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Differentiated Instruction Approach Through Flipped Classroom Strategy in Fostering Students' Metacognition and Science Thinking Skills

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Abstract*—This study aims to assess the effectiveness and relationship of differentiated instruction approaches through a flipped classroom strategy in fostering students' metacognition and science thinking skills. Specifically, it examines the relationship between differentiated instruction strategies: complex instruction, flexible learning, self-directed learning, student-centered learning, personalized learning and students' metacognitive skills, including self-regulation, self-awareness, self-assessment, reflective thinking, and strategic planning. It also determined on these instructional approaches the effect on students' science thinking skills in terms of comprehension, analysis, critical thinking, and problem-solving. Quantitative-descriptive research design was used involving 90 Grade 9 students from Pedro Guevara Memorial National High School selected through purposive sampling technique. Data were gathered using a survey, a researcher-made Likert-scale questionnaire, and a 60-item science thinking skills test. Frequency, percentage, and mean were used to analyze the data, while Pearson's r determined the relationship between the flipped classroom strategy and students' metacognition, and the t-test assessed its effect on science thinking skills. Results showed that differentiated instruction through the flipped classroom strategy was rated High to Very High, especially in flexible and student-centered learning. Students' metacognitive skills, self-regulation, self-awareness, self-assessment, reflective thinking, and strategic planning were also rated High to Very High. Moreover, their science thinking skills in comprehension, analysis, critical thinking, and problem-solving were rated Very Satisfactory. From the findings in the study, it was found that there is a statistically significant association between differentiated instruction using the flipped classroom method and metacognitive skills of the students in science. In relation to the development of science thinking skills, further practice and incorporation of other learning techniques may be required aside from just applying differentiated instructions. In conclusion, Differentiated Instruction Approach Through Flipped Classroom Strategy and Students' Metacognition in Science show significant relationship in all dimension and hence null hypothesis is rejected. On the other hand, there is no significant effect in Differentiated Instruction Approach Through Flipped Classroom Strategy and Students' Science Thinking Skills which leads to accepting the null hypothesis. Therefore, it is recommended that teachers may continue to utilize the differentiated instruction strategy in a flipped classroom setting to improve the metacognitive skills of the students and encourage more independent learning. They may integrate additional higher-order thinking activities alongside differentiated instruction to further develop students' science thinking skills.*

***Keywords*—** *Differentiated Instruction, Flipped Classroom Strategy, Metacognition, Science Thinking Skills, Flexible Learning.*

I. INTRODUCTION

In the 21st century, education calls for teaching approaches that meet the diverse needs of learners and develop higher-order thinking skills needed for lifelong learning. Historically, teachers taught in a classroom via the same manner as students learned, with a general approach to learning that often relied on what students themselves brought to the learning situation. Traditional teacher-directed practices focused on getting the class to school and performed their roles as students listening to the teacher or teacher explaining ideas and failed to consistently support more engaging learning approaches, better accommodating the different learning preferences of students, with varying student interests, or student ability to learn, etc. As a result, new episodic learning approaches that incorporate student-centered strategies have been implemented emphasizing the improvement of learning and metacognition, thus improving learning efficacy and choice.

Differentiated instruction is an educational methodology that acknowledges the diversity of student population and modifies the curriculum accordingly in terms of its content, process, product, and the learning environment to cater to the readiness level of individual learners as well as their interests and preferences. In other words, it is the movement away from a "one-size-fits-all" concept to a more inclusive practice of teaching that ensures each student is afforded an equitable opportunity to learn. Science education is filled with abstract and complex understandings and Differentiated Instruction assists with scaffolding learning, allowing students to build their knowledge at their own pace and capacity.

Alongside this method, Flipped Classroom approach has emerged as a creative instructional model. Instead of the conventional model of teaching where students are introduced to the lesson in class that is often in a lecture format and practice the content outside of class spaces the students were provided with the opportunity to engage the lesson outside of class (usually through video, reading, or a digital platform) and use the classroom time for active, collaborative and application-based learning, again freeing up space for deeper interactions, peer learning, and teacher mediated support. This approach not only maximizes the opportunities for face-to-face interaction during class, but also allows students to engage with the lesson ahead of time, fostering accountability and a sense of responsibility in their learning process.

Maycelyn Napula Arellano, "Differentiated Instruction Approach Through Flipped Classroom Strategy in Fostering Students' Metacognition and Science Thinking Skills," *International Journal of Multidisciplinary Research and Publications (IJMRAP)*, Volume 9, Issue 2, pp. 199-209, July 2026.

The promise of Differentiated Instruction integrated with a Flipped Classroom method is also to enhance both cognitive and metacognitive levels of learning. Metacognition, defined as the awareness and control over one's own thinking and learning processes, is a key competency for students to master in Science if they wish to succeed, as metacognition is an important skill base for students to engage in self-monitoring, problem solving and critical thinking. If we teach our students to think about their ways of learning, assess their level of knowledge, and modify the methods to accommodate this knowledge, they will be more successful at learning.

In this context, students are exposed to more complex scientific concepts and processes, it becomes important to incorporate strategies that promote various learner needs and enhance thinking about the learners' own thinking. By utilizing Differentiated Instruction in combination with Flipped Classroom strategy, educators can provide opportunities of personal learning, stimulate active engagement, and develop metacognitive capacities that can positively impact success.

Thus, the aim of this study was to explore the effectiveness of Differentiated Instruction approach through Flipped Classroom strategy in developing Grade 9 students' metacognition and science thinking skills. In doing so, this study aimed to add in the existing empirical literature to show how new instructional approaches can impact classroom practice through relevant and effective learning experiences that will enhance quality education within the presence of today's complex learning environments.

1.1 Statement of the Problem

Problem/s which were addressed by the research

This study utilized differentiated instruction through flipped classroom strategy in fostering students' metacognition and science thinking skills.

Specifically, the study sought answers to the following questions:

1. What is the level of using Differentiated Instruction Approach Through Flipped Classroom Strategy in Science in terms of:
   1.1 Complex Instruction;
   1.2 Flexible Learning;
   1.3 Self-Directed Learning;
   1.4 Student-Centered Learning; and
   1.5 Personalized Learning?
2. What is the level of Students' Metacognition in Science in terms of:
   2.1 Self- Regulation;
   2.2 Self- Awareness;
   2.3 Self- Assessment;
   2.4 Reflective Thinking; and
   2.5 Strategic Planning?
3. What is the level of Students' Science Thinking Skills in terms of:
   3.1 Comprehension;
   3.2 Analyzation;
   3.3 Critical Thinking; and
   3.4 Problem Solving?
4. Is there a significant relationship between Differentiated Instruction Approach Through Flipped Classroom Strategy and Students' Metacognition in Science?
5. Is there a significant effect in Differentiated Instruction Approach Through Flipped Classroom Strategy and Students' Science Thinking Skills?

II. METHODOLOGY

Quantitative-descriptive research design was used involving 90 Grade 9 students from Pedro Guevara Memorial National High School selected through purposive sampling technique. Data were gathered using a survey, a researcher-made Likert-scale questionnaire, and a 60-item science thinking skills test. Frequency, percentage, and mean were used to analyze the data, while Pearson's r determined the relationship between the flipped classroom strategy and students' metacognition, and the t-test assessed its effect on science thinking skills.

III. RESULTS AND DISCUSSION

This part deals with the presentation, analysis, and interpretation 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.

Level of Using Differentiated Instruction Approach Through Flipped Classroom Strategy in Science

In this study, the level of using Differentiated Instruction Approach Through Flipped Classroom Strategy in Science refers to Complex Instruction; Flexible Learning; Self-Directed Learning; Student-Centered Learning and; Personalized Learning. The level of the using Differentiated Instruction Approach Through Flipped Classroom Strategy in Science is revealed in the following table, which shows the statement, mean, standard deviation, remarks, and verbal interpretation.

Table 1 shows the level of using Differentiated Instruction Approach Through Flipped Classroom Strategy in Science in terms of Complex Instruction. The respondents Strongly Agree that collaborating with their classmates to solve complex problems (M=4.38, SD=0.73), followed by providing them with chances to use real life concepts in everyday life (M=4.22, SD=0.73), and requiring them to think critically in doing activities (M=4.21, SD=0.73), indicating a very high interpretation respectively. Likewise, exploring multiple solutions to a single problem (M=4.02, SD=0.75), and also analyzing and solve challenging problems (M=3.97, SD=0.76), responded as Agree which both indicating a high interpretation respectively.

This means that the students strongly agree that collaborating with their classmate to solve complex problems is evident in their learning, highlighting the importance of teamwork in understanding difficult concepts. They also strongly agree that applying real-life concepts and engaging in activities that require critical thinking help deepen their learning.

Moreover, students agree that they are encouraged to explore multiple solutions and solve challenging problems,

Maycelyn Napula Arellano, "Differentiated Instruction Approach Through Flipped Classroom Strategy in Fostering Students' Metacognition and Science Thinking Skills," *International Journal of Multidisciplinary Research and Publications (IJMRAP)*, Volume 9, Issue 2, pp. 199-209, July 2026.

indicating the development of flexible thinking and problem-solving skills. Overall, the results show that the approach promotes active participation and enhances students' thinking skills.

Table 1. Level of Using Differentiated Instruction Approach Through Flipped Classroom Strategy in Science in terms of Complex Instruction

Statement In a flipped classroom, I engage in complex instruction through…	Mean	SD	Remarks
…providing me with chances to use real life concepts in everyday life.	4.22	0.73	Strongly Agree
…requiring me to think critically in doing activities.	4.21	0.73	Strongly Agree
…exploring multiple solutions to a single problem.	4.02	0.75	Agree
…analyzing and solve challenging problems.	3.97	0.76	Agree
…collaborating with my classmates to solve complex problems.	4.38	0.73	Strongly Agree
Weighted Mean	4.16		
SD	0.75		
Verbal Interpretation	High		

The level of using differentiated instruction approach through flipped classroom strategy in science in terms of complex instruction attained a weighted mean score of 4.16 and a standard deviation of 0.75 and verbally interpreted as High among the respondents.

The results imply that using differentiated instruction approach through flipped classroom strategy in Science in terms of complex instruction positively help students explore multiple solutions and analyze challenging problems and improves academic performance.

Table 2 shows the level of using Differentiated Instruction Approach Through Flipped Classroom Strategy in Science in terms of Flexible Learning that respondents Strongly Agree in allowing them to learn at their own speed (M= 4.30, SD= 0.79), followed by enabling them to study on their own schedule (M= 4.28, SD= 0.76), and viewing video lessons and materials as many times they want (M= 4.26, SD= 0.73), indicating a Very High interpretation respectively. Likewise, changing their study time according to their convenience comfortably (M=4.12, SD=0.75), and accessing the lessons anytime and anywhere through online resources (M=4.12, SD=0.70), responded as Agree which both indicating a High interpretation respectively.

Table 2. Level of Using Differentiated Instruction Approach Through Flipped Classroom Strategy in Science in terms of Flexible Learning

Statement In a flipped classroom, I adapt to a flexible learning by…	Mean	SD	Remarks
…enabling me to study on my own schedule.	4.28	0.76	Strongly Agree
…allowing me to learn at my own speed.	4.30	0.79	Strongly Agree
…viewing video lessons and materials as many times as I want.	4.26	0.73	Strongly Agree
…accessing the lessons anytime and anywhere through online resources.	4.12	0.70	Agree
…changing my study time according to my convenience comfortably.	4.12	0.75	Agree
Weighted Mean	4.22		
SD	0.75		
Verbal Interpretation	Very High		

The level of using differentiated instruction approach through flipped classroom strategy in science in terms of flexible learning attained a weighted mean score of 4.22 and a standard deviation of 0.75 and verbally interpreted as Very High among the respondents.

As the respondents strongly agree that the approach allows them to learn more in control of their learning process. They also strongly agree that studying on their schedule and repeatedly accessing video lessons help them better understand the content, showing that flexibility supports mastery of the lessons. They also agree that they can adjust their study time according to their convenience and access learning materials anytime and anywhere, suggesting increased independence and responsibility in learning. Overall, the responses indicate that the flipped classroom strategy provides a highly effective and flexible learning environment that enhances students' engagement, autonomy, and ability to manage their own learning based on their preferences and needs. This further supports the development of self-directed and lifelong learning skills among students.

This implies that using differentiated instruction approach through flipped classroom strategy in Science in terms of flexible learning provides the students with greater control of their learning process that enhances their autonomy, engagement and responsibility in learning the lesson. Furthermore, the consistency of responses shows that these successful teaching strategies are used consistently with many students.

Table 3. Level of Using Differentiated Instruction Approach Through Flipped Classroom Strategy in Science in terms of Self-Directed Learning

Statement In a flipped classroom, I pursue self-directed learning through…	Mean	SD	Remarks
…doing pre-class learning activities responsibly.	4.03	0.77	Agree
…planning my own learning prior to attending class.	3.97	0.79	Agree
…preparing questions according to the lessons I have learned at home.	3.77	0.79	Agree
…ensuring that I know the material prior to class discussions.	4.09	0.71	Agree
…looking for additional resources to enhance my understanding actively.	4.22	0.72	Strongly Agree
Weighted Mean	4.02		
SD	0.77		
Verbal Interpretation	High		

The level of using differentiated instruction approach through flipped classroom strategy in science in terms of self-directed learning attained a weighted mean score of 4.02 and a standard deviation of 0.77 and verbally interpreted as High among the respondents.

Table 3 shows level of using Differentiated Instruction Approach Through Flipped Classroom Strategy in Science in terms of Self-Directed Learning that respondents Strongly Agree in looking for additional resources to enhance their understanding actively (M= 4.22, SD= 0.72), indicating a Very High interpretation respectively. Likewise, in ensuring that they know the material prior to class discussions (M= 4.09, SD= 0.71), in doing pre-class learning activities

Maycelyn Napula Arellano, "Differentiated Instruction Approach Through Flipped Classroom Strategy in Fostering Students' Metacognition and Science Thinking Skills," *International Journal of Multidisciplinary Research and Publications (IJMRAP)*, Volume 9, Issue 2, pp. 199-209, July 2026.

responsibly (M= 4.03, SD= 0.77), in planning their own learning prior to attending class (M=3.97, SD=0.79), and preparing questions according to the lessons they have learned at home (M=3.77, SD=0.71), responded as Agree which indicating them as High interpretation respectively.

The highest-rated indicator shows that students strongly agree in actively seeking additional resources to deepen their understanding, suggesting a strong sense of initiative and independent learning. Meanwhile, students also demonstrate consistent engagement in preparatory behaviors, such as ensuring familiarity with lesson content before class, completing pre-class tasks responsibly, and planning their learning activities in advance, all of which fall under a high level of interpretation.

These findings imply that the flipped classroom setup encourages learners to take responsibility for their own learning process. However, the comparatively lower mean in preparing questions based on prior learning, although still rated high, suggests that while students are actively engaged in independent study, they may still need further support in developing higher-order thinking skills such as inquiry and critical questioning. This implies that learners are more confident in accessing and understanding materials than in formulating deeper analytical questions based on their learning experiences. Overall, the results highlight that the strategy effectively promotes self-directed learning, particularly in terms of preparation, resourcefulness, and independent learning habits, but there is still room to strengthen students' critical inquiry skills.

This implies that using differentiated instruction approach through flipped classroom strategy in Science in terms of self-directed learning fosters the student's initiative and motivation to understand the lesson more deeply.

Table 4 shows level of using Differentiated Instruction Approach Through Flipped Classroom Strategy in Science in terms of Student-Centered Learning that respondents Strongly Agree in participating in class discussions and group work actively (M= 4.58, SD= 0.69), and by encouraging themselves to express their own ideas and opinions (M= 4.40, SD= 0.72), indicating a Very High interpretation respectively. While on the other hand, in considering their ideas and opinions during class activities (M= 4.20, SD= 0.75), followed by engaging in learning activities compared to traditional lectures (M=4.03, SD=0.71), and emphasizing their involvement in class activities rather than teacher instruction alone (M= 3.96, SD= 0.73), responded as Agree which indicating them as High interpretation respectively.

The level of using differentiated instruction approach through flipped classroom strategy in science in terms of student-centered learning attained a weighted mean score of 4.23 and a standard deviation of 0.75 and verbally interpreted as Very High among the respondents.

Students strongly agree that they actively participate in class discussions and group work and feel encouraged to express their own ideas and opinions, indicating that the learning environment effectively supports active engagement and learner voice. Additionally, the remaining indicators show that students feel involved in class activities, their ideas are valued, and they are more engaged than in traditional lectures. The slightly lower ratings indicate a need to further strengthen learner autonomy and reduce teacher dependence. Overall, the findings suggest that the flipped classroom combined with differentiated instruction successfully fosters a student-centered environment, particularly in promoting participation, collaboration, and self-expression.

Table 4. Level of Using Differentiated Instruction Approach Through Flipped Classroom Strategy in Science in terms of Student-Centered Learning

Statement In a flipped classroom, I participate student-centered learning through…	Mean	SD	Remarks
…encouraging myself to express my own ideas and opinions.	4.40	0.72	Strongly Agree
…considering my ideas and opinions during class activities.	4.20	0.75	Agree
…participating in class discussions and group work actively.	4.58	0.69	Strongly Agree
…engaging in learning activities compared to traditional lectures.	4.03	0.71	Agree
…emphasizing my involvement in class activities rather than teacher instruction alone.	3.96	0.73	Agree
Weighted Mean	4.23		
SD	0.75		
Verbal Interpretation	Very High		

The results imply that using differentiated instruction approach through flipped classroom strategy in Science in terms of student-centered learning promotes deeper understanding that makes the students take a more active role in constructing their knowledge and applying concepts meaningfully rather than solely on teacher-centered instruction. Student-centered instruction has become a widely recognized approach in contemporary education, reflecting a shift from traditional teacher-centered practices.

Table 5. Level of Using Differentiated Instruction Approach Through Flipped Classroom Strategy in Science in terms of Personalized Learning

Statement In a flipped classroom, I design my personalized learning by…	Mean	SD	Remarks
…allowing me to select learning materials that work for me.	4.32	0.67	Strongly Agree
…spending more time on difficult areas.	3.79	0.80	Agree
…providing feedback that enhances my own learning.	4.18	0.68	Agree
…adjusting the learning activities to my needs and abilities.	4.19	0.69	Agree
…finding ways that support my preferred learning style.	4.37	0.68	Strongly Agree
Weighted Mean	4.17		
SD	0.73		
Verbal Interpretation	High		

The level of using differentiated instruction approach through flipped classroom strategy in science in terms of personalized learning attained a weighted mean score of 4.17 and a standard deviation of 0.73 and verbally interpreted as High among the respondents.

Table 5 shows level of using Differentiated Instruction Approach Through Flipped Classroom Strategy in Science in terms of Personalized Learning that respondents Strongly

Maycelyn Napula Arellano, "Differentiated Instruction Approach Through Flipped Classroom Strategy in Fostering Students' Metacognition and Science Thinking Skills," *International Journal of Multidisciplinary Research and Publications (IJMRAP)*, Volume 9, Issue 2, pp. 199-209, July 2026.

Agree in finding ways that support their preferred learning style (M= 4.37, SD= 0.68), and by allowing them to select learning materials that works for them (M= 4.32, SD= 0.67), indicating a Very High interpretation respectively. Likewise, adjusting the learning activities to their needs and abilities (M= 4.19, SD= 0.69), followed by providing feedback
that enhances their own learning (M=4.18, SD=0.69), and spending more time on difficult areas (M=3.79, SD=0.80) was responded as Agree which indicating them as High interpretation respectively.

Students strongly agree that they are able to find strategies aligned with their preferred learning styles and are given the freedom to select learning materials that best suit their needs, reflecting a strong sense of learner autonomy and adaptability. Moreover, the remaining indicators, interpreted as effective, suggest that students are generally able to adjust learning activities based on their abilities, benefit from feedback that supports their improvement, and allocate more time to challenging topics. The slightly lower mean in spending more time on difficult areas may imply that some learners still need guidance in managing their time or identifying areas that require deeper focus.

Overall, the findings demonstrate that the approach effectively supports personalized learning by allowing flexibility, promoting self-awareness, and addressing individual learning differences, while still leaving room to enhance students' ability to fully manage their own learning pace.

This implies that using differentiated instruction approach through flipped classroom strategy in Science in terms of personalized learning allowing the students to strengthen their understanding based on their own level of readiness and capability.

Level of Students' Metacognition in Science

In this study, the level of the Students' Metacognition in Science refers to Self-Regulation; Self-Awareness; Self-Assessment; Reflective Thinking and Strategic Planning.

The level of Students' Metacognition in Science is shown in the following table, which shows the statement, mean, standard deviation, remarks, and verbal interpretation.

Table 6 presents the level of Students' Metacognition in Science in terms of Self-Regulation that respondents Strongly Agree that focusing on tasks even when they are challenging (M=4.33, SD=0.69), and managing their time to finish tasks on time (M=4.31, SD=0.79), which both indicating Very High verbal interpretation respectively. Likewise, adjusting their learning methods when they understand that they are not effective (M=4.19, SD=0.72), keeping their attention on their studies even when distractions are present (M=4.09, SD=0.71), and tracking their progress while working on an assignment (M=4.01, SD=0.71), responded as Agree which indicating them as High verbal interpretation respectively.

The level of students' metacognition in science in terms self-regulation attained a weighted mean score of 4.19 and a standard deviation of 0.73 and verbally interpreted as High among the respondents.

The highest-rated indicators reveal that students are able to stay focused on challenging tasks and manage their time effectively to complete requirements, suggesting strong discipline and persistence in learning. The remaining indicators, all interpreted as high, further indicate that students are capable of adjusting their learning strategies when needed, maintaining attention despite distractions, and monitoring their progress during tasks. These behaviors reflect essential components of self-regulated learning, particularly in terms of planning, monitoring, and evaluating one's own performance. Overall, the results indicate that students possess well-developed self-regulation skills, as reflected in their ability to manage tasks, maintain focus, and regulate their learning behaviors effectively. However, despite these positive outcomes, there is still room to further strengthen their consistency in adjusting learning strategies when faced with difficulties and in sustaining focus across varying learning situations. This indicates that while students are generally capable of self-regulated learning, continuous support and practice are still needed to fully enhance their adaptability and persistence in more complex academic tasks.

Table 6. Level of the Students' Metacognition in Science in terms of Self-Regulation

Statement As a student, I practice self-regulation by…	Mean	SD	Remarks
…focusing on tasks even when they are challenging.	4.33	0.69	Strongly Agree
…tracking my progress while working on an assignment.	4.01	0.71	Agree
…adjusting my learning methods when I understand that they are not effective.	4.19	0.72	Agree
…keeping my attention on my studies even when distractions are present.	4.09	0.71	Agree
…managing my time to finish tasks on time.	4.31	0.79	Strongly Agree
Weighted Mean	4.19		
SD	0.73		
Verbal Interpretation	High		

The findings imply that students demonstrate a high level of self-regulation which can positively impact classroom dynamics, their own productivity in class and overall academic performance.

Table 7 presents the level of Students' Metacognition in Science in terms of Self-Awareness that respondents Strongly Agree that being aware other strengths and weaknesses in learning (M=4.49, SD=0.67), followed by being aware of their effort and motivation in learning (M=4.43, SD=0.72), also managing their emotions to support their learning (M=4.42, SD=0.69), figuring out when they do not understand a lesson (M=4.38, SD=0.71), and recognizing the approaches that suit them best (M=4.38, SD=0.71), which all of them interpreted as Very High respectively.

The level of students' metacognition in science in terms self-awareness attained a weighted mean score of 4.40 and a standard deviation of 0.71 and verbally interpreted as Very High among the respondents.

This indicates that students exhibit a very high level of metacognitive self-awareness in Science. The results show that learners are highly conscious of their strengths and weaknesses, as well as their level of effort and motivation, reflecting a strong understanding of their own learning

Maycelyn Napula Arellano, "Differentiated Instruction Approach Through Flipped Classroom Strategy in Fostering Students' Metacognition and Science Thinking Skills," *International Journal of Multidisciplinary Research and Publications (IJMRAP)*, Volume 9, Issue 2, pp. 199-209, July 2026.

processes. Additionally, students demonstrate the ability to manage their emotions in ways that support learning, recognize when they do not fully understand a lesson, and identify the strategies that work best for them. These consistently very high ratings suggest that learners possess a well-developed sense of self-awareness, which is essential for effective metacognition. Overall, the findings imply that students are highly reflective and mindful of their cognitive and emotional states, enabling them to make informed decisions about their learning. This strong self-awareness provides a solid foundation for further enhancing their self-regulation and overall academic performance.

Table 7. Level of the Students' Metacognition in Science in terms of Self-Awareness

Statement As a student, I cultivate self-awareness through…	Mean	SD	Remarks
…being aware of my strengths and weaknesses in learning.	4.49	0.67	Strongly Agree
…recognizing the approaches that suit me best.	4.28	0.75	Strongly Agree
…figuring out when I do not understand a lesson.	4.38	0.71	Strongly Agree
…being aware of my effort and motivation in learning.	4.43	0.72	Strongly Agree
…managing my emotions to support my learning.	4.42	0.69	Strongly Agree
Weighted Mean	4.40		
SD	0.71		
Verbal Interpretation	Very High		

Table 8 presents the level of Students' Metacognition in Science in terms of Self-Assessment that respondents Strongly Agree that check if their answers are correct before finalizing them (M=4.49, SD=0.64), followed by analyze the quality of their work before submitting it (M=4.48, SD=0.66), also question themselves if they have learned the lesson fully (M=4.27, SD=0.72), compare their current performance with their previous performance (M=4.26, SD=0.82), and seek feedback to improve their performance (M=4.21, SD=0.79), which all of them interpreted as Very High respectively.

Table 8. Level of the Students' Metacognition in Science in terms of Self-Assessment

Statement As a student, I conduct self-assessment to…	Mean	SD	Remarks
…question myself if I have learned the lesson fully.	4.27	0.72	Strongly Agree
…check if my answers are correct before finalizing them.	4.49	0.64	Strongly Agree
…seek feedback to improve my performance.	4.21	0.79	Strongly Agree
…analyze the quality of my work before submitting it.	4.48	0.66	Strongly Agree
…compare my current performance with my previous performance.	4.26	0.82	Strongly Agree
Weighted Mean	4.34		
SD	0.73		
Verbal Interpretation	Very High		

The level of students' metacognition in science in terms self-assessment attained a weighted mean score of 4.34 and a standard deviation of 0.73 and verbally interpreted as Very High among the respondents.

The students demonstrate a highly acceptable level of metacognitive self-assessment in Science. The highest-rated indicators indicate that students consistently check the accuracy of their answers and evaluate the quality of their work before submission, reflecting careful review and attention to detail.

Furthermore, students also show strong tendencies to reflect on their learning by questioning their level of understanding, comparing their current performance with previous outputs, and seeking feedback for improvement. These behaviors highlight their ability to critically evaluate their own work and learning progress. Overall, the results suggest that students possess well-developed self-assessment skills, enabling them to monitor and improve their academic performance effectively. This indicates that they are capable of engaging in reflective practices that support continuous learning and improvement.

The findings imply that students demonstrate a high level of self-assessment which the students seek feedback and judge their own understanding and learning for improvement of themselves.

Table 9 presents the level of Students' Metacognition in Science in terms of Reflective Thinking that respondents Strongly Agree on looking back on what they have learned to be a better person in the future. (M=4.46, SD=0.69), followed by thinking about the relationships between things they already understand and new information (M=4.36, SD=0.68) reflecting on their past mistakes and how they can prevent them in the future (M=4.34, SD=0.69), which indicating them a Very High verbal interpretation respectively. Likewise, examining why a particular strategy succeeded or failed (M=4.19, SD=0.73), keeping their attention on their studies even when distractions are present (M=4.09, SD=0.71), and considering different perspectives when solving problems (M=4.17, SD=0.75), responded as Agree which indicating both as High verbal interpretation respectively.

Table 9. Level of the Students' Metacognition in Science in terms of Reflective Thinking

Statement As a student, I conduct self-assessment to…	Mean	SD	Remarks
…reflecting on my past mistakes and how I can prevent them in the future.	4.34	0.69	Strongly Agree
…examining why a particular strategy succeeded or failed.	4.19	0.73	Agree
…thinking about the relationships between things I already understand and new information.	4.36	0.68	Strongly Agree
…considering different perspectives when solving problems.	4.17	0.75	Agree
…looking back on what I have learned to be a better person in the future.	4.46	0.69	Strongly Agree
Weighted Mean	4.30		
SD	0.71		
Verbal Interpretation	Very High		

The level of students' metacognition in science in terms reflective thinking attained a weighted mean score of 4.30 and

Maycelyn Napula Arellano, "Differentiated Instruction Approach Through Flipped Classroom Strategy in Fostering Students' Metacognition and Science Thinking Skills," *International Journal of Multidisciplinary Research and Publications (IJMRAP)*, Volume 9, Issue 2, pp. 199-209, July 2026.

a standard deviation of 0.71 and verbally interpreted as Very High among the respondents.

This indicates that students demonstrate a very high level of reflective thinking in Science. The highest-rated responses show that learners actively reflect on what they have learned to improve themselves, connect prior knowledge with new information, and learn from past mistakes. These findings suggest that students are highly capable of meaningful reflection, which supports deeper understanding and personal growth.

Meanwhile, the remaining indicators, interpreted as high, reveal that students are generally able to evaluate the effectiveness of their learning strategies, maintain focus despite distractions, and consider different perspectives when solving problems. These findings suggest that learners are already practicing important aspects of reflective thinking that support meaningful learning and decision-making in Science. Although these are still strong results, they also indicate that there is room to further enhance critical reflection, particularly in deeply analyzing the effectiveness of strategies used and consistently integrating multiple viewpoints when solving complex tasks. Strengthening these areas may help students become more deliberate and flexible in their thinking processes. Overall, the results imply that students possess well-developed reflective thinking skills, enabling them to process learning experiences, refine their approaches, and apply insights gained to improve future learning outcomes in a more thoughtful and strategic manner.

Table 10. Level of the Students' Metacognition in Science in terms of Strategic Planning

Statement As a student, I carry out strategic planning to…	Mean	SD	Remarks
…set goals before starting a task or activity clearly.	4.34	0.67	Strongly Agree
…prepare my materials before I begin studying.	4.48	0.69	Strongly Agree
…prioritize tasks based on how important they are.	4.40	0.68	Strongly Agree
…plan ahead the steps I need to take to complete an activity.	4.32	0.68	Strongly Agree
…think ahead of time about possible problems and how to resolve them.	4.33	0.73	Strongly Agree
Weighted Mean	4.38		
SD	0.69		
Verbal Interpretation	Very High		

The level of students' metacognition in science in terms strategic planning attained a weighted mean score of 4.38 and a standard deviation of 0.69 and verbally interpreted as Highly Acceptable among the respondents.

Table 10 presents the level of Students' Metacognition in Science in terms of Strategic Planning that respondents Strongly Agree that prepare their materials before they begin studying (M=4.48, SD=0.69), followed by prioritize tasks based on how important they are (M=4.40, SD=0.68), also set goals before starting a task or activity clearly (M=4.34, SD=0.67), think ahead of time about possible problems and how to resolve them (M=4.33, SD=0.73), plan ahead the steps they need to take to complete an activity (M=4.32, SD=0.68), which all of them interpreted as Very High respectively.

Students exhibit a very high level of metacognitive strategic planning in Science. The results indicate that they consistently prepare their materials in advance, prioritize tasks based on importance, and set clear goals before starting activities, reflecting strong organizational and planning skills. They demonstrate the ability to anticipate potential challenges and think of possible solutions, as well as plan the necessary steps to complete tasks effectively. These consistently very high ratings suggest that learners are proactive and systematic in managing their learning processes. Overall, the findings imply that students possess well-developed strategic planning skills, which enable them to perform academic tasks with clarity that results in a more efficient and effective learning outcomes.

The findings imply that students demonstrate high level of strategic planning where in students had the ability to select and organize appropriate strategies to finish task and achieve learning goals.

Level of Students' Science Thinking Skills

In this study, the level of Students' Thinking Skills in Science refers to the learners' abilities in terms of comprehension, analyzation, critical thinking, and problem-solving. These skills represent essential cognitive processes that enable students to understand scientific concepts, interpret information, evaluate ideas, and apply knowledge in solving real-life and academic problems.

The level of students' thinking skills in Science is presented in the following table, which provides a detailed summary of the results. It includes the raw scores, frequency distribution, percentage, mean, standard deviation, and corresponding verbal interpretation. These statistical measures are used to clearly describe and interpret the overall performance of the students in relation to each component of thinking skills

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

Raw Score	Frequency (f)	Percentage (%)	Descriptive Equivalent
13 - 15	46	51.11 %	Outstanding
10 -12	39	43.33 %	Very Satisfactory
7- 9	5	5.56 %	Satisfactory
4 - 6	0	0 %	Fair
1 - 3	0	0 %	Needs Improvement
	N = 90	100 %	
Weighted Mean		12.41	
SD		2.03	
Verbal Interpretation		Very Satisfactory	

The data reveals that more than half of the respondents (51.11%) achieved an Outstanding level in comprehension, while 43.33% performed at a Very Satisfactory level. Only a small fraction (5.56%) fell into the Satisfactory category, and no students scored within the "Fair" or "Needs Improvement" ranges. The overall mean score of M=12.41 indicates a Very Satisfactory performance in comprehension. This indicates that the students possess a high capability to grasp scientific concepts, interpret information, and translate scientific data

into understandable forms. The low Standard Deviation (SD=2.03) suggests that the students' comprehension levels are relatively consistent across the group.

The results imply that the students exhibit a high level of comprehension, indicating that they are able to effectively understand, interpret, and apply scientific concepts and ideas presented during instruction. This strong comprehension enables them to analyze information critically, connect theories to practical situations, and retain important knowledge more efficiently. As a result, the students are more capable of answering assessment tasks accurately and confidently, which leads to better performance in quizzes, examinations, laboratory activities, and other academic requirements.

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

Raw Score	Frequency (f)	Percentage (%)	Descriptive Equivalent
13 - 15	34	37.78 %	Outstanding
10 -12	47	52.22 %	Very Satisfactory
7- 9	9	10 %	Satisfactory
4 - 6	0	0 %	Fair
1 - 3	0	0 %	Needs Improvement
	N = 90	100 %	
Weighted Mean		11.83	
SD		1.97	
Verbal Interpretation		Very Satisfactory	

The results show that the majority of the students (52.22%) fall under the Very Satisfactory category. While 37.78% of the students still reached an Outstanding level, the percentage is lower compared to the comprehension results. Exactly 10% of the respondents performed at a Satisfactory level.

With a mean score of M=11.83, the students' skill in analyzation is interpreted as Very Satisfactory. While still a strong performance, the slight dip in the mean compared to comprehension indicates that students find the process of "analyzing" (distinguishing between facts and inferences or breaking down components) slightly more challenging than "comprehending" basic concepts. However, the high scores overall indicate a strong foundation in analytical thinking.

The results imply that the students are able to examine information carefully, identify relationships among ideas, and interpret learning materials effectively. This indicates that they possess the ability to engage in deeper cognitive processing, which allows them to make sense of complex scientific content in a more organized and meaningful way. In addition, they can break down complex concepts into simpler parts, enabling them to better understand lessons and respond accurately to various academic tasks. This also indicates that students are developing analytical skills that support clearer understanding and improved learning performance in Science.

The data shows that a majority of the students (51.11%) are at a Very Satisfactory level. While 27.78% achieved an Outstanding rating, about one-fifth of the group (21.11%) remains at the Satisfactory level. The absence of scores in the "Fair" or "Needs Improvement" categories indicates a generally strong performance. With a mean score of M=11.29, the students demonstrate a Very Satisfactory level of critical thinking. This indicates that students are capable of evaluating information, identifying biases, and forming reasoned judgments. However, the higher Standard Deviation (SD=2.17) compared to previous tables indicates a wider variance in skill levels within the group, showing that critical thinking is a more varied competency among the learners.

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

Raw Score	Frequency (f)	Percentage (%)	Descriptive Equivalent
13 - 15	25	27.78 %	Outstanding
10 -12	46	51.11 %	Very Satisfactory
7- 9	19	21.11 %	Satisfactory
4 - 6	0	0 %	Fair
1 - 3	0	0 %	Needs Improvement
	N = 90	100 %	
Weighted Mean		11.29	
SD		2.17	
Verbal Interpretation		Very Satisfactory	

The results imply that the students are still capable of analyzing information, evaluating ideas, and making logical judgments in their learning tasks despite the challenges they may encounter in the learning process. Their ability to think critically allows them to examine concepts carefully, identify relationships among ideas, and apply appropriate reasoning when answering questions or solving problems. This demonstrates that the students possess essential cognitive skills that help them process information effectively and participate actively in academic activities. Therefore, it suggests that students' capacity for analysis and logical reasoning plays a significant role in enhancing their academic achievement and overall learning experience. Furthermore, these abilities provide pupils the confidence to tackle challenging assignments and make well-informed judgments. Developing critical thinking skills can also help students become more self-reliant, introspective, and effective in a variety of academic and practical contexts.

Table 14. Level of Students' Science Thinking Skills in terms of Problem Solving

Raw Score	Frequency (f)	Percentage (%)	Descriptive Equivalent
13 - 15	17	18.89 %	Outstanding
10 -12	56	62.22 %	Very Satisfactory
7- 9	17	18.89 %	Satisfactory
4 - 6	0	0 %	Fair
1 - 3	0	0 %	Needs Improvement
	N = 90	100 %	
Weighted Mean		10.93	
SD		1.73	
Verbal Interpretation		Very Satisfactory	

The results indicate that the largest portion of students (62.22%) performs at a Very Satisfactory level. Notably, the "Outstanding" and "Satisfactory" groups are equal in size, each representing 18.89% of the total population.

The mean score of 10.93 confirms a Very Satisfactory level of performance. Problem-solving represents the most challenging cognitive level in this study, as reflected by it having the lowest mean score among the four thinking skills. This downward trend across the skills suggests that while students are proficient, their mastery decreases as the cognitive complexity increases.

Maycelyn Napula Arellano, "Differentiated Instruction Approach Through Flipped Classroom Strategy in Fostering Students' Metacognition and Science Thinking Skills," *International Journal of Multidisciplinary Research and Publications (IJMRAP)*, Volume 9, Issue 2, pp. 199-209, July 2026.

Significant Relationship between Using Differentiated Instruction Approach Through Flipped Classroom Strategy Flipped Classroom Strategy and Students' Metacognition in Science

Table 15 presents the relationship between the use of differentiated instruction through the flipped classroom strategy and students' metacognitive skills in Science, specifically in terms of self-regulation, self-awareness, self-assessment, reflective thinking, and strategic planning. It provides a comprehensive analysis of how these instructional approaches are associated with the development of students' metacognitive abilities. The table further illustrates how the implementation of differentiated instruction within a flipped classroom environment have an impact on students' capacity to control their own educational processes, increase their awareness of their strengths and shortcomings, assess their performance, and consider what they have learned experiences, and devise plans for academic assignments. Through the presented statistical data, the study aims to determine the extent and significant relationship between these variables in enhancing students' metacognitive skills in Science learning.

Table 15. Significant Relationship between Using Differentiated Instruction Approach Through Flipped Classroom Strategy and Students' Metacognition in Science

Using Differentiated Instruction Approach Through Flipped Classroom Strategy in Science		Students' Metacognition in Science				
		SR	SA	SAs	RT	SP
Complex Instruction	Pearson Correlation	0.439*	0.445*	0.422*	0.449*	0.339*
	Sig. (2-tailed)	0.000	0.000	0.000	0.001	0.000
	N	90	90	90	90	90
Flexible Learning	Pearson Correlation	0.564*	0.521*	0.465*	0.520*	0.486*
	Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000
	N	90	90	90	90	90
Self-Directed Learning	Pearson Correlation	0.595*	0.530*	0.468*	0.576*	0.600*
	Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000
	N	90	90	90	90	90
Student-Centered Learning	Pearson Correlation	0.548*	0.517*	0.516*	0.589*	0.507*
	Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000
	N	90	90	90	90	90
Personalized Learning	Pearson Correlation	0.680*	0.564*	0.482*	0.632*	0.531*
	Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000
	N	90	90	90	90	90

The findings revealed that all aspects of differentiated instruction have strong and positive relationships with the metacognition of the students, as confirmed by the Pearson correlation coefficient, ranging from 0.339 to 0.680 respectively and p-values ranging from 0.000 to 0.001 respectively which are lower than the 0.05 level of significance. Among the components, the strongest relationships were seen for the component of personalized learning, especially in terms of self-regulation (r = 0.680) and reflective thinking (r = 0.632). This reveals that when the learning process is individualized to meet the unique learning needs of the students, they tend to be more aware and in control of their learning process.

Similarly, self-directed learning was seen to have strong relationships, especially in terms of strategic planning (r = 0.600) and reflective thinking (r = 0.576), confirming that when students are encouraged to take responsibility for their own learning, they tend to be more aware and in control of their learning process.

Moreover, student-centered learning and flexible learning also showed moderate positive relationships with all metacognitive components. This indicates that a student-centered and flexible learning environment can also improve students' metacognitive skills. Although complex instruction showed lower correlation levels compared to other strategies, the relationships remain statistically significant. This indicates that complex learning tasks also help to develop students' metacognitive skills.

The findings of this study clearly indicate that the application of differentiated instruction with the flipped classroom strategy can significantly help to develop students' metacognitive skills in Science.

According to Tomlinson (2017), differentiated instruction allows teachers to address students' diverse learning needs, interests and readiness levels which improves student engagement and understanding. This approach becomes more effective when combined with innovative teaching strategies such as the flipped classroom because students are given opportunities to learn at their own pace and actively participate during classroom activities.

Furthermore, studies have shown that flipped classroom instruction enhances students' metacognitive awareness. For instance, Limueco and Prudente (2019) found that the flipped classroom model improved students' metacognitive awareness by encouraging self-regulation, reflection, planning, and monitoring of learning tasks. Their findings suggest that students become more conscious of their thinking strategies when exposed to flipped learning environments.

Similarly, Clark, Kaw, and Guldiken (2023) explained that repeated reflection and metacognitive instruction within a flipped classroom significantly enhanced students' planning, monitoring, and evaluation skills. The study highlighted that flipped learning environments encourage learners to become more independent and reflective in science and STEM-related subjects.

Moreover, research by Tan, Yangco, and Que (2020) revealed that inquiry-based flipped classroom instruction improved students' conceptual understanding and science process skills. This indicates that flipped classroom strategies support higher-order thinking skills and deeper comprehension in science education.

The conclusions drawn from these findings indicate that the use of differentiated instruction strategies contributes significantly to the students' development of greater self-reflection, self-awareness, and strategic approaches to learning. In other words, it implies that learners are

Maycelyn Napula Arellano, "Differentiated Instruction Approach Through Flipped Classroom Strategy in Fostering Students' Metacognition and Science Thinking Skills," *International Journal of Multidisciplinary Research and Publications (IJMRAP)*, Volume 9, Issue 2, pp. 199-209, July 2026.

encouraged to engage in deeper self-reflection and become better aware of their personal learning styles and skills.

At the same time, learners are provided with an opportunity to strategically choose specific learning methods that will help them develop a deeper understanding of new information. In summary, it is evident that these advancements demonstrate the importance of differentiated instruction in enhancing metacognitive skills, as it fosters key competencies like self-reflection, self-awareness, and strategic learning.

Significant Effect between Differentiated Instruction Approach Through Flipped Classroom Strategy Flipped Classroom Strategy and Students' Thinking Skills in Science

Table 16 presents the significant effect of differentiated instruction through the flipped classroom strategy on students' thinking skills in Science, specifically in terms of comprehension, analyzation, critical thinking, and problem-solving. It provides a detailed examination of how the instructional approach influences the development of students' higher-order cognitive abilities in Science learning. The table further highlights the extent to which differentiated instruction implemented through a flipped classroom setting contributes to improving students' ability to understand scientific concepts, analyze information, evaluate evidence, and apply knowledge in solving problems. Through the presented statistical results, the study aims to determine whether the strategy has a significant impact on enhancing students' thinking skills and overall academic performance in Science.

The results show that the majority of the differentiated instruction strategies do not have a significant effect on the students' thinking skills, as the p-values are higher than the level of significance of 0.05. In the case of the complex instruction, the results show that there is no significant effect on comprehension (p-value of 0.063), analyzation (p-value of 0.423), critical thinking (p-value of 0.799), and problem solving (p-value of 0.072).

The same applies to the self-directed learning, the student-centered learning, and the personalized learning, as the p-values of these strategies ranged from 0.115 to 0.888, which is higher than the level of significance of 0.05. This implies that the direct effect of these strategies on the improvement of the students' thinking skills was not statistically strong.

However, flexible learning was found to have a significant effect on analyzation, which gave a t-value of 2.289 and a p-value of 0.024, which is less than 0.05. This implies that the learning strategy helps the students to improve their ability to analyze the concepts and information in Science.

Similarly, a study conducted by Gong, Yang, and Cai, (2020), found that flipped-classroom instruction positively influenced students' computational thinking skills, learning motivation, and learning strategies. Their findings revealed that interactive and student-centered learning environments significantly improve students' higher-order thinking skills.

In addition, research by Borja & Panoy, (2024), showed that flipped science classrooms effectively developed Grade 10 students' critical thinking skills through interactive and indirect instruction. The study emphasized that flipped learning strategies encourage students to evaluate information, interpret concepts, and make logical judgments during science activities and assessments.

Table 16. Significant Effect between Differentiated Instruction Approach Through Flipped Classroom Strategy and Students' Science Thinking Skills

Using Differentiated Instruction Approach Through Flipped Classroom Strategy in Science		Students' Science Thinking Skills			
		Comprehension	Analyzation	Critical Thinking	Problem Solving
Complex Instruction	t-value	1.886	0.805	0.255	1.823
	Sig. (2-tailed)	0.063	0.423	0.799	0.072
	N	90	90	90	90
Flexible Learning	t-value	1.740	2.289*	0.927	0.471
	Sig. (2-tailed)	0.085	0.024	0.357	0.639
	N	90	90	90	90
Self-Directed Learning	t-value	1.453	1.250	-0.718	0.141
	Sig. (2-tailed)	0.150	0.215	0.475	0.888
	N	90	90	90	90
Student-Centered Learning	t-value	1.800	0.245	-0.408	0.264
	Sig. (2-tailed)	0.075	0.807	0.685	0.793
	N	90	90	90	90
Personalized Learning	t-value	1.569	1.591	-0.629	0.708
	Sig. (2-tailed)	0.120	0.115	0.531	0.481
	N	90	90	90	90

Moreover, Wijayanto, Gani, Hasan & Widowati, (2023), concluded that flipped classroom instruction enhanced students' critical thinking and scientific literacy considerably. The study demonstrated how active and student-centered learning strategies support students' development as more imaginative, thoughtful, and proficient problem solvers in science classrooms.

From the study, it is evident that although the learning strategies through the flipped classroom may help the students, the impact may take a longer time and more learning activities. The study partially supports the effectiveness of differentiated instruction in enhancing specific thinking skills, including analyzation via flexible learning, but not all thinking skill domains.

IV. Conclusion and Recommendations

Differentiated Instruction Approach Through Flipped Classroom Strategy and Students' Metacognition in Science show significant relationship in all dimension leading to rejection of the null hypothesis. This signifies that differentiated instruction implemented through the flipped classroom strategy significantly supports the development of students' metacognitive skills in Science. Instructional approaches that focus on personalized learning, self-directed learning, and student-centered activities are more likely to enhance students' metacognitive skills.

On the other hand, there is no significant relationship between Differentiated Instruction Approach Through Flipped Classroom Strategy and Students' Science Thinking Skills, leading to acceptance of the null hypothesis. Although differentiated instruction contributes to students' learning engagement and metacognitive development, it has no statistical significant influence on students' higher-order

Maycelyn Napula Arellano, "Differentiated Instruction Approach Through Flipped Classroom Strategy in Fostering Students' Metacognition and Science Thinking Skills," *International Journal of Multidisciplinary Research and Publications (IJMRAP)*, Volume 9, Issue 2, pp. 199-209, July 2026.

thinking skills, such as comprehension, critical thinking, and problem solving. Flexible learning environments can enhance students' analyzation skills by allowing them greater autonomy and opportunities to engage with learning materials in meaningful ways. Metacognitive development could be a stepping stone towards enhancing students' higher-order thinking skills, but more instructional approaches could be required to enhance students' thinking skills significantly.

Based on the results of the study, the following recommendations are suggested:

Science Teachers may continue to utilize the differentiated instruction strategy in a flipped classroom to improve the metacognitive skills of the students and encourage more independent learning.

Teachers may incorporate much higher-order thinking activities to improve the critical thinking and problem-solving skills of the students.

Schools and the Educational Administrators may offer training and seminars for the teachers to effectively apply the concepts of differentiated instruction and flipped classrooms.

Curriculum Implementers may also consider adding more activities to promote the use of HOTS in a flipped classroom strategy using differentiated instruction to promote a more holistic metacognitive skills of the students.

Future researchers may conduct the same study with a larger sample size and a longer time frame to investigate the influence of tailored education on students' thinking skills.

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