

Science Teacher Approach Through Design Thinking Process Based Learning Materials on the Students' Scientific Literacy and Critical Thinking Skills

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Abstract—This study, titled "Science Teacher Approach Through Design Thinking Process Based Learning Materials on the Students' Scientific Literacy and Critical Thinking Skills" aimed to assess the effectiveness of the said approach on the improvement of students' scientific literacy and critical thinking skills in science. Specifically, it sought to answer the level of science teacher approach through design thinking process based, scientific literacy, and critical thinking skills. The study also aimed to determine the significant relationship between the science teacher approach through design thinking process-based learning materials on students' scientific literacy, and its significant effects on the students' critical thinking skills. The researcher employed a descriptive-experimental research method in conducting this study. The respondents of the study are one hundred twenty (120) students who were selected purposively. To analyze the collective data from the respondents, the research instruments, including learning materials, a self-made survey questionnaire, and assessments, were validated by the experts. The instruments used in the study are the mean, standard deviation, Multiple Regression using Pearson Product Correlation Coefficient or Pearson-r and T-Test. The findings indicate that the level of science teacher approach through design thinking process-based learning materials used by the learners was interpreted as Very High. Next, the level of students' scientific literacy was also interpreted as Very High. In terms of the level of students' critical thinking skills were all rated as Very Satisfactory. The science teacher approach through design thinking process-based learning materials shows a significant relationship with scientific literacy in science. Lastly, the study also showed that there is no significant effect between the science teacher approach through design thinking process-based learning materials and critical thinking skills. Based on the finding of the study, there is a significant relationship between the science teacher approach through design thinking process-based learning materials thus the null hypothesis was rejected. The results confirm that the learning materials on the design thinking process greatly enhance students' scientific literacy in all areas. However, the study also showed that there is no significant effect between the science teacher approach through design thinking process-based learning materials and critical thinking skills; the null hypothesis was accepted. This implies that the learning materials have no impact on the critical thinking skills of the students. The recommendation suggests that the design thinking process can be continuously improved and developed, and the local environment can be included in learning activities that foster critical thinking, scientific understanding, and problem-solving abilities. Future researchers are encouraged to have a deeper investigation on the use of design thinking in teaching and examine its effect on other variables such as students' motivation and engagements.

Keywords— Approach, Design Thinking Process, learning materials, scientific literacy, critical thinking skills

I. INTRODUCTION

In the 21st century, the definition of education has not only been defined as the pursuit of knowledge; rather, it is the process by which important skills like scientific literacy and critical thinking are learned. Scientific literacy refers to the understanding, application of, and formulation of data using scientific knowledge. Critical thinking, on the other hand, refers to the generation of new ideas or concepts based on analysis of data (Baldonaza & Santos, 2024). These capabilities are essential in preparing students to strive beyond the classroom setting.

Scientific literacy skills are essential for developing students' critical thinking skills, as they enable students to comprehend and resolve real-world issues (Hamdani et al. 2022; Muzana et al. 2021). Developing critical thinking abilities is crucial for success in the classroom and in the workplace (Shaw et al. 2020). Critical thinking is fundamental for making informed judgments about complex challenges, particularly in scientific learning, as it enables the assessment of facts and concepts through decision-making and logical reasoning (Faridi et al. 2021). As a result of enhancing the scientific literacy of the students, the critical thinking skills of the students are also developed by exposing them to apply knowledge in a real-world scenario, analyze and evaluate existing knowledge, and be able to create new ideas from the previous knowledge.

However, even with a change in curriculum and the implementation of a learner-centered approach, many students continue to show difficulty in applying scientific knowledge and showcasing higher-order thinking skills. Traditional approaches have been criticized for its lack on producing a classroom environment that foster critical thinking and application of knowledge. Since teaching approaches remain teacher-centered, the main focus is on the content delivery of the lesson rather than meaningful learning experiences of the students (Serin, 2018). This gap underscores the demand for innovative instruction to strengthen students' scientific literacy and critical thinking.

To enhance scientific literacy and critical thinking skills, students must always be exposed to a teaching approach based on learning materials that will enhance their ability to apply their knowledge of scientific concepts and think critically. One

of the approaches is the integration of the science teacher approach through design thinking process based learning materials. In this approach, the role of the teacher will be facilitating and guiding students to participate in guided learning activities utilizing the stages in design thinking, which includes empathizing, defining, ideating, prototyping, and testing, in order to create a learning material in science. The Design Thinking method of problem-solving is characterized by human-centered solutions, where there is an emphasis on empathy, collaboration, and iterative process (Razzouk & Shute, 2016).

Therefore, this study aims to investigate how science teachers approach using Design Thinking process based learning materials in enhancing the scientific literacy and critical thinking skills. The researcher seeks to contribute to innovative pedagogical learning that strengthens the foundational skills and also promotes critical thinking, collaboration, and creative thinking essential for 21st-century skills.

1.1 Statement of the Problem

Problem/s which were addressed by the research

This study aimed to determine the effectiveness of the science teacher approach through Design Thinking process-based learning materials on the scientific literacy and critical thinking skills of the students.

This study sought to answer the following questions:

1. What is the level of Science Teacher Approach Through Design Thinking Process Based Learning Materials in terms of:
 - 1.1 Empathy Stage;
 - 1.2 Define Stage;
 - 1.3 Ideate Stage;
 - 1.4 Prototype Stage; and
 - 1.5 Testing Stage?
2. What is the level of students’ scientific literacy in science in terms of:
 - 2.1 Scientific vocabulary;
 - 2.2 Scientific knowledge;
 - 2.3 Application of scientific knowledge; and
 - 2.4 Scientific Understanding?
3. What is the level of students’ critical thinking skills in science in terms of:
 - 3.1 Applying;
 - 3.2 Analyzing;
 - 3.3 Evaluating; and
 - 3.4 Creating?
4. Is there a significant relationship between the use of Science Teacher Approach Through Design Thinking Process Based Learning Material on students’ scientific literacy?
5. Is there a significant effect between the use Science Teacher Approach Through Design Thinking Process Based Learning Material on students’ critical thinking skills?

II. METHODOLOGY

The researcher employed a descriptive-experimental research method in conducting this study. The respondents of the study are one hundred twenty (120) students who were

selected purposively. To analyze the collective data from the respondents, the research instruments, including learning materials, a self-made survey questionnaire, and assessments, were validated by the experts. The instruments used in the study are the mean, standard deviation, Multiple Regression using Pearson Product Correlation Coefficient or Pearson-r and T-Test..

III. RESULTS AND DISCUSSION

This chapter discussed the presentation, interpretation, and analysis of data gathered to answer the sub-problem relative to the main problem of this study. This part discusses the findings of the study based on the questions.

The findings aim to assess the utilization of science teacher approach through Design Thinking process-based learning materials in promoting scientific literacy and critical thinking skills. Tables included in this chapter provide a visual representation and clarity to the data trends. Furthermore, interpretations are provided to explain how learners responded to the instructional interventions and whether a meaningful correlation exists between on their scientific literacy and demonstrate ability in critical thinking skills. The chapter also compares the results to existing literature and highlights key implications for classroom instruction and future research.

Level of Design Thinking Process Based Material

In this study, the level of Science Teacher Approach Through Design Thinking Process Based Learning Material refers to Empathy Stage; Define Stage; Ideate Stage; Prototype Stage; and Testing Stage.

The level of Science Teacher Approach Through Design Thinking Process Based Learning Materials was revealed in the following table, which shows the statement, mean, standard deviation, remarks, and verbal interpretation.

Table 1 show the level of Science Teacher Approach Through Design Thinking Process Based Learning Material in terms of Empathy Stage.

Table 1. Level of Science Teacher Approach through Design Thinking Process Based Learning Material in terms of Empathy Stage

Statement	Mean	SD	Remarks
Science Teacher Approach through the Design Thinking process based materials it ...			
... help me express my ideas clearly using appropriate scientific terminology.	4.44	0.71	Strongly Agree
... support my understanding of the problem by considering and analyzing the perspective of others.	4.25	0.75	Strongly Agree
... guide me in developing empathy and compassion toward individuals affected by the issue.	4.35	0.66	Strongly Agree
... allow me to connect my feelings and emotional responses with relevant scientific concepts and knowledge	4.28	0.72	Strongly Agree
... Feelings are valued when I share ideas related to scientific knowledge	4.34	0.72	Strongly Agree
Weighted Mean	4.33		
SD	0.71		
Verbal Interpretation			Very High

Table 1 shows the result of the level of science teacher approach through design thinking process-based learning

materials in terms of empathy stage. The most rated indicator is help me expressing ideas clearly using appropriate scientific terminology, with a mean of (M= 4.44, SD = 0.71), with a Strongly Agree written interpretation. It shows that students felt more capable of clearly expressing ideas by identifying what they think, feel, say and do in the given situation, which is important for communicating scientific ideas, and understand an environmental problem. In contrast, support my understanding of the problem by considering and analyzing the perspectives of others got a lower rating, which got a mean of 4.25 (SD = 0.75) but still had a Strongly Agree rating. It is possible due to students having less prior experience in perspective-taking and collaboration, which are component of empathy. While the materials appear to use the skills in expressing ideas that requires deeper social and empathy analysis.

Overall, the findings shows that the weighted mean average of 4.33 and a standard deviation of 0.71 with a verbal interpretation of Very High indicating that the science teacher approach during the empathy stage is highly effective. This means that using the learning materials it was successfully foster students' ability to express their emotions and feelings using scientific terminology and understand problems by considering others' perspective by answering activities such as empathy mapping, weather emotion cards, and concluding reaction. These types of activity enable students to give their honest opinion and reaction based on their experience. However, even though they are capable of expressing their feelings and emotions, students need a more structure empathy activities that will help students to analyze and understand opinions of other. Generally, the result shows that in empathy stage it successfully developed students' ability to express ideas and understand problems based on each other's' perspective.

This section, table 2, shows the result on the level of science teacher approach through design thinking process-based learning materials used by students, in terms of define stage with a focus on identifying a problem. It emphasizes how to identify, organize and think critically in solving scientific problems.

Table 2. Level of Science Teacher Approach through Design Thinking Process Based Learning Material in terms of Define Stage

Statement	Mean	SD	Remarks
Science Teacher Approach through the Design Thinking process based materials it			
...			
... guide me in identifying the main problem in a scientific issue.	4.36	0.74	Strongly Agree
... assist me to organize information to understand the issue.	4.31	0.70	Strongly Agree
... enable me to determine the causes of the problem.	4.38	0.70	Strongly Agree
... allow me to think critically and identify problems scientifically.	4.30	0.72	Strongly Agree
... develop my skills in identifying scientific problem.	4.43	0.72	Strongly Agree
Weighted Mean	4.35		
SD	0.71		
Verbal Interpretation	Very High		

Table 2 presents the results of the science teacher approach through design thinking process-based learning materials used, during the define stage. The most rated indicator is developing my skills in identifying scientific problems, with a mean of (M= 4.43, SD = 0.72), with a Strongly Agree written interpretation. It shows that using the materials, students were clearly able to recognize problems and defining scientific issues using different activities in the learning materials such as mind mapping and phenomena analysis. In mind mapping, students were task to list all the information and important data from each other's perspective, and phenomena analysis helped them to explain the cause and effects of a certain climatic factor. While the least rated indicator allows me to think critically and identify problems scientifically, with a mean of (M = 3.30, SD = 0.72) but still had a Strongly Agree rating. This means that although the students know how to identify problems using the mind map and identifying cause and effect, but it indicates that students need more deeper support in critical analysis and providing a more structured and guided activities. It is recommended to provide various activities that will help learners to think deeply such a graph analysis.

Therefore, the results indicate that the science teacher approach through design thinking process-based learning materials in terms of define stage has an interpretation of Vey High, as reflected by the weighted mean average (M = 4.35, SD = 0.71), indicating that it was effective in supporting students in identifying, organizing, and analyzing the problem and its cause on the define stage. Despite this, for the students to help clarify and analyze the identified problems, they must be provided a more critically structured and guided activities such as graph analysis that will promote more on their critical thinking skills. Overall, the result shows in the define stage it effectively enhances students' ability to identify problems based on the experiences provided on the empathy stage.

This section, Table 3, present the result on the level of science teacher approach through design thinking process-based learning materials in terms of Ideate stage. It focuses on the exchanging ideas in the form of brainstorming, evaluating different solutions, and combining scientific knowledge into a creative idea.

Table 3. Level of Science Teacher Approach Through Design Thinking Process Based Materials in terms of Ideate Stage

Statement	Mean	SD	Remarks
Science Teacher Approach through the Design Thinking process based materials it			
...			
... inspire me to exchange ideas based on scientific knowledge.	4.38	0.74	Strongly Agree
... guide me to critically evaluate different solutions before choosing.	4.27	0.72	Strongly Agree
... give me an opportunity to think outside the box.	4.34	0.70	Strongly Agree
... encourage me to brainstorm problem-solving ideas.	4.26	0.68	Strongly Agree
... help me combine scientific knowledge into a creative idea.	4.33	0.69	Strongly Agree
Weighted Mean	4.32		
SD	0.70		
Verbal Interpretation	Very High		

The data, Table 3, shows the results of the science teacher approach through design thinking process-based learning materials used, during the ideate stage. The most rated indicator inspired me to exchange ideas based on scientific knowledge, with a mean of 4.38 (SD = 0.74), with a Strongly Agree interpretation. Implying that the materials help students to communicate with others to exchange ideas using a collaborative activity. Since the design thinking process-based materials promotes collaborative learning specifically from define to testing stage. This proves that students are being able to express ideas and share their experiences through different kinds of activity. While the least rated indicator encouraged me to brainstorm problem-solving ideas (M = 4.26, SD = 0.68) but still had a Strongly Agree rating. This means that students must be expose more on structured brainstorming activities that are completely engaging, such as mind mapping.

This indicate that the overall concept of the materials is Very High, as reflected by the weighted mean average of 4.32 and a standard deviation of 0.70, which means that through the materials promote creativity and idea generation among students. Activities on the ideate stage includes the identifying the negative impacts and brainstorming on the pros and cons of using geothermal powerplant, beneficial effects and possible problems on volcanic eruption and mitigation and adaptation on climatic phenomena. In conclusion, these activity shows that the science teacher approach in ideate stage enhances students collaborative thinking and creative idea generation. This proves that from starting the activity from sharing their experiences, emotions and feelings from empathy stage helps them to conceptualize the problems and identify the best possible solution. At the same time, giving them a more engaging activity that will help to analyze and create solutions based on the identified problems.

Table 4 shows the evaluation process on the level of science teacher approach through design thinking process-based learning materials in terms of prototype stage. In this section, it focuses on guiding students in developing a prototype based on the ideas gathered from the ideate stage

Table 4. Level of Science Teacher Approach Through Design Thinking Process Based Material in terms of Prototype Stage

Statement	Mean	SD	Remarks
Science Teacher Approach through the Design Thinking process based materials it ...			
... guide me in applying scientific knowledge in creating models, plans, or drawings.	4.40	0.68	Strongly Agree
... enable me to develop solutions grounded in scientific knowledge and generate new ideas.	4.23	0.74	Strongly Agree
... show me how scientific ideas can be turned into real-life solutions.	4.34	0.65	Strongly Agree
... improve my ability to demonstrate knowledge through real-life applications.	4.33	0.71	Strongly Agree
... help me collaborate with my groups to create models, plans, or drawings.	4.35	0.68	Strongly Agree
Weighted Mean	4.33		
SD	0.69		
Verbal Interpretation			Very High

The table shows that the indicator 1, guide me in applying scientific knowledge in creating models, plans, or drawings, has the most rated with a mean of 4.40 and a standard deviation of 0.68, Strongly Agree, showing that students are able to apply conceptual knowledge into a practical output while guiding them. This illustrates how well the materials connect scientific information with real-world application, which is crucial in experiencing and constructivist learning. This was evident on the activities in the prototype stage, in which the students produced output such as infographic making for awareness dissemination, preparedness campaign on the awareness of natural phenomena such as volcanic eruption and climate change. While indicator 2, enable me to develop solutions grounded in scientific knowledge and generate new ideas, got the lowest mean of 4.23 (SD = 0.74) but still interpreted as Strongly Agree. This implies that even if students may apply what they have learned, they could still need extra support to come up with creative or innovative ideas. It is possible that rather than creating original output on their own, students rely more on guided examples. This suggest that some students still need structured learning activities, where there are examples given and well-structured instructions must be provided. It also exhibits the creativity of every student in making a plans or models of their developed solutions.

The science teacher approach in prototype stage has a weighted mean of 4.33 and a standard deviation of 0.69, indicates that it is with great extent in supporting students in applying scientific knowledge in creating the best possible solutions. Generally, the results show the prototype stage in the science teacher approach through design thinking process-based learning materials effectively enhances students' ability to apply their understanding of science knowledge into a concrete real-life solution to a scientific problem.

This section, Table 5, present the level of science teacher approach through design thinking process-based learning materials in terms of testing stage. This part emphasizes the application of scientific knowledge in presenting the prototype.

Table 5. Level of Science Teacher Approach Through Design Thinking Process Based Learning Materials in terms of Testing Stage

Statement	Mean	SD	Remarks
Science Teacher Approach through the Design Thinking process based materials it ...			
... help me explain my prototype using scientific knowledge.	4.42	0.72	Strongly Agree
... evaluate my application of scientific ideas to the prototypes.	4.35	0.63	Strongly Agree
... develop my ability to analyze and think critically to evaluate my prototype.	4.38	0.72	Strongly Agree
... guide me improve my prototype based on others feedback or evaluation.	4.32	0.67	Strongly Agree
... give me confidence when presenting my prototype to other students.	4.33	0.76	Strongly Agree
Weighted Mean	4.36		
SD	0.70		
Verbal Interpretation			Very High

The table 5 reveals that indicator 1, help me explain prototype using scientific knowledge, got the highest mean score of (M = 4.42, SD = 0.72), Strongly Agree interpretation, which demonstrate that students feel more confident to explain their output because students know how to use the word correctly in the oral presentation. Adding the vocabulary words in the learning materials greatly help the students to understand easily the terminologies given on the lesson. With this, they know how to justify their output using scientific knowledge. While, guide me improve my prototype based on others feedback or evaluation, the lowest mean was (M = 4.32, SD = 0.67), although still Strongly Agree. This may imply that students are not used on receiving constructive feedback, this may possible due to lack of peer-evaluation assessment. During the learning process, one of the good practices is providing feedback to the students, either from the teacher, classmates, or from themselves.

This means that the science teacher approach used in the testing stage has an overall rating of Very High on the learning materials, with a weighted mean of 4.36 and a standard deviation of 0.70, in presenting the prototype grounded by scientific ideas and be able to critically analyze and evaluate feedback. However, while students can explain prototype using scientific knowledge, the utilization of the teacher’s approach through learning materials may be enhanced by integrating a well-structured peer-evaluation system that helped them improve their output. Since the design thinking process-based materials provided only an oral feedback on the presentation of the output, the must include a self-assessment and peer-assessment for them to get used to giving and receiving feedback to improve their prototype.

Level of Students’ Scientific Literacy in Science

In this study, the level of Students’ Scientific Literacy in Science refers to Scientific Vocabulary; Scientific Knowledge; Application of Scientific Knowledge; and Scientific Understanding. These indicators were then used to assess students’ comprehension, application, and interpretation of science concepts. The results provide a broad overview of students’ performance levels across every aspect of scientific literacy.

The level of Students’ Scientific Literacy in Science was revealed in the following table, which shows the statement, mean, standard deviation, remarks, and verbal interpretation. Table 6 show the level of Students’ Scientific Literacy in Science in terms of Scientific Vocabulary.

The level of scientific literacy in terms of scientific vocabulary is outlined in table 5. This shows that remembering scientific terms easily has a highest mean of 4.44 and a standard deviation of 0.71, with a remark of Strongly Agree, indicating that the science teacher approach utilizing the design thinking process-based learning materials effectively enhance the retention of scientific vocabulary through repetitive usage of the scientific terms on every activity. From the empathy to testing stage, the scientific terms were to connect students’ experiences to the correct meanings of scientific words, allowing them to properly apply these concepts in recognizing problem and formulating solutions.

Which are fundamental in building a strong foundation of knowledge for understanding scientific concepts. In contrary, engaging me to use scientific terms when collaborating with my classmates has a lowest mean of (M = 4.25, SD = 0.70), but still with a remark of Strongly Agree, indicates that although it enhances the retention and understanding of scientific terms students may not consistently apply it in collaborative or conversational contexts.

Table 6. Level of Students’ Scientific Literacy in Science in terms of Scientific Vocabulary

Statement	Mean	SD	Remarks
The Science Teacher Approach Through Design Thinking process based learning materials enhance my scientific literacy through ...			
... understanding the meaning of each scientific term.	4.42	0.71	Strongly Agree
... improving my ability to use scientific vocabulary in answering the activity.	4.36	0.68	Strongly Agree
... relating scientific terms to real-life situations.	4.27	0.74	Strongly Agree
... engaging me to use scientific terms when ... collaborating with my classmates.	4.25	0.70	Strongly Agree
... remembering scientific terms easily.	4.44	0.71	Strongly Agree
Weighted Mean	4.35		
SD	0.71		
Verbal Interpretation			Very High

This imply that the science teacher approach through design thinking process based learning materials effectively improve the students’ scientific literacy in terms of scientific vocabulary with an overall weighted mean of (M = 4.35, SD = 0.71), with a verbal interpretation of Very High, which means that the integration of the design thinking on the learning materials help students to build a strong foundational knowledge by remembering and understanding the meaning of each scientific terms and use it in answering activity. This is evident on the materials that shows that before answering an activity, vocabulary words must be presented first in order for the students to look back the meaning of each word to easily understand the activity.

Table 7 show the level of Students’ Scientific Literacy in terms of Scientific Knowledge. It focuses on the understanding the science concepts and connecting existing ideas into new ideas to create clear scientific statements.

Table 7 shows the level of students’ scientific literacy in terms of scientific knowledge. This depicts that indicator 3, improving my understanding of how sciences are applied to real-world scenarios, has the most rated indicator with a mean of (M = 4.46, SD = 0.66) with a remark of Strongly Agree. This demonstrate that students are able to understand science concepts. It was showed through an informative article that includes contextual problems that introduced before the empathy and define stages and applied in the prototype and testing stages. This is important in promoting meaningful learning, since students able to see the importance of science outside classroom setting and able to connect it into real-life situations. On the other hand, developing my ability to identify cause-and-effect relationships, had the lowest mean (M = 4.28, SD = 0.69), yet the remarks were Strongly Agree. This means

that although students demonstrated a strong understanding of the concept, their ability to identify the cause-and-effect relationship may further need a development. This means that integrating an activity such as scenario-based analysis and open-ended task within the science teacher approach through design thinking process-based learning materials helped them to develop critical thinking skills such as analyzing and reasoning.

Table 7. Level of Students' Scientific Literacy in Science in terms of Scientific Knowledge

Statement	Mean	SD	Remarks
The Science Teacher Approach Through Design Thinking process based learning materials enhance my scientific literacy through ...			
... deepen my understanding of science concepts.	4.41	0.65	Strongly Agree
... connecting ideas from the past into a new idea.	4.41	0.68	Strongly Agree
... improving my understanding of how sciences are applied to real-world scenarios.	4.46	0.66	Strongly Agree
... creating clear scientific statements.	4.45	0.68	Strongly Agree
... developing my ability to identify cause-and-effect relationships.	4.28	0.69	Strongly Agree
Weighted Mean	4.40		
SD	0.67		
Verbal Interpretation			Very High

Overall, the table shows that the level of students' scientific literacy in science in terms of scientific knowledge has a verbal interpretation of Very High, with an overall mean of 4.40 and a standard deviation of 0.67. This implies that the level of students' scientific literacy in terms of scientific knowledge was evident on the science teacher approach in utilizing the design thinking process-based learning materials. This signifies that the process effectively enhanced the students' understanding of scientific knowledge and apply it by answering the activities on the learning materials.

Through the stages of design thinking process such as empathy, define, ideate, prototype and testing stage, students are guided to engage on what they know but also on how they are going to use the knowledge in real-world context to solve environmental problems. Additionally, giving them support on the development of their critical thinking skills, students must be given a more analytic and logical reasoning activity in developing the cause-and-effect relationship.

Table 8 shows the level of students' scientific literacy in science in terms of application of scientific knowledge that focuses on the applying scientific concepts in finding solutions to solve real-world problems.

The table presented the highest rated indicator is the relating scientific knowledge into environmental issues or concerns (M = 4.46, SD = 0.65), with a remark of Strongly Agree. This indicates that science teacher approach through design thinking process-based learning materials successfully bridge the gap of classroom learning and environmental concerns, as a sense of promoting scientific responsibilities. Which means they are able to relate the importance of addressing environmental issues, which is a component of a

scientific literacy. Ideate and prototype stage signify the application of what they have learned to design solution. On the other hand, even though it represents a Strongly Agree interpretation, creating a plan to solve problems, has a lowest mean of (M = 4.29, SD = 0.74). This confirm that the teacher approach and materials helpfully develop planning and application skills some students find this shift from understanding the concept into creating a solution more challenging than relating the knowledge into real-life application.

Table 8. Level of Students' Scientific Literacy in Science in terms of Application of Scientific Knowledge

Statement	Mean	SD	Remarks
The Science Teacher Approach Through Design Thinking process based learning materials enhance my scientific literacy through ...			
... applying scientific knowledge to real-life situations.	4.43	0.68	Strongly Agree
... using scientific findings to solve problems.	4.33	0.78	Strongly Agree
...relating scientific knowledge into environmental issues or concern.	4.46	0.65	Strongly Agree
... engaging myself in formulating solutions to solve environmental problems.	4.33	0.69	Strongly Agree
... creating a plan to solve problems.	4.29	0.74	Strongly Agree
Weighted Mean	4.37		
SD	0.71		
Verbal Interpretation			Very High

The table reveals the level of students' scientific literacy skills in science in terms of application of scientific knowledge with an overall verbal interpretation of Very High and a weighted mean of 4.37 and a standard deviation of 0.71. This means that using design thinking process as a teacher's approach, through the implementation of design thinking process-based learning materials highly enhance the application of scientific knowledge through the ideate and prototype stage in the design thinking process-based materials. This part of the learning materials showcases the ability of the students to connect and apply their understanding of scientific knowledge into formulating a concrete solution to environmental problems, which are important in enhancing the literacy skills of every student.

Table 9 shows the level of students' scientific literacy in terms of application of scientific understanding that focuses on understanding scientific ideas and be able to use it to form new ideas.

The table shows the level of students' scientific literacy in terms of scientific understanding and it shows that the indicator 3, understanding science concepts, has a highest mean of 4.44 with a standard deviation of 0.75, indicating a Strongly Agree on remarks. This indicates that the main strength of the science teacher approach through design thinking process-based learning materials is a strong foundation of fundamental ideas that shows on the define stage of the learning materials, where the students be able to identify problems based on the how they understand of scientific concepts and they are going to use it in the activity. Additionally, the materials incorporate supportive features

such as information articles and vocabulary area, which further enhances the scientific understanding. This feature help students to grasps difficult scientific terms and clarify ideas. In contrast, the indicator 3, creating new ideas based on the existing knowledge, got the lowest mean of (M = 4.33, SD = 0.70, but still interpreted as Strongly Agree, implies that students understand the concept well, however, ideate stage, the act of turning existing ideas into a new established form of ideas, became more challenging to them because their critical thinking skills are still developing.

Table 9. Level of Students' Scientific Literacy in Science in terms of Scientific Understanding

Statement	Mean	SD	Remarks
The Science Teacher Approach through Design Thinking process based materials enhance my scientific literacy through ...			
... understanding science concepts.	4.44	0.75	Strongly Agree
... improving my ability to explain science concepts using my own words.	4.38	0.70	Strongly Agree
... creating new ideas based on the existing knowledge.	4.33	0.70	Strongly Agree
... applying what I learned to solve real-world problems.	4.43	0.63	Strongly Agree
... thinking critically when formulating a solution.	4.38	0.72	Strongly Agree
Weighted Mean	4.39		
SD	0.70		
Verbal Interpretation	Very High		

Hence, the table shows that the level of students' scientific literacy in terms of scientific understanding has an overall rating of (M = 4.39, SD = 0.70), verbally interpreted as Very High. This shows that the learning materials truly enhances the scientific understanding of each student. This finding also implies that although the students show a mastery of the concept, incorporating a more brainstorming activities, collaborative task and guided activities to bridge the gap between understanding and creating new ideas based on the existing knowledge.

Level of Students' Critical Thinking Skills in Science

Table 10 shows the level of students' critical thinking skills in science in terms of applying. This data focuses on the use of scientific concepts in real-world situations.

This section shows the Level of Students' Critical Thinking Skills in Science in terms of applying, analyzing, evaluating, and creating. This focus on the critical development through the approach.

Table 10. Level of Students' Critical Thinking Skills in Science in terms of Applying

Raw Score	Frequency (f)	Percentage (%)	Descriptive Equivalent
13-15	77	64.17	Outstanding
10-12	41	34.17	Very Satisfactory
7-9	2	1.67	Satisfactory
4-6	0	0	Fair
1-3	0	0	Needs Improvement
	120	100	Very Satisfactory

Mean=12.88 SD=1.26 VI=VS

The table shows the level of critical thinking skills in terms of applying. The majority of the students, totaling of 77

students (64.17%), achieved a raw score of between 13 - 15 with an Outstanding verbal interpretation, while 41 students (34.17%) are classified as Very Satisfactory. This indicates that a significant portion of the students has mastered the ability to use scientific knowledge into practical applications. This proves by exposing them on teacher's approach through design thinking from empathy to testing activities. In the empathy, they relate their experience on prior knowledge to define a community-based problem. Define stage, use to identify and investigate these problems. Moreover, ideate and prototype, students used to relate these problems in making solutions. Lastly, testing stage, in which they're going to present and evaluate data to improve their solutions. On the other hand, 1.67% (2 students) got a score of between 7 - 9, which rated as Satisfactory, and no one classified on the lower level. Indicating the students know how to apply scientific understanding into practice.

Overall, the students' level of critical thinking in terms of applying has mean of 12.88 (SD = 1.26), with a Very Satisfactory result means that the students demonstrate a strong competency on the understanding scientific concept and its application in to real-life problems. In this regard, the science teacher approach through design thinking processed based learning materials foster the application of knowledge on students from the empathy to testing stage, whereas the students share their experiences and emotions then used it to define and analyze problems, collaborate and fins solution to those specific problems.

The table 11 present the level of students critical thinking skills in science in terms of analyzing. This data emphasizes on how the students be able to break down complex ideas into smaller ones to understand the concept and be able to form new complete idea to solve the problem.

Table 11. Level of Students' Critical Thinking Skills in Science in terms of Analyzing

Raw Score	Frequency (f)	Percentage (%)	Descriptive Equivalent
13-15	72	60	Outstanding
10-12	45	37.5	Very Satisfactory
7-9	3	2.5	Satisfactory
4-6	0	0	Fair
1-3	0	0	Needs Improvement
	120	100	Very Satisfactory

Mean=12.82 SD=1.47 VI=VS

The table indicates the level of students critical thinking skills in science in terms of analyzing. It demonstrates that 60% (f = 72) of the students got a raw score of 13 - 15 with an Outstanding remark, while 37.5% (f = 45) of the students got a Very Satisfactory as a remark. Only 2.5% (f = 3) of the students are on the Satisfactory level, and no one are on below lower level. This suggests that students are excellent at analyzing relationships, identifying patterns, and analyzing difficult scientific ideas. Activities like concept mapping and problem-analysis, which ask students to consider causes and effects, are responsible for the performance level.

Overall, the level of students' critical thinking skills in terms of analyzing has a verbal interpretation of Very Satisfactory (M = 12.82, SD = 1.47). It indicates the science teacher approach through design thinking process-based

learning materials helped students improved their critical thinking skills specifically the analyzing skills. This skill is evident of the define stage of the materials, in which the students are able to breakdown complex information to produce new ideas that will be used to solve a problem. This high level of performance can be linked to the activities on the define and ideate stage such as concept mapping and problem analysis matrix, which required students to analyze the cause and effects, which enhances the analytical skills.

Table 12 present the level of students' critical thinking skills in science in terms of evaluating. This data emphasizes on how the students be able give good judgement to evaluate data and information they gather to form or create a new profound knowledge.

Table 12. Level of Students' Critical Thinking Skills in Science in terms of Evaluating

Raw Score	Frequency (f)	Percentage (%)	Descriptive Equivalent
13-15	62	51.67	Outstanding
10-12	56	46.67	Very Satisfactory
7-9	2	1.67	Satisfactory
4-6	0	0	Fair
1-3	0	0	Needs Improvement
	120	100	Very Satisfactory

Mean= 12.59 SD=1.147 VI=VS

This section shows that 51.67% (f = 62) of the students got a score between 13-15 with a highest remark of Outstanding, while 46.67% (f = 56) of the students got a raw score of 10-12, with a remark of Very Satisfactory, and 1.67% (f = 2) got a raw score of 7-9 has a verbal interpretation of Satisfactory, and none got classified as fair and needs improvement, this suggest that the students clearly possess a good impact on critical thinking skills specifically in evaluating. This denotes those students show a strong ability to evaluate and make judgements.

The table shows an overall rating of Very Satisfactory with a mean of 12.59 (SD = 1.47). This means the science teacher approach through design thinking process-based learning materials effectively enhances the students' ability to evaluate information. Specifically, it manifested on the ideate, prototype and testing stage, where the students be able to collaborate to make decisions, compare possible solutions, and justify their choices based on the information given. Through these activities, it prepares students to think critically. Moreover, it involves in providing feedback and evaluation to strengthen their ability to assess solutions.

Table 13 present the level of students' critical thinking skills in science in terms of creating. This section focusses on the process of putting all the ideas and information gathered to form a new functional idea.

Table 13. Level of Students' Critical Thinking Skills in Science in terms of Creating.

Raw Score	Frequency (f)	Percentage (%)	Descriptive Equivalent
13-15	50	41.67	Outstanding
10-12	69	57.5	Very Satisfactory
7-9	1	0.83	Satisfactory
4-6	0	0	Fair
1-3	0	0	Needs Improvement
	120	100	Very Satisfactory

Mean= 12.38 SD=1.20 VI=VS

The tables present the data from the level of students' critical thinking skills in terms of creating. A majority of the students, 57.50% (f = 69), fall in the category of Very Satisfactory, followed by 41.67% (f = 50), who have shown Outstanding performance. Only a very small percentage OF 0.83% (1), have shown Satisfactory performance. This shows that the students have highly developed skills in creative thinking, especially in the areas of creating new ideas and solutions to scientific problems.

The data reveals that the overall rating on the level of students' critical thinking skills in science in terms of creating is Very Satisfactory with a mean of (M = 12.38, SD = 1.20). This high level of performance implies that science teacher approach through design thinking process-based learning materials effectively promote students' capacity for creating. Activities involved such as making an evacuation plan, poster for mitigation and adaptation, and infographics for awareness helped the students to be creative. For instance, the design thinking process's support students to develop innovative ideas, design possible solutions, and improve their outputs accordingly. This gives students the chance to think creatively and utilize their knowledge in creating meaningful and innovative outputs. Additionally, the design thinking process's iterative nature enables students to improve their ideas, thus promoting their creativity in the field of science.

Significant Relationship Between the Science Teacher Approach Through Design Thinking Process Based Learning Materials and the Students' Scientific Literacy in Science

In this study, the Science Teacher Approach Through Design Thinking Process Based Learning Materials refers to Empathy Stage; Define Stage; Ideate Stage; Prototype Stage; and Testing Stage. Meanwhile, the Students' Scientific Literacy in Science refers to Scientific Vocabulary; Scientific Knowledge; Application of Scientific Knowledge; and Scientific Understanding.

The Significant Relationship Between the Science Teacher Approach Through Design Thinking Process Based Learning Materials and the Students' Scientific Literacy in Science was revealed in the following table, which shows the Pearson Product Moment Correlation Coefficient or Pearson-r, p-value, and number of observation or respondents.

Table 14 shows the Significant Relationship Between the Science Teacher Approach Through Design Thinking Process Based Learning Materials and the Students' Scientific Literacy in Science.

Table 14 presents the significant relationship between the science teacher approach design thinking process based learning materials across stages of empathy, define, ideate, prototype, and testing and the students' scientific literacy in four domains, scientific vocabulary, scientific knowledge, application of scientific knowledge, and scientific understanding. Pearson-r was used to determine its significant relationship, with a sample size of N = 120. A significance level of 0.05 was used to determine whether the observed effects are statistically significant.

The data reveals that design thinking process exhibit positive relationship and are statistically significant with a p-

value ranging from 0.000 to 0.001 on the different domains in the scientific literacy. In empathy stage, moderate relationship was observed between the application of scientific knowledge ($r = 4.20$) and scientific knowledge ($r = 4.03$), indicates understanding students' perspective and emotions enhances the ability of the students on scientific knowledge and its application on the real-life practices. However, scientific vocabulary ($r = 0.367$) and scientific understanding (0.289) have a lower relationship, this implies that although students enhance the ability to apply scientific knowledge using their perspectives, it is less effective in developing deeper conceptual understanding and mastery of scientific terms.

Table 14. Significant Relationship Between the Science Teacher Approach Through Design Thinking Process Based Learning Materials and the Students' Scientific Literacy in Science

Science Approach Design Process Materials	Teacher Students' Scientific Literacy in Science				
	Through Scientific Thinking Based	Scientific Vocabulary	Scientific Knowledge	Application of Scientific Knowledge	Scientific Understanding
Empathy Stage	Pearson Correlation	0.367*	0.403*	0.420*	0.289*
	Sig. (2-tailed)	0.000	0.000	0.000	0.001
	N	120	120	120	120
Define Stage;	Pearson Correlation	0.356*	0.299*	0.313*	0.182*
	Sig. (2-tailed)	0.000	0.001	0.000	0.046
	N	120	120	120	120
Ideate Stage	Pearson Correlation	0.365*	0.264*	0.430*	0.325*
	Sig. (2-tailed)	0.000	0.004	0.000	0.000
	N	120	120	120	120
Prototype Stage	Pearson Correlation	0.395*	0.236*	0.336*	0.400*
	Sig. (2-tailed)	0.000	0.009	0.000	0.000
	N	120	120	120	120
Testing Stage	Pearson Correlation	0.479*	0.442*	0.383*	0.374*
	Sig. (2-tailed)	0.000	0.000	0.000	0.000
	N	120	120	120	120

In define stage, the results show a generally lower relationship in all four domains of scientific literacy—scientific vocabulary ($r = 0.365$, $p = 0.000$), application of scientific knowledge ($r = 3.13$, $p = 0.000$), scientific knowledge (0.299 , $p = 0.001$), and scientific understanding ($r = 1.82$, $p = 0.046$). While the relationships are all significant it appears that scientific understanding have the lowest correlation among the four. This means that incorporating the scientific vocabulary alone may deepen the scientific understanding of students.

In ideate stage, the table shows a moderate relationship with application of scientific knowledge has the strongest ($r = 0.430$, $p = 0.000$), which means that generating and collaborating ideas enhances the creative application and understanding of the terms, promoting a higher-order thinking

skill. In addition, scientific vocabulary ($r = 0.365$, $p = 0.000$) and scientific understanding (0.325 , $p = 0.000$) also shows a moderate relationship, indicating that creating new ideas support both communication and comprehension of scientific concept that are essential in brainstorming. Although, the four domains of scientific literacy and design thinking process are all significantly related, scientific knowledge ($r = 0.264$, $p = 0.004$) got the lowest relationship implies that strengthening students' acquisition of factual and conceptual scientific knowledge is considerably less of its focus.

While in prototype stage, it presents a generally moderate relationship but comparatively lower relationship among the variables. However scientific understanding ($r = 400$, $p = 0.000$) and scientific vocabulary ($r = 0.395$, $p = 0.000$) got the strongest relationship among the four. This indicates that creating a solution based from their idea generation helps students to have a deeper understanding of the scientific concept that will show on the prototypes made by the students. On the other hand, application of scientific knowledge ($r = 336$, $p = 0.000$) and scientific knowledge ($r = 236$, $p = 0.009$) shows a relatively lower relationship. This suggest that while the prototype stage foster students' scientific vocabulary and factual understanding, it is less effective in applying scientific knowledge.

Lastly, the Testing Stage shows the highest correlations in all areas, including scientific vocabulary ($r = 0.479$), scientific knowledge ($r = 0.442$), the application of scientific knowledge ($r = 0.383$), and scientific understanding ($r = 0.374$). This demonstrates the significance of the evaluation, testing, and solution-refinement processes in raising students overall scientific literacy. It demonstrates the significance of reflection and learning processes in improving comprehension, information retention, and the application of concepts in practical contexts.

The findings confirm that the science teacher approach through design thinking process-based learning materials significantly improves students' scientific literacy across all domains. It shows that in every stage of design thinking contributes meaningfully to enhance the scientific literacy of the students. Specifically, focus on both conceptual and applied knowledge, where the students start the learning from identifying each other's perspective and will use it to identify problems to create a concrete solution. In addition, testing stage shows a strongest influence on the scientific literacy, indicating that presenting the prototype shows the process of learning from identifying a problem to idea generation. It also implies that reflection and evaluation are also critical in developing scientific literacy because students learn beyond simply applying the knowledge toward a higher order thinking, where they critically examine and justify their understanding. Additionally, the strongest correlation among the areas is found in the application of scientific knowledge, since the science teacher approach through design thinking process-based learning materials emphasizes not only the conceptual knowledge but actively using the knowledge to create and solve real-life problems. It also shows the increasing strength from the empathy stage to testing stage and that students deeper learning as they engage in creating and

evaluating solutions. In conclusion, since all of the areas shows that a $p > 0.05$, the null hypothesis is rejected. There is a significant relationship between the science teacher approach through design thinking process-based learning materials and students' scientific literacy.

Significant Effect Between the Science Teacher Approach Through Design Thinking Process Based Learning Materials on the Students' Critical Thinking Skills in Science

In this study, the Science Teacher Approach Through Design Thinking Process Based Learning Material refers to Empathy Stage; Define Stage; Ideate Stage; Prototype Stage; and Testing Stage. Meanwhile, the Students' Critical Thinking Skills in Science refers to Applying; Analyzing; Evaluating; and Creating.

The significant effect between the variables were revealed in the following table, which shows the T -Test, with the computed t-value (t-cal), p-value, number of observations or respondents, and critical t-value (t-crit) or constant.

Table 15. Significant Effect Between the Science Teacher Approach Through Design Thinking Process Based Learning Materials on the Students' Critical Thinking Skills in Science

Science Teacher Approach Through Students' Critical Thinking Skills in Design Thinking Process Based Science Learning Materials	Applying Analyzing Evaluating Creating				
	t-value	0.279	1.522	-1.459	-0.537
Empathy Stage	Sig. (2-tailed)	0.781	0.131	0.147	0.592
	N	120	120	120	120
Define Stage	t-value	0.771	1.794	-0.900	1.307
	Sig. (2-tailed)	0.442	0.075	0.370	0.194
	N	120	120	120	120
Ideate Stage	t-value	-0.890	0.073	-0.691	-0.889
	Sig. (2-tailed)	0.375	0.942	0.491	0.376
	N	120	120	120	120
Prototype Stage	t-value	1.706	1.412	0.202	-0.513
	Sig. (2-tailed)	0.091	0.161	0.840	0.609
	N	120	120	120	120
Testing Stage	t-value	0.712	1.483	-0.469	-1.632
	Sig. (2-tailed)	0.478	0.141	0.640	0.105
	N	120	120	120	120

Table 15 presents the significant effect between the science teacher approach through design thinking-based learning materials across stages of empathy, define, ideate, prototype, and testing and the students' critical thinking skills in science in particularly in applying, analyzing, evaluating, and creating. T-test was used to determine its significant effect, with a sample size of $N = 120$. The data include the t-value and a significance level of 0.05 was used to determine whether the observed effects are statistically significant.

The finding indicates that the variables does not have a significant effect on students' critical thinking skills in science across all areas. This implies that all p-values are greater than 0.05 ($p > 0.05$). Furthermore, the t-values (ranging from -1.632 – 1.794) did not exceed the critical t-value of 1.980. While the design thinking process exhibits a potential, still it has no effect on the students' critical thinking skills. This means that the development of critical thinking skills may depend on

other factors such as duration of exposure, and students' prior engagement on activities on critical thinking abilities. It is also possible that the implementation period was not long enough to foster the critical thinking skills of the students. It can also conclude that there is a mismatch of activities and skilled measure on the design thinking process, therefore there is a need on further enhancement of well-structured activity. Another factor that contributes is the students already possess a high level of critical thinking skills that showed on the previous tables. However, some stages of design thinking process show a relatively higher t-values in terms of define and prototype stage implies that it may have an emerging influence, but still, it did not reach the level of critical value ($t\text{-crit} = 1.980$).

IV. CONCLUSION AND RECOMMENDATIONS

There is a significant relationship between the science teacher's approach through design thinking process based learning materials and students' scientific literacy in science, leading to the rejection of the hypothesis. This means that in the design thinking process based on materials, students did not only memorize concepts but they are deepening their scientific vocabulary and scientific understanding because they are applying the concepts to solve problems.

There is no significant effect on the use of design thinking process based material on students' critical thinking skills in science, thus the null hypothesis is accepted. This means that design thinking process based material did not affect the critical thinking skills of the students due to the following factors: possess a competent critical thinking skills, short-term exposure to critical thinking activities, and a well-structured activity.

Based on the findings of this study, several recommendations are suggested and proposed to enhance students' scientific literacy and critical thinking skills.

The school administration also encourages to support the use of design thinking stages on the delivery of lesson and classroom activities. They can also provide training programs for teachers that focuses on the use of the design thinking process, strategies that will enhance the critical thinking skills of the students, and effective assessment for critical thinking skills.

The teachers are encouraged to continuously use the design thinking process since it has been proven that it can help to improve the scientific literacy of the students. However, in order to enhance the critical thinking skills of the students, it is said that the learning materials integrated in the design thinking process must be well-structured and explicitly critical thinking activities that may include guided questioning that focus on asking "why" and "how" certain phenomena happen, they may also include problem analysis and justification activities that will help students to deepen their understanding in science by applying, creating and evaluating. Lastly, a reflection journal that provides continuous feedback and scaffolding to help students develop critical thinking skills.

Parents are also encouraging of the active learning of the students. They need to actively support their children during

the learning process. They can create a supportive learning environment for the students, allowing them to explore, make mistakes, and reflect on their experiences by simple activities like discussing school tasks, reviewing lessons, and giving constructive feedback that can help reinforce the learning process by extending learnings at home.

The students are encouraged to participate actively in design thinking activities by engaging not only in task completion but also in deep thinking and reflection. Students may engage themselves in activities that practice analyzing and identifying problems. Tasks that will help them nurture their ability to justify their answers and decisions. Promotes collaborative learning that will help them to express their ideas during the process. And more importantly, students are advised to use constructive self-assessment and peer evaluation to reflect on feedback and recommendations to improve their outputs.

Future researches are encouraged to have a deeper investigation of design thinking process based materials by having a longer exposure of the materials on the students, integrating other approaches such as problem-solving skills and inquiry-based learning. They can also examine the relationship of design thinking process on the students' motivation and engagement.

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