions to confront them [33]-[34].

Congruency of objectives, activities, and evaluation. Andrews [35] and Smith and Ragan [36] argued that in developing instructional materials, it is important to make sure that the lesson objectives, activities and evaluation tools are in congruence and consistent with one another. Accordingly, as shown in Table 4, the developed lessons on ecology have been found that its learning objectives, instructional activities and evaluation strategies are in congruent with one another which obtained an over-all rating of 4.70 from the expert jurors which can be verbally interpreted as Excellent rating.

The consistency of the lesson content with the stated objectives and the attainability of the learning objectives was extremely evident among the five lessons as confirmed by the jurors with an overall rating of 4.72 which is interpreted as Excellent rating. This shows that the lesson objectives are in congruence with the content of the lessons and that these learning objectives are attainable by the students' level and development and measureable among the teachers. Similarly, an excellent rating (4.72) of the jurors attested that the learning objectives in each lesson are aligned with the instructional activities and assessment employed therein.

Table 4. Summary of jurors' evaluation on the congruency of objectives, activities, and evaluation (n=10)

Criteria	Lessons					WM	VI
3. Congruency of Objectives, Activities, and Evaluation	**L1**	**L2**	**L3**	**L4**	**L5**		
3.1. The lesson content relates directly to the stated objectives and is likely to accomplish them.	4.70	4.80	4.60	4.70	4.80	4.72	EX
3.2. The learning objectives are aligned with the instructional activities and assessment.	4.70	4.70	4.70	4.80	4.70	4.72	EX
3.3. The learning objectives depict the three domains of learning (cognitive, psychomotor and affective).	4.80	4.60	4.70	4.70	4.70	4.70	EX
3.4. The type of assessment employed is in congruence with the learning objectives.	4.70	4.60	4.70	4.60	4.60	4.64	EX
Average Weighted Mean	**4.73**	**4.68**	**4.68**	**4.70**	**4.70**	**4.70**	**EX**

L1-L5: Lesson 1 to Lesson 5; WM: Weighted Mean; VI: Verbal Interpretation; EX: Excellent

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Furthermore, the learning objectives along the five lessons were found to depict the three domains of learning (cognitive, psychomotor & affective) which was generally rated 4.70 by the jurors, which can be interpreted as Excellent rating. The result shows that the three learning domains [37] were covered and considered in creating the learning objectives in each lesson so as to develop the students' mental skills, attitude as well as the physical or motor skills.

And lastly, the type or mode of assessment employed in each of the lessons was in congruence with the stated learning objectives which was rated excellently (4.64) by the expert jurors for the developed lessons.

The use of varied assessment techniques is vital in determining students' actual performance and outputs in class to determine if the learning objectives were successfully achieved by the learners [30],[35].

Table 5. Inter-rater reliability index of the ratings provided by the jurors for the five developed lessons

Lesson	Inter-rater Reliability Index (AC2)	Description
1. Ecosystem: The Principles Within	0.930	Almost perfect agreement
2. Biodiversity: Stability in the Diversity of Life	0.940	Almost perfect agreement
3. Biotic Potential and Environmental Resistance: Limiting Population Growth	0.940	Almost perfect agreement
4. Terrestrial and Aquatic Ecosystems: Interconnectivity in the Biosphere	0.943	Almost perfect agreement
5. The Ecological Footprint: Assessing Human Environmental Impact	0.958	Almost perfect agreement
Mean	**0.942**	**Almost perfect agreement**

Most of the individual ratings provided by the jurors for each lesson run from 4 to 5 rating which can be interpreted as very good to excellent rating. As gleaned in Table 5, the degree of agreement among the expert jurors was measured using an inter-rater reliability index (Gwet's AC2). The results showed that the degree of agreement among the jurors' ratings was high (Gwet's AC2=0.942) which can be verbally interpreted as an almost perfect agreement. The result indicates that the jurors are in consonance with one another regarding their assessment on the consistency, validity and appropriateness of the five lessons. This further established the quality of the lessons, validity and fitness for classroom integration and implementation.

CONCLUSION AND RECOMMENDATION

The five developed lessons on Interaction and Interdependence incorporated into Earth and Life Science Course for Grade 11 learners were: 1) Lesson 1 - Ecosystem: The Principles Within; 2) Lesson 2 - Biodiversity: Stability in the Diversity of Life; 3) Lesson 3 - Biotic Potential and Environmental Resistance: Limiting Population Growth; 4) Lesson 4 - Terrestrial and Aquatic Ecosystems: Interconnectivity in the Biosphere; and 5) Lesson 5 - The Ecological Footprint: Assessing Human Environmental Impact. Meanwhile, the concepts and principles of Sustainable Development that were incorporated into the five lessons were: Lesson 1 (Water Conservation); Lesson 2 (Biodiversity Conservation); Lesson 3 (Earth's Carrying capacity; Responsible Parenthood and Family Planning); Lesson 4 (Interdependency and Environmental Justice); Lesson 5 (Ecological Footprint and Environmental Stewardship).

The five developed lessons passed the content validity examination of the expert jurors and therefore can be used in teaching ecology for Grade 11 students. Evidently, the five developed lessons have been found to exhibit consistency of the learning outcomes with the subject matter, appropriateness and relevance of integrated Sustainable Development concept, and congruency of objectives, activities, and evaluation.

Inter-rater reliability test reveals that the Jurors' assessments were consistent and reliable which further established the validity of the five lessons for implementation.

Therefore, it is recommended that the lessons can be adopted and implemented in Grade 11 ecology to raise a strong awareness on sustainable development principles and practices. Teachers, on the other hand, may further contextualize and simplify the contents without compromising the learning competencies for easy understanding of the learners.

Further, this module can also be used as a stand-alone unit that can be integrated in other environmental education or introductory ecology courses such as natural sciences, general biology, environmental science and many others. Similarly, the integrated concepts of sustainable development can be incorporated in other disciplines such as chemistry, social science, sociology, literatures and management subjects whenever it is necessary and appropriate.

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It is also highly recommended that a follow-up study may be conductive to examine the effect of the lessons on conceptual understanding and attitudes of the students toward ecology and sustainability principles and concepts.

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