DO IT YOURSELF! (DIY): ENGINEERING DESIGN BASED LEARNING ACTIVITY SHEETS FOR GRADE 11-STEM LEARNERS IN EARTH SCIENCE

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Abstract

This study aimed to assess the effectiveness and experiences of engineering design-based learning activity sheets on the creative thinking skills and conceptual knowledge of Grade 11- STEM learners in Earth Science. A mixed method using sequential explanatory design was used, including adapted and researcher-made tests and interviews to understand the experiences before, during, and after the intervention. The participants were Grade 11-STEM learners from Regional Science High School for Region VI. The research used the Plan, Implement, and Evaluate model, and data analyses were conducted using Mean, SD, T test, Cohen's D, and thematic analysis. The findings showed that Grade 11-STEM learners in the control group demonstrated evident creative thinking skills and evident to very evident conceptual knowledge in Earth Science during both the pre-test and post-test assessments. In contrast, the experimental group exhibited very high creative thinking skills and very high to extremely high conceptual knowledge in the pretest and posttest assessments. While no significant difference was found between the control and experimental groups. However, significant differences were observed within the experimental group between the pretests and posttests. Thematic analysis revealed several themes before using Engineering Design Based Learning Activity Sheets: Lack of Resources and Supplementary Materials, Distractions and Limited Interaction. During the activity, learners integrated theoretical learning with real-world application, created miniature models, and experimented hands-on. After the activity, learners experienced enhanced understanding, critical thinking, knowledge expansion beyond lesson content, and promoting innovative approaches. The study demonstrates that incorporating Engineering Design Based Learning Activity Sheets into Earth Science lessons enhances students' understanding, critical thinking, and innovative approaches, thereby promoting a dynamic and engaging learning environment.

Keywords: *Engineering Design, Learning Activity Sheets, Creative Thinking, Conceptual Understanding, and Earth Science*

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Context and Rationale

COVID-19 pandemic upended such learning options. Whether educators are teaching remotely, in-person or in a hybrid model, STEM classes look very different today. Safety precautions, spatial limitations and changes to learners' schedules require a new, flexible approach to STEM lessons (Eastern Washington University, 2021).

According to Chandramouli (2020), learners and educators all around the world are gearing up to a new way of learning and teaching, and many subjects have successfully transitioned online. However, STEM learning is a particularly challenging area to replicate online since it requires fieldwork and physical access to laboratories. While there is no denying the challenge, educators worldwide are also seeing it as an opportunity to include diverse, real-world activities in their learners' STEM-learning experiences.

Despite the challenges posed by the ongoing pandemic, cultivating the ability to generate innovative solutions to diverse problems remains crucial for learners at Regional Science High School for Region VI. Specifically, Grade 11-STEM learners are currently immersed in the study of Earth Science, delving into the critical issues our planet confronts. However, empirical data reveals that a significant percentage of these learners, approximately almost 45%, encountered difficulties in both remembering and comprehending the various ideas and rules governing Earth's processes.

The impact of the pandemic has impaired learners' learning challenges, particularly in the realm of Earth Science. The shift to virtual and hybrid learning modes has further strained their capacity to engage intimately with the material, with 85% of learners acknowledging a negative impact on their ability to grasp Earth Science concepts. Conventional teaching approaches have proven inefficient, as reported by 60% of learners, emphasizing the pressing need for alternative strategies (RSHS VI Quality Assurance Team, 2021).

Lin et al. (2020) concurred that enhancing the implementation of STEM education involves strategically designing technology-based learning activities, including hands-on experiences, that integrate engineering design. This approach aims to provide learners with a holistic cross-disciplinary experience, offering more opportunities to apply their STEM knowledge and skills in problem-solving and addressing real-world needs. In contrast to solely focusing on the acquisition of subject-specific knowledge, this emphasizes the practical application of STEM competencies.

Atman et al. (2017) proposed that learners should pay more attention to problem scoping, information gathering, and decision-making as they develop their cognitive structures and schematic processes in engineering design.

Engineering design is an interactive, methodical problem-solving process that calls for imagination, expertise, and a wealth of subject-specific information. It is also a dynamic process rather than a strict methodology. It is important to distinguish between science and engineering because they are sometimes misunderstood. A question is the starting point of scientific investigation, which next develops and tests hypotheses to find an answer.

It is in this light that the purpose of this research would like to conduct to produce alternative learning activity sheets that use Engineering Design Processes that may help to increase the learner's creative thinking and conceptual knowledge of Earth Science, providing a tailored solution to the unique learning environment created by the pandemic.

Innovation, Intervention and Strategy

For two (2) years, teachers and learners have continuously delivered lessons through Modular Instruction either with the use of module or learning activity sheet. Delivering STEM education in this time of pandemic should not be compromised. That is why the researcher created a strategy that incorporates Engineering Design in some learning activities in modules.

Engineering Design is the method that engineers use to identify and solve problems. It has been described and mapped out in many ways, but all descriptions include some common attributes. It is a process that helps to solve problems that always begin with an explicit goal. Designers must choose solutions that include the most desired features and the fewest negative characteristics. It is a systematic and interactive that includes steps that can be repeated, although not always in the same order. Steps include things like planning, modeling, testing, and improving designs and this process is often done in small teams that include people with different kinds of knowledge and experience. Designers are continuously communicating with clients, team members, and others (Sneider, 2021).

Furthermore, the Engineering Design is composed of four (4) stages, namely: (a) define- or the problem identification; (b) imagine- asking expertise to other people; (c) plan- brainstorm ideas and develop possible solutions and (d) test- evaluate the proposed solution (NASA, 2022).

This intervention was anchored in the theory of Constructivist Theory of Jean Piaget (1972). He believed that intelligence was a single capacity that developed the same way in all individuals. Constructivism is a theory of knowledge that argues that humans generate knowledge and meaning from an interaction between their experiences and their ideas.

In addition, this is also anchored in the theory "learning by doing" by Jhon Dewey (1983) which states that "it is a process whereby people make sense of their experiences, especially those experiences in which they actively engage in making things and exploring the world." Learning by doing is an educational approach that makes use of engaging learning activities that are tailored to the needs and interests of the learners. In the same way, teachers who utilize the Learning by Doing approach motivate students to learn by stimulating their curiosity (Abuzandah, 2020).

The researcher chose four (4) topics in which Engineering Design Approach were applicable namely: Water as a Resources, Soil and Soil Quality, Endogenic Process, and Plate Tectonics. The researcher adapted, modified, and contextualized laboratory activities that suited the materials that were seen at home. The researcher also made sure that the activities were aligned to the learning standards set by the Department of Education- Most Essential Learning Competencies (MELCS).

Action Research Questions

This study aimed to assess the effectiveness and experiences of engineering design-based learning activity sheets on the creative thinking skills and conceptual knowledge of Grade 11- STEM learners in Earth Science.

Specifically, this study sought to answer the following questions:

1. What is the level of creative thinking skills and conceptual knowledge in Earth Science of Grade 11-STEM learners in the pretests and posttests scores of the control and experimental groups?
2. Is there a significant difference in the level of creative thinking skills and conceptual knowledge in Earth Science of Grade 11-STEM learners in the pretest scores of the control and experimental groups?

3. Is there significant difference in the level of creative thinking skills and conceptual knowledge in Earth Science of Grade 11-STEM learners in the pretest and posttest scores of the control group?
4. Is there significant difference in the level of creative thinking skills and conceptual knowledge in Earth Science of Grade 11-STEM learners in the pretest and posttest scores of the experimental group?
5. Is there a significant difference in the level of creative thinking skills and conceptual knowledge in Earth Science of Grade 11-STEM learners in the posttest scores of the control and experimental groups?
6. What is the effect size of the Engineering Design Based Learning Activity Sheets on the
creative thinking skills and conceptual knowledge in Earth Science of Grade 11-STEM learners?
7. What are the experiences of Grade 11-STEM learners in the experimental group before, during, and after using the Engineering Design Based Learning Activity Sheets?
8. What action can be taken after the conduct of the study?

Action Research Method

Research Design

The study used a mixed method, specifically using a sequential explanatory design. Explanatory sequential design starts with quantitative data collection and analysis and then follows up with qualitative data collection and analysis, which leads to interpretation. This helps determine what quantitative results need further explanation (Harvard Catalyst, nd).

For the quantitative part, the quasi- experimental research using Static Group Comparison research design aimed to assess the effectiveness of engineering design-based learning activity sheets on the creative thinking skills and conceptual knowledge of Grade 11- STEM learners in Earth Science at Regional Science High School for Region VI.

According to Cadornigara (2018), Static Group Comparison Design is an appropriate for research that determines the effect of a given treatment being studied and compares the degree of the effect based on a control group that did not receive such treatment.

The diagram below presented the Static Group Comparison Design.

[T] ← X
--> --> --> O_1
[C] --> O_2

where:

T is the test group (with intervention/treatment)
X is the intervention/treatment
O_1 is the test group post test
O_2 is the control group post test

On the other hand, Narrative Inquiry was used to account the experiences of Grade 11-STEM learners before, during, and after using the engineering design-based learning activity sheets.

Participants and/or other Sources of Data and Information

The participants of this study were the Grade 11 Science, Technology, Engineering and Mathematics (STEM) learners of Regional Science High School for Region VI.

For the quantitative part, a simple random sampling technique was used to assign 2 sections as the control group and experimental group. But there was no picking of each learner that would be assigned in the respective groups. All sections were still intact.

Match pairing was implemented for each group based on their consistency on attendance, academic achievement, and sex as to have an equal participating number of learners for both groups. Once one learner from the experimental group consistently failed to attend the virtual classes and perform the activities due to any circumstances, s/he and his/her pair from the control group were excluded from the study for the consistency of data and number of participating learners.

When trimmed down, there were 48 learners from the STEM 1 who served as the experimental group and forty- eight 48 learners from the STEM 2 served as the control group. The table below presents the distribution of participants.

Table 1. Distribution of Participants according to section

Participants	N	%
STEM 1 (Experimental Group)	48	50
STEM 2 (Control Group)	48	50
Total	**96**	**100**

On the other hand, seven (7) learner-participants were chosen using purposive sampling for the interview on the experiences before, during, and after using the activity sheets.

Inclusive criteria were as follows:

1. must belong to the experimental group;
2. must complete and submit all the tasks on the google classroom on time; and
3. must be willing to participate and answer the interview guide questions.

Table 2. Characteristics of Participants during the Interview

Pseudonyms	Age	Sex
Student 1	16	Female
Student 2	16	Female
Student 3	17	Male
Student 4	17	Male
Student 5	17	Female
Student 6	17	Female
Student 7	17	Female

Research Instrument

A combination of adapted and researcher made tests were used to measure the level of creative thinking skills and the level of conceptual knowledge of the Grade 11-STEM learners in Earth Science and an interview guide was used to understand the experiences before, during, and after using the engineering design-based learning activity sheets.

Creativity Thinking Questionnaire. This was a 30-item checklist questionnaire adopted from Sumi (2011) to measure the creative thinking of the learners toward the conduct of Engineering Design Based learning.

A 5-point Likert Scale and 5 level arbitrary mean scale were used to describe the level of creative thinking of the learners:

Likert Scale	Description	Mean Scale	Description
5	strongly agree	4.21-5.00	Very Evident
4	agree	3.41- 4.20	Evident
3	undecided	2.61- 3.40	Moderately Evident
2	disagree	1.81- 2.60	Less Evident
1	strongly disagree	1.00- 1.80	Least Evident

Conceptual Knowledge Test. This was a 50-item multiple type of test with four (4) choices prepared by the researcher and all questions were based on and aligned to the Most Essential Learning Competencies (MELCs) prescribed by DepEd. A Table of Specification was also prepared by the researcher.

After the pilot testing, from 50 items, there were only 30 items that were accepted. The researcher edited the Table of Specification and revised the test questionnaire.

To describe the conceptual knowledge of the learners, a mean scale below was used.

Mean Interval	Description
24.01- 30.00	Extremely High
18.01- 24.00	Very High
12.01- 18.00	High
6.01-12.00	Low
0.00 – 6.00	Very Low

Interview Guide. This was an eight (8) item researcher made interview guide. The questions included in the guide were open-ended or unstructured to allow the researcher to incorporate follow-up questions. This approach was chosen to extract the most comprehensive and substantial information during the interview process.

Validity. All questionnaires underwent content validity to assess the quality of the items on the test. Research experts, a Master Teacher or with Masters/Doctoral degree in Science or Earth Science validated all the questionnaires. A Validation form adopted from Good and Scates (nd) cited by Pineda (2014) was used.

All comments, suggestions, and recommendations were incorporated in the final questionnaires before it was subjected to reliability testing.

Reliability. After the validation of the instruments, it underwent pilot testing to 30 Grade 11 learners who were not participants of the study. After which, the data underwent reliability testing using Cronbach Alpha and KR-20. According to Taber (2017), coefficient reliability of greater or equal to .70 indicates high reliability.

For creative thinking, the Cronbach alpha value was 0.797, and for conceptual understanding, the Cronbach alpha value was 0.854.

Action Research Process

Furthermore, the researcher used PIE or the Plan, Implement and Evaluate model in conducting the research. The Plan, Implement, Evaluate (PIE) model from Newby, Stepich, Lehman, and Russell (1996) encourages an emphasis on considering how technology assists with instructional design, focusing on the what, when, why, and how. This phase produced an artifact or plan that was then put into action during implementation followed by evaluating both learner performance and instruction effectiveness.

Planning Phase

During the planning phase, the researcher planned and prepared the Engineering Design Based Learning Activity Sheets together with the research instruments and which was validated by the panel of experts.

After which, one week before the start of the intervention, the researcher conducted pretests to both experimental and control groups. The pretest was conducted through online videoconferencing using google meet (with open camera) to ensure the validity of the result.

Implementation/ Phase

After the pretest, Engineering Design Based Laboratory Activity Sheets were given together with the Self-Learning Modules to the experimental group. While in the control group, only a Self-Learning Modules for Earth Science was given.

Google meet conference and messenger were used to monitor and reinforce the learning and activities of the learners.

Evaluation Phase

After five (5) weeks of intervention, a posttest was given to the learners both in experimental and control groups through online videoconferencing using google meet (with open camera) to ensure the validity of the result.

After the data collection period, the scores were automatically encoded in MS Excel. Then data were subjected to analysis using the Statistical Packages for Social Sciences for processing and interpreting.

In addition, an online interview was conducted to the selected seven (7) learners to examine and give feedback on their experiences before, during, and after using the Engineering Design Based Learning Activity Sheets.

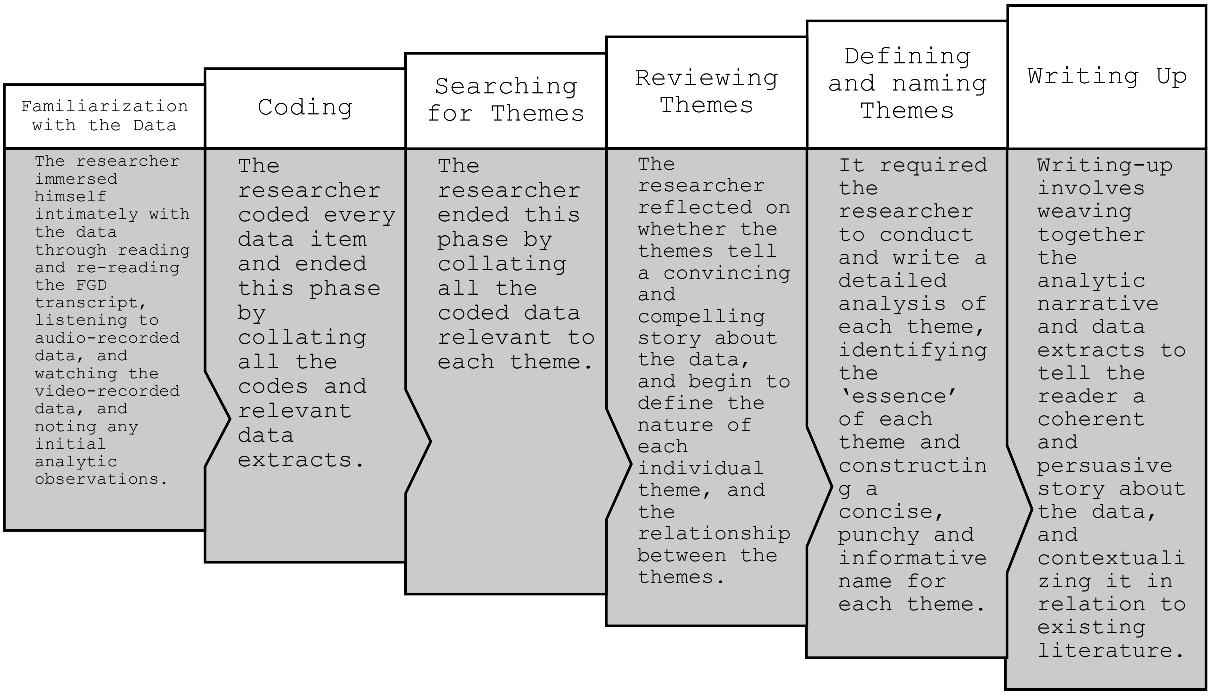
After the data collection period, the scores were automatically encoded in MS Excel and Word.

Data Analysis

For the quantitative data analysis, the data were subjected to analysis using the Statistical Packages for Social Sciences for processing and interpreting. Mean was used to determine the extent of creative thinking skills and conceptual knowledge of the participants. T- test was used to determine the significant difference among the variables. Cohen's D, in addition, was used to determine the effect size of the intervention used. All inferential tests were set at 0.05 alpha level of significance.

For the qualitative data analysis, thematic analysis was used. To analyze the data using thematic analysis, six (6) phases of thematic analysis were used (Braun and Clarke, 2006 as cited in Naelgas, 2022). This should not be viewed as a linear model, where one cannot proceed to the next phase without completing the prior phase (correctly); rather analysis is a recursive process (Naelgas, 2022).

Figure 1 shows the phases of thematic analysis that was used in this study.



Results and Discussion

Quantitative Analysis

Table 2 presents the level of Creative Thinking Skills and Conceptual Knowledge in Earth Science of Grade 11-STEM learners in the pretests and posttests scores of the control and experimental groups.

Table 2. Level of Creative Thinking Skills and Conceptual Knowledge in Earth Science of Grade 11-STEM Learners in the Pretests and Posttests Scores of the Control and Experimental Groups

Variable	Test	Control			Experimental		
		Mean	**Description**	**SD**	**Mean**	**Description**	**SD**
Creative Thinking Skills	Pretest	3.88	Evident	0.51	4.04	Evident	0.50
	Posttest	4.06	Evident	0.47	4.69	Very Evident	0.31
Conceptual Understanding	Pretest	18.13	Very High	3.54	19.10	Very High	3.63
	Posttest	20.90	Very High	3.17	25.86	Extremely High	3.41

Creative Thinking Skills		Conceptual Understanding	
Mean Scale	Description	Mean Scale	Description
4.21-5.00	Very Evident	24.01- 30.00	Extremely High
3.41- 4.20	Evident	18.01- 24.00	Very High
2.61- 3.40	Moderately Evident	12.01- 18.00	High
1.81- 2.60	Less Evident	6.01-12.00	Low
1.00- 1.80	Least Evident	0.00 – 6.00	Very Low

As to Creative Thinking Skills of the control group, both pretest and posttest results are in evident level ($\bar{X}$=3.88, SD= 0.51 and $\bar{X}$=4.06, SD= 0.47, respectively). The study's findings suggest that the self-learning module is a useful tool for fostering learners' capacity for original thought. From the pretest to the posttest, the learners in the control group showed a definite improvement in their capacity for creative thought, demonstrating that they were able to apply their pre-existing abilities to the problems posed in the SLM. This outcome highlights the value of giving children the chance to exercise and use their critical thinking abilities in a variety of situations, as it can support their general development and progress. It also highlights the Self-Learning Module's potential as a useful resource for facilitating the development of these skills, which are essential for success in many areas of life.

Furthermore, in experimental group, it shows that the level of creative thinking skills of the students increased from evident ($\bar{X}$=4.04, SD= 0.50) to very evident ($\bar{X}$=4.69, SD= 0.31). The result has a significant improvement in the learners' creative thinking skills. The learners demonstrated exceptional creativity by exploring multiple ideas and reflecting on various solutions to solve the different tasks presented in the activity sheets. The activity sheets were designed to promote critical thinking and problem-solving skills, which encouraged the learners to think outside the box and come up with innovative solutions to real-world problems. The learners' feedback on the activity sheets reflected their enthusiasm and engagement in the learning process, indicating that this approach was an effective way to enhance their creative thinking skills.

As to Conceptual Understanding of the control group, both the pretest and posttest results are in very high level ($\bar{X}$=18.13, SD= 3.54 and $\bar{X}$=20.90, SD= 3.17, respectively). This means that learners have prior knowledge in Earth Science. It was confirmed by the learners that most of the topics were discussed in their Junior High School classes, especially in Endogenic Process and Plate Tectonics topics. Also, with the help of SLM, learners improved their understanding of the different facts and concepts in Earth Science. On the other hand, learners in the experimental group showed a very high to extremely high conceptual understanding based on their pretest and posttest tests scores ($\bar{X}$=19.10, SD= 3.63 and $\bar{X}$=25.86, SD= 3.41, respectively). This exceptional understanding of the learners showed the effectiveness of Engineering Design as a tool in teaching Earth Science. Learners revealed that although some topics were discussed during their Grade 10 but because of the activities provided to them, they were able to understand better the concepts and facts.

The result of the study is congruent to the study of Lin et al. (2021) wherein a chi-square test revealed a statistically significant difference between the engineering design group (experimental group) and problem-solving group (control group). Applying the engineering design process to STEM project-based learning is beneficial for developing pre-service technology teachers' schema of design thinking, especially with respect to clarifying the problem, generating ideas, modeling, and feasibility analysis.

Significant Difference in the Level of Creative Thinking Skills and Conceptual Knowledge in Earth Science of Grade 11-STEM Learners in the Pretest Scores of the Control and Experimental Groups

Table 3 presents the significant difference in the level of Creative Thinking Skills and Conceptual Knowledge in Earth Science of Grade 11-STEM learners in the pretest scores of the control and experimental groups.

Table 3. Significant Difference in the Level of Creative Thinking Skills and Conceptual Knowledge in Earth Science of Grade 11 STEM Learners in the Pretest Scores of the Control and Experimental Groups

Variable	Group	Mean	df	t	p	Interpretation
Creative Thinking Skills	Control	3.88	94	-1.702*	0.092	Not Significant
	Experimental	4.04				
Conceptual Understanding	Control	18.13	94	-1.337*	0.184	Not Significant
	Experimental	19.10				

**Significant at 0.05 alpha level*

In the creative thinking, the pretest results show that there is no significant difference in the control and experimental groups (t (94) -1.702, p= 0.092). This means that both groups have established a good level of creative thinking skills. Strong creative thinking abilities help learners analyze and solve complex problems, come up with original ideas and solutions, and effectively communicate their findings. The fact that both the control and experimental groups demonstrated a good level of creative thinking skills in the pretest results, it manifests the quality of education in STEM disciplines.

It also suggests that learners are being adequately prepared to meet the demands of the modern world, where creativity and innovation are increasingly essential. In addition, the ability of learners to innovate and problem-solve is not only relevant to their academic pursuits but also to their future careers and personal lives.

In Conceptual Understanding, the pretest results show that there is no significant difference in the control and experimental groups (t (94) -1.337, p= 0.184). A good retention of basic concepts in Earth Science demonstrated by the learners is a positive indication that they have a solid foundation upon which to build their knowledge and understanding of more complex topics in the field. This could lead to better performance in future Earth Science-related courses, as well as in their future careers if they choose to pursue a field in STEM. Moreover, a strong conceptual understanding also enables learners to critically analyze and evaluate scientific information related to Earth Science, helping them to make informed decisions about environmental and societal issues.

The result was affirmed by Iskandar et al. (2021) wherein STEM-based learning improves creative thinking skills by 0.663 or 66.3% in the medium category. This shows that STEM-based learning is effective in developing students' creative thinking, STEM-based learning also provides experience to students in collaborating between technological science, engineering, and mathematics in optimizing learning.

Significant Difference in the Level of Creative Thinking Skills and Conceptual Knowledge in Earth Science of Grade 11-STEM Learners in the Pretest and Posttest Scores of the Control Group

Table 4 shows the significant difference in the level of Creative Thinking Skills and Conceptual Knowledge in Earth Science of Grade 11-STEM learners in the pretest and posttest scores of the control group.

Table 4. Significant Difference in the Level of Creative Thinking Skills and Conceptual Knowledge in Earth Science of Grade 11 STEM Learners in the Pretests and Posttest Scores of the Control Group

Variable	Test	Mean	df	t	p	Interpretation
Creative Thinking Skills	Pretest	3.88	47	-2.774*	0.009	Significant
	Posttest	4.06				

Conceptual Understanding	Pretest Posttest	18.13 20.90	47	-12.505*	0.000	Significant

**Significant at 0.05 alpha level*

In terms of creative thinking skills, the data shows that there is a significant difference in the creative thinking skills in Earth Science of Grade 11-STEM learners in the pretest scores of the control group (t (47)-2.774, p= 0.009). This means that the Self Learning Module given by DepEd can help learners in improving their creative thinking skills.

In terms of conceptual understanding, there is a significant difference in the conceptual understanding in Earth Science of Grade 11-STEM learners in the pretest scores of the control group (t (47)-12.505, p= 0.000). This simply means that the SLM given by the DepEd is designed to provide facts, concepts, and ideas regarding the topic. Hence, learners showed understanding on the topic with the of SLM.

Significant Difference in the Level of Creative Thinking Skills and Conceptual Knowledge in Earth Science of Grade 11 STEM Learners in the Pretest and Posttest Scores of the Experimental Group

Table 5 shows the significant difference in the level of Creative Thinking Skills and Conceptual Knowledge in Earth Science of Grade 11 STEM learners in the pretest and posttest scores of the experimental group.

Table 5. Significant Difference in the Level of Creative Thinking Skills and Conceptual Knowledge in Earth Science of Grade 11 STEM Learners in the Pretest and Posttest Scores of the Experimental Group

Variable	Test	Mean	df	t	p	Interpretation
Creative Thinking Skills	Pretest Posttest	4.04 4.69	47	-8.721*	0.000	Significant
Conceptual Understanding	Pretest Posttest	19.1 25.86	47	-2.611*	0.012	Significant

**Significant at 0.05 alpha level*

The data shows that there is a significant difference in the level of creative thinking skills in Earth Science of Grade 11-STEM learners in the pretest scores of the experimental group (t (47)-8.721, p= 0.000). This finding suggests that the Engineering Design approach can be a highly effective method in enhancing the creative thinking skills of learners. By integrating engineering design activities, learners can develop their ability to generate and evaluate multiple solutions to real-world problems, which is a key aspect of creative thinking.

The data also shows that there is a significant difference in the level of conceptual understanding in Earth Science of Grade 11-STEM learners in the pretest scores of the experimental group (t (47)-8.721, p= 0.000). The result suggests that the Engineering Design approach is highly effective in improving the conceptual understanding of the learners in Earth Science. This approach can help the learners achieve an excellent level of understanding of the subject matter.

The study of Sutanto et al. (2019) affirmed that the implementation of Problem/Engineering Based Learning can enhance the creativity of Mechanical Engineering Students Program in Universitas Nusantara PGRI Kediri.

Significant Difference in the Level of Creative Thinking Skills and Conceptual Knowledge in Earth Science of Grade 11-STEM Learners in the Posttest Scores of the Control and Experimental Groups

Table 6 presents the significant difference between the level of Creative Thinking Skills and Conceptual Knowledge in Earth Science of Grade 11-STEM learners in the posttest scores of the control and experimental groups.

Table 6. Significant Difference in the Level of Creative Thinking Skills and Conceptual Knowledge in Earth Science of Grade 11-STEM Learners in the Posttest Scores of the Control and Experimental Groups

Variable	Group	Mean	df	t	p	Interpretation
Creative Thinking Skills	Control	4.06	94	-4.970*	0.000	Significant
	Experimental	4.69				
Conceptual Understanding	Control	20.9	94	-5.064*	0.000	Significant
	Experimental	25.86				

**Significant at 0.05 alpha level*

Comparing the posttest scores of both control and experimental groups as to creative thinking skills, it shows that there is a significant difference between the level of creative thinking skills (t (94)-4.970, p=0.000) in Earth Science of Grade 11-STEM learners in the posttest scores of the control and experimental groups. The result indicates that the Engineering Design Learning Activities have a significant impact on improving the creative thinking skills of the learners, which is more effective than the Self Learning Module. This finding suggests that incorporating Engineering Design approach in teaching can be a promising way to enhance learners' ability to think creatively and innovatively. It also highlights the importance of hands-on and experiential learning activities in promoting learners' creativity.

On the other context, the data also shows that there is a significant difference in the conceptual knowledge in Earth Science of Grade 11-STEM learners in the posttest scores of the control and experimental groups (t (94)-5.064, p=0.000). This result demonstrates the effectiveness of Engineering Design Learning Activities in enhancing learners' understanding and ability to apply Earth Science concepts in real-life situations. The hands-on approach of the Engineering Design Learning Activities allows the learners to not only learn the concepts but also experience and apply them, leading to a deeper understanding and appreciation of their relevance. This highlights the potential of the Engineering Design approach to promote meaningful learning and practical application of concepts.

The result of the study is supported by Lin et al. (2021) wherein the chi-square test showed that there was a statistically significant difference between the experimental and control groups in terms of their ability to provide advanced explanations for idea generation.

Effect Size of the Engineering Design Based Learning Activity Sheets on the Creative Thinking Skills and Conceptual Knowledge in Earth Science of Grade 11-STEM Learners

Table 7 shows Cohen's D result of the Engineering Design based learning activity sheets on the creative thinking skills and conceptual knowledge in Earth Science of Grade 11-STEM learners.

Table 7. Effect Size of the Engineering Design Based Learning Activity Sheets on the Creative Thinking Skills and Conceptual Knowledge in Earth Science of Grade 11-STEM Learners

Variable	Test	Mean	SD	D	Description
Creative Thinking Skills	Pretest	4.15	0.5	1.39	Large
	Posttest	4.73	0.311		
Conceptual Understanding	Pretest	20.9	3.63	1.46	Large
	Posttest	25.86	3.17		

Cohen's D	Description
>0.8	Large
0.5	Medium
<0.2	Small

The data shows that using Engineering Design Learning Activity Sheets has a large effect in the creative thinking skills (D= 1.39) and conceptual understanding (D=1.46) in earth Science. This means that 92% of the entire population size really appreciated and has a great practical significance on creative thinking skills and conceptual understanding.

The result of the study confirms the findings of Lin et al. (2021) that EDP-STEM-PBL can be used to systematically cultivate the scientific, technological, mathematical, and engineering knowledge of learners through the engineering design thinking process, thus expanding learners' perspectives, and mitigating the lack of practicality in conventional pedagogy, which tends to overemphasize theoretical learning. EDP-STEM-PBL repurposes engineering design studies into pedagogical tools for teaching engineering design.

Qualitative Analysis

The Experiences of Learners Before the Engineering Design-Based Learning Activity Sheets on Creative Thinking Skills and Conceptual Knowledge in Earth Science

The learners' experiences with learning Earth Science during the pandemic were diverse, reflecting the challenges posed by the unconventional learning environment. These learners in Grade 11 of Regional Science High School for Region VI have difficulty understanding concepts that are new to them because of the limited face-to-face interaction and further discussion.

Constrained Barriers to Effective Learning

Many learners, including learners 1, 3 and 6 faced challenges in comprehending new Earth Science concepts due to lack of in-person interactions, distractions, and lack of resources. The need for repeated readings and additional online resources highlighted the struggle to grasp unfamiliar topics.

> *"The learning difficulties I experienced in learning Earth Science during this pandemic are difficulty in understanding new concepts and facing distractions. The topics in Earth Science are new to me and I had to read the learning materials more than twice and look for supplementary materials online to further deepen my understanding."*

Learner 1 mentioned that before the application of this new intervention, she had experienced struggling in grasping new concepts in Earth Science. This could be attributed to the nature of the subject, which may involve complex scientific principles, terminology, and interconnected ideas. The transition to remote learning during the pandemic might have contributed to this difficulty. Learning challenging topics independently without the immediate assistance of a teacher or classmates can be more demanding.

The same experience with another learner. Learner 3 also pointed out distractions and a lack of learning materials as hindrances. Limited access to resources compelled this learner to be creative and innovative in their learning approaches.

> *"For me was the lack of learning materials for us to access and make use of. (Limited Access to Resources). Siguro sir it [there] was a time where [in] we had to be creative and innovative with our answers and outputs. The absence of in-person classes can lead to a lack of direct interaction with classmates and instructors, making it more challenging to ask questions, participate in discussions, or collaborate on projects."*

In Regional Science High School for Region VI, the competence of learners is improved through various activities during face-to-face classes. But, when pandemic hit the country, a lot of difficulties were encountered by the learners especially in terms of their academic performance. Face-to-face interactions among the learners are essential for clarifying doubts, engaging in real-time discussions, and building a deeper understanding of the subject matter. The absence of direct communication led to misunderstandings or incomplete comprehension of complex concepts.

The result of the study has a parallel result to that of Gao et al. (2021). The findings revealed that during the SY 2020–2021, 60 percent of districts provided supplemental instructional materials, 43 percent provided summer science programs, and 40 percent addressed social-emotional learning in support of science education. Only a quarter of districts provided small group instruction and very few offered extended science learning time during the regular school year. Only 40 percent of districts provided additional support to English learners.

Pervasive Presence of Distractions

Distractions are mentioned as a factor affecting the learning process of Grade 11 learners. The shift to online or remote learning can bring about various distractions, such as interruptions at home, the temptation of non-educational online activities, or difficulties in maintaining focus without the structure of a traditional classroom. Having to read learning materials more than twice indicates the effort required to comprehend and internalize the information. This repetition might be necessary due to the complexity of the subject matter.

> *"Having no face-to-face classes can lead to a lack of direct interaction with classmates and instructors, making it more challenging to ask questions, participate in discussions, or collaborate on projects."*

Face-to-face classes often involve dynamic discussions where learners can actively participate. Compared to virtual classes, discussion forums or video conferencing tools may be used, but some learners might find it challenging to express themselves in this medium. Technical issues or a lack of real-time feedback can also impact the quality of discussions.

As observed by the teacher-researcher, learners have difficulty in understanding the lessons based on the given modules. They need more learning resources that could give them additional information about the topics for them to learn better.

As experienced by learner 6, the learner emphasized the absence of face-to-face classes, leading to a shortage of direct interaction with classmates and instructors. This limitation hindered the ability to ask questions, participate in discussions, and collaborate on projects.

The findings of this study were congruent to the study conducted by Adarkwah (2021). The findings indicated that Ghanaian learners considered online learning as ineffective due to several challenges that they encountered. Among these were lack of social interaction among students, poor communication, lack of ICT resources, and poor learning outcomes.

The Experiences of Learners During the Engineering Design-Based Learning Activity Sheets on Creative Thinking Skills and Conceptual Knowledge in Earth Science

During the application of Engineering Design-Based Learning Activity Sheets, learners perceived significant benefits during the application of the engineering design-based learning activity sheets in Earth Science. These benefits include a deeper understanding, integration of theoretical and practical knowledge, development of observational skills, expansion of knowledge beyond the curriculum, newfound appreciation, and a more natural absorption of concepts. The hands-on approach, resembling real laboratory activities, enhances the overall learning experience.

Bridging the Gap Between Theoretical Learning and Real-world Application

Engaging in real-world applications allowed the learners to explore the subject from different perspectives. The activities provided opportunities for contextual learning, connecting theoretical concepts with real-world problems or current research. Challenges included material availability during the pandemic, leading to creativity and problem-solving to find alternatives.

Learner 5 highlighted the challenging and experimental nature of the engineering-design activities. These activities pushed the learners to think creatively within the given situations and restrictions, fostering a critical yet inventive mindset.

“These activities were not like the average or usual activities we’d do in our modules. The engineering-design activities were crafty and experimental but also critically challenging.”

During the intervention, the learners were encouraged to think outside the box, explored unconventional solutions, and engaged in practical, hands-on work. Their artistry in the execution of these tasks indicates that they may require a certain level of craftsmanship which makes them feel excited because they really want to explore and expand their ideas.

Moreover, learner 2 highlighted the value of combining theoretical learning with real-world application, leading to a deeper understanding of Earth Science concepts.

“Participating in these activities not only tested my creativity but also sharpened my critical thinking skills. I had to explore unconventional solutions, think innovatively, and demonstrate resourcefulness to make the setup successful. This experience significantly improved my capacity to address challenges with a blend of creativity and efficiency.”

Based on the shared statement of learner 2, the learner emphasized the importance of problem-based learning and engagement with scientific literature in providing contextual learning opportunities. Connecting theoretical concepts with real-world problems enhances the perception of relevance and practical applications in Earth Science.

Learner 7 also shared that the experience significantly improved his capacity to address challenges with a blend of creativity and efficiency. The application of creative thinking skills in problem-solving contributed to a more holistic understanding of Earth Science.

"This experience really improved my capacity to address challenges with a blend of creativity and efficiency."

As observed by the teacher-researcher, these learners are not only creative and hands-on but also intellectually demanding. Learners likely need to apply critical thinking skills and problem-solving abilities, and perhaps even push the boundaries of their existing knowledge to successfully complete these engineering-design tasks given to them.

Unleashing Creativity through Miniature Models

Some found inspiration from unexpected sources, such as cartoons, making the learning experience more enjoyable and creative. Learner 1 noted that creating miniature models to emulate natural processes enhanced understanding. The task of designing realistic models challenged the learners to think creatively and apply their knowledge in a practical context.

"Aside from accomplishing the activities, I also had to design these models to be as realistic as possible which improved my creativity."

Likewise, this was supported by learner 4:

For our experiments, we applied our knowledge in Earth Science to create miniature models that mimicked natural processes. This hands-on experience not only deepened our understanding of the real environment but also sparked our interest in utilizing its properties responsibly.

The teacher-researcher included the use of miniature models so that the learners will include their theoretical understanding of Earth Science and translate it into practical, tangible representations. By engaging them in hands-on experiments with the miniature models, the learners likely gained a deeper understanding of how natural processes work. This experiential learning approach goes beyond simply reading about these processes in a textbook; it allows for a more immersive and practical understanding.

Engaging Hands-On Exploration in Experiments

During the conduct of this intervention, the learners consistently expressed that the hands-on, practical nature of the activities deepened their understanding of Earth Science concepts.

Learner 4 explained that hands-on experience in experiments deepened understanding and sparked interest in responsibly utilizing the environment. The engineering-design activities demanded critical thinking and craftsmanship, fostering a more profound connection with Earth Science concepts.

"This hands-on experience not only deepened our understanding of the real environment but also sparked our interest in utilizing its properties responsibly. The projects demanded critical thinking and craftsmanship as we designed, constructed, and optimized our models."

As observed, the hands-on experience not only increased understanding but also ignited an interest in utilizing Earth's properties responsibly. The teacher-researcher made sure that the learners recognized the importance of being mindful of the environment and sought to apply their knowledge in a way that considers the impact on Earth's systems through various hands-on activities given to them.

The Experiences of Learners After the Engineering Design-Based Learning Activity Sheets on Creative Thinking Skills and Conceptual Knowledge in Earth Science

The engineering design-based learning activities had a positive impact on the students' creative thinking skills, providing them with opportunities to apply theoretical knowledge in practical scenarios. The different activities played a crucial role in addressing the challenges posed by the pandemic, fostering creative thinking, and enhancing the students' understanding of Earth Science concepts. After the intervention was given, a lot of changes were observed form the students, especially in terms of their academic performance. They also shared different experiences and challenges encountered but ended up with a positive impact in their overall performance.

Enhancing Understanding through Experience and Clarification

Through these various activities, the Grade 11 learners' understanding was enriched through direct experience, and the hands-on activities not only clarified existing questions but also uncovered additional knowledge. This kind of experiential learning goes beyond the confines of a structured lesson, fostering a more dynamic and interconnected comprehension of Earth science. It also emphasizes the practical relevance of gaining knowledge beyond what is inside the classroom. Reaching the learners' needs despite having virtual classes gave the teacher extra effort, time, and preparation to help the learners in terms of the difficulties they experienced in this subject.

Learner 1 expressed that her understanding deepened because of the hands-on activities, providing a tangible experience that clarified questions.

"My understanding was deepening [deepened] because I was able to experience it and my questions were clarified. Also, these activities gave knowledge about other aspects of Earth Science that were not even part of the lesson but are [were] still necessary."

Through these hands-on activities, the learners actively engaged with the subject matter, likely through practical activities and experiments given by the teacher. This hands-on approach provided a different dimension to learning compared to more passive methods, such as reading or listening to lectures. The hands-on activities not only deepened understanding but also clarified the individual's questions. The teacher-researcher believes that the practical application of knowledge helped to resolve any uncertainties or areas of confusion, providing a more comprehensive and clearer picture of the subject.

This was also supported by the statement of learner 4, noting that hands-on experimentation and direct observation were crucial in enhancing their foundational knowledge, especially when some concepts were challenging through traditional reading.

"Conducting these projects has significantly enhanced my foundational knowledge of Earth Science. While some concepts were challenging to grasp solely through reading the module, hands-on experimentation and direct observation provided clarity and enabled me to resolve my questions. Moreover, the

projects provided new ideas and insights to the lessons that are not yet tackled."

The teacher-researcher made sure that the activities not only addressed the specific lesson content but also imparted knowledge about other aspects of Earth Science that were not initially part of the lesson. The teacher-researcher observed that the learners' hands-on experiences can lead to serendipitous discoveries and a broader understanding of the subject.

Cultivating Critical Thinking and Resourcefulness

Learners were engaged in various approaches, from explaining concepts to strategizing setups and improvising with available materials. The innovative outputs and resourcefulness of the learners enhanced their problem-solving skills and improved their creativity. According to them, they were thinking creatively, perhaps finding alternative ways to achieve their goals and make their outputs in the best way they can. This mindset is a key to successful experimentation, especially since these learners only have limited resources at home.

Learner 2 highlighted that the activities tested creativity, sharpened critical thinking skills, and demanded resourcefulness. The need to explore unconventional solutions and demonstrate efficiency in setup contributed to a blend of creativity and problem-solving.

This involved creating a rough sketch of the setup and strategizing the approaches I needed to utilize for it to be more organized and well-constructed. I had to think innovatively, be resourceful, and learn to improvise with the available materials I had on hand. Conducting these experiments was an enjoyable experience, particularly because they took place at home, providing a convenient and comfortable environment for exploration and discovery."

The learners were not only learning concepts themselves but also taking on the role of educators by explaining these concepts to their parents to ask for help. Teaching others is a powerful way to reinforce one's own understanding of a subject. This challenges them to think creatively and find alternative ways to achieve their goals, fostering problem-solving skills.

Extending Boundaries of Knowledge Beyond Lesson Content

Engaging in hands-on activities or experiments allows the learners for a more immersive experience, tapping into different learning modalities. Based on the result of their performance, their active participation resulted in a more profound comprehension of the subject matter.

Learners 1, 3 and 4 mentioned that the activities provided knowledge about aspects of Earth Science that were not explicitly covered in the lesson. But with the use of the engineering-based approach, the hands-on projects broadened the scope of their learning and introduced new ideas and insights.

"My understanding was deepened because I was able to "experience" it and my questions were clarified. Also, these activities gave knowledge about other aspects of Earth Science that were not even part of the lesson but are still necessary."

Also, learner 3 emphasized the role of contextual learning in Earth Science, indicating that connecting theoretical concepts with real-world problems or current research helps learners see the practical applications of their knowledge.

"Problem-based learning and engagement with scientific literature provide opportunities for contextual learning. Connecting theoretical concepts with real-world problems or current research helps individuals see the relevance and practical applications of Earth Science."

The teacher-researcher aimed to include experiential learning as a holistic approach, allowing learners to explore related concepts or discover connections that might not be immediately apparent in a traditional classroom setting. This broader understanding enhances the learner's overall knowledge based on Earth Science.

"Conducting these projects has significantly enhanced my foundational knowledge of Earth Science. Moreover, the projects provided new ideas and insights to the lessons that are not yet tackled."

With the positive impact experienced by the learners, the richness of experiential learning emphasizes its ability to deepen understanding, address questions, and unveil knowledge beyond the scope of the formal lesson. It underscores the importance of active engagement and hands-on experiences in the learning process, allowing the Grade 11 learners to have a more holistic and interconnected understanding of Earth Science.

Fostering Innovative Approaches

Learners felt that the activities made learning more fun, interactive, and reminiscent of a traditional classroom setting. The innovative approach bridged the gap between theory and application, providing a meaningful and deeper connection with Earth Science concepts.

Learners 2 and 6 expressed a newfound appreciation for the wonders of Earth Science because of the varied activities. The exploration of the subject through different perspectives, as mentioned by learner 2, contributes to a richer understanding.

"The innovative activities allowed me to have a meaningful and deeper connection with the different concepts. Additionally, it boosted my confidence and competence as I gained firsthand experience in applying acquired knowledge in practical situations, thereby solidifying my understanding and retention of the concepts at hand."

The teacher-researcher also emphasized that laboratory activities and experiments allowed learners to explore scientific concepts in a controlled way.

Conclusion and Recommendations

The study shows that before the introduction of the Self Learning Module and Engineering Design Based Learning Activity Sheets, learners in both the control and experimental groups showed strong conceptual knowledge and creative thinking abilities in Earth Science. When the control group was exposed to the Self Learning Module, both creative thinking abilities and conceptual comprehension slightly increased. However, the Engineering Design Based Learning Activity Sheets produced a remarkable rise in both areas, demonstrating a more dynamic and successful learning environment. The experiences of Grade 11 learners at Regional Science High School in Region VI during the pandemic highlighted the significance of the Engineering Design approach, fostering enhanced understanding, increased retention, and the development of critical thinking skills among learners in Earth Science.

Learners are encouraged to maintain their study habits to sustain their high level of creative thinking skills and conceptual understanding. Teachers should establish open channels of communication with students and encourage the development of adaptive self-efficacy through appropriately challenging tasks. Likewise, the integration of the Engineering Design approach is recommended not only in Earth Science but also in other science subjects to further enhance learners' creative thinking skills. Educators are urged to expand the use of the engineering-based approach beyond Earth Science to other science subjects, fostering a solid conceptual understanding that can be applied in real-life situations. Education Program Supervisors in Science and Mathematics are recommended to conduct seminars and training workshops to equip teachers with the knowledge and skills to incorporate the Engineering Design teaching and learning approach, thereby enhancing learners' problem-solving, systems thinking, and collaboration skills essential for success in STEM education.

Proposed Action Plan

This action plan targets the enhancement of educational practices through strategic interventions in three key areas: Engineering Design-Based Learning Activity Sheets, Creative Thinking Skills in Earth Science, and Conceptual Understanding in Earth Science.

Key Areas	Hindering Factors	Strategy, Activity	Time Frame	Person's Involved	Expected Output/Outcome
Engineering Design Based Learning Activity Sheets	Teachers are not trained to contextualize activity sheets	Teachers training in contextualizing available worksheets	1 month	EPS Science and Science Teachers	The result helps the teachers to develop more Engineering Design Based Learning Activity Sheets

Creative Thinking Skills in Earth Science	Limited number of activities Difficulty in constant monitoring of the learners in performing the activities.	Additional number of activities Time scheduling in monitoring the learners	1 month weekly	Science Teacher Science Teacher	The result may help the student to improve creative thinking skills while in the modular distance learning. The result may help the teacher to document the difficulties of the students while conducting the activities and may give feedback immediately.
Conceptual Understanding in Earth Science	Irregular feedbacking/class of teacher	Conduct online class or feedback giving regarding the subject matter	weekly	Science Teachers	There is a much increase in the Conceptual Understanding in Earth Science

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Financial Report

The table below reveals the breakdown of expenses needed for the conduct of the study with the total amount estimated is Nine Thousand Five Hundred (Php 9, 500.00).

QTY	UNIT	PARTICULARS	UNIT COST	TOTAL COST
5	reams	bond paper	200.00	1,000.00
5	bottles	ink cartridges	300	1,500.00
31	pcs	folders	10.00	310.00
10	boxes	pencils	70.00	700.00
2	units	stapler (no.35)	150.00	300.00
48	pax	Snacks to the experimental group of participants during the conduct of action research	80	3840
10	pax	Internet Load for Focus Group Discussion	50	500
2	copies	Bookbinding/reproduction of final Output	250.00	500
6	pax	Token for Panel of Experts	200.00	1,200.00
		Overall TOTAL		**9,850.00**

Research Instrument

Part I. Creative Thinking Skills Questionnaire

Check the appropriate response for each item that best describes your creative thinking skills in conducting science activities.

Statements	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
	5	4	3	2	1
1. I try out new ways of doing things.					
2. When I do something wrong, I review it to see what I could have done differently.					
3. I enjoy activities that involve patterns such as crosswords and jigsaw puzzles.					
4.I typically create new ideas by combining existing ideas.					
5. I like finding connections between things.					
6. My ideas can be odd or original.					
7. I try to use techniques that help me differently.					
8. I am curious about the unknown.					
9.I find it easy to start a project.					
10. I am eager to research on my ideas.					
11. I enjoy discussion with people with different viewpoints.					
12. I give focus on the goals and objectives of a project/task.					
13. When I examine existing products, I critically evaluate them to see how I can improve them.					
14. I accept ideas with initial faults but find ways to make them work.					
15. I enjoy discovering new things.					

16.I used my previous skills to solve an unfamiliar task.					
17. I can reflect on my own work and can figure out where did I go wrong and correct them immediately.					
18. I explore several ideas before setting on a solution to any problem.					
19. I like working with creative people.					
20.I don't mind if ideas have more than one interpretation.					
21. I am open to any new ideas.					
22. I spend time thinking and reflecting on how I learn.					
23. I read widely to come up with new ideas.					
24. I like ideas which that are new or novel something that other people have not thought of.					
25. I am confident about the benefits of new thinking techniques					
26 My mind can sometimes solve a problem when I leave it alone for a while.					
27. I like my own idea and I pursue working on it.					
28. I work hard on new challenges.					
29. I like thinking about the connections and similarities between things					
30. I explore other solutions in solving problems.					

Part II. Conceptual Knowledge in Earth Science

Answer the following statements.

1. It is mining of certain metals that have also caused surface water to become more acidic, producing a discharge called _________.
   a. acid drainage
   b. metal drainage
   c. acid mine drainage
   d. metal mine drainage
2. Which of the following can give a large cause of degradation of streams and lakes in urban areas?
   a. improper waste disposal
   b. population growth in the urban areas
   c. conversion into fishponds
   d. mining
3. This type of water is used for irrigation, in industry, to maintain stream flow and to replenish aquifers.
   a. groundwater
   b. non potable water
   c. potable water
   d. sea water
4. They are built to provide additional water resources in the different areas.
   a. dams
   b. reservoirs
   c. both a and b are correct
   d. none of them
5. It is a process to reduce the mineral contents by taking salt out of saltwater and brackish water to produce freshwater.
   a. sedimentation
   b. desalination
   c. salination
   d. evaporation
6. Which of the following human activities affect water resources?
   a. Population growth
   b. Pollution from the factories, cities, and farmlands
   c. Movement of large number of people from the countryside to towns and cities
   d. All of the above
7. Which of the following addressed the country's water problem through an integrated water management program of developing new water resources and conserving identified watershed?
   a. Executive Order No. 222 (1995)
   b. National Water Crisis Act of 1995
   c. Presidential Decree No. 424 (1974)
   d. The Philippine Clean Water Act of 2004
8. They are plowable lands which could be used to grow crops.
   a. arable land for agriculture
   b. desertification
   c. soil compaction
   d. filtering of potential pollutants
9. All are examples of human activities that degraded the soil quality. EXCEPT ONE.
   a. soil erosion
   b. soil compaction
   c. increasing crop rotation
   d. intensive agriculture
10. According to UN FAO, by how much of the global soil is moderately to highly degraded through human activities?
   a. 55%
   b. 48%
   c. 40%
   d. 33%
11. One of the services given by the soil is where carbon, nitrogen, phosphorus and other essential nutrients are stored, transformed and cycled in the soil.
   a. nutrient cycling
   b. nutrient deposit
   c. mineral cycling
   d. mineral deposit
12. Why farmers are encouraged to increase the use of soil organic matter?
   a. It improves the soil structure and increases its quality.

b. It maintains the soil quality and decreases nutrient holding capacity.
c. It enhances water holding capacity and decreases nutrient holding capacity.
d. All of the above

13. All are the functions of minerals and microbes in soil of organic and inorganic materials. EXCEPT ONE.
a. degrading c. mobilizing
b. detoxifying d. filtering

14. How soil erosion can be prevented?
a. efficient use of pest and nutrient management to the soil.
b. keeps the ground covered and vegetated.
c. makes a crop rotation
d. none of them

15. Those are waves that travel within the interior of the Earth
a. Love waves c. Surface waves
b. Body waves d. Rayleigh waves.

16. It is a fracture on which one body of rockslides past another.
a. epicenter c. fault
b. earthquake d. blocks

17. It is the place where rock ruptures and slips.
a. epicenter c. waves
b. hypocenter d. fault

18. It is the amount of damage brought about by an earthquake usually denoted as Roman Numerals.
a. intensity c. explosive
b. magnitude d. fault

19. Which of the following statement is correct about P waves and S waves?
a. S- waves travel the fastest, followed by the P- waves
b. P- waves and S- waves travels at the same speed.
c. P- waves move back and forth perpendicular to the direction of the wave motion while S- waves move back and forth parallel to the direction of wave motion.
d. P- waves travel the fastest, followed by the S- waves.

20. It is an instrument that consist of a heavy mass suspended on a spring and a rotating drum that records the motion.
a. accelerator c. barometer
b. seismograph d. speedometer

21. They contribute to a large number of earthquakes in the planet.
a. large landslide c. volcano eruption
b. meteorite impact d. movement of existing faults

22.The energy released from the hypocenter of an earthquake travels is called _____.
a. Rayleigh waves c. Love waves
b. Secondary waves d. Seismic waves

23. This plate occurs when two tectonic plates move away from each other.
a. transform c. divergent
b. convergent d. fault

24. How mountain is formed?
a. when each continental plate collides forming of collision of mountain belt.
b. when each oceanic plate collides forming of collision of mountain belt.
c. when each continental plate collides forming of a subduction zone.
d. when each oceanic plate collides forming of a subduction zone.

25. All are major tectonic plates in the world, except one.
a. African Plate c. Scotia Plate
b. Juan de Fuca Plate d. Korea Plate

26.What is the side of a mountain called?
a. arete c. slope
b. peak d. crag

27. What is the tallest mountain in the world?
a. Mount Fuji c. Mount Everest
b. Mount Kilimajaro d. Mount Olympus

28. According to the article, how tall must a geological formation be to be called a mountain?
a. 10 feet c. 1000 feet
b. 100 feet d. 10 000 feet

29. What type of mountains are formed when magma erupts all the way to the surface of the Earth?
a. Fold mountains c. Dome mountains
b. Volcanoes d. Fault- block mountains

30. What is the highest point of a mountain called?
a. arete c. slope
b. peak d. crag

Part III. Interview Guide.

1. What are your learning difficulties in learning Earth Science during this time of Pandemic?
2. In what ways do you believe these activities have influenced your ability to think creatively when working on Earth Science concepts or problems?
3. How do you feel your understanding of Earth Science concepts has improved because of these activities?
4. Do you believe the activities have contributed to your long-term retention of Earth Science knowledge?
5. Can you share some experiences while you conduct the experiments and activities using the Engineering Design Based Learning Activity Sheets.
6. Were there any challenges or difficulties you faced while engaging in these design-based activities?
7. In your opinion, how does learning through engineering design-based activities differ from traditional self-learning module in terms of enhancing creative thinking skills and understanding Earth Science concepts?
8. Looking back on your experiences with these activities, how do you feel they have impacted your overall learning in Earth Science?