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Research Article

Critical Thinking Skills and Attitude Towards Science: Mediating Effect of Study Engagement

*[1,2]Emelene P. Superio, [2]Hazel G. Carreon

About Article

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About Author

[1] Department of Education, Pangantucan, Bukidnon, Philippines

[2] Univeristy of Mindanao, Davao City, Philippines

Contact @ Emelene P. Superio
e.superio.543261@umindanao.edu.ph

ABSTRACT

This quantitative, correlational research study explored the levels and interrelationships among critical thinking skills, study engagement, and attitude toward science. It further examined the mediating role of study engagement in the relationship between critical thinking and attitude toward science. A total of 301 Grade 11 students from public schools in Pangantucan, Bukidnon were selected using Raosoft sampling from a population of 1,361. The adapted instrument underwent expert validation, translation, and revision before administration. All ethical procedures were observed, and data collection was carried out with proper permissions and systematic processing for analysis. Weighted mean, Pearson r and path analysis were used to analyzed the data. Results revealed that students exhibited moderate critical thinking skills and high levels of both study engagement and attitude toward science. There were significant correlations found among variables and study enagement partially mediates critical thinking skils and attiude towards science. The results indicated that improving critical thinking skills and study engagement could help students develop a more positive attitude toward science and guide educators and school administrators in designing targeted interventions that promote interests in science education.

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1. INTRODUCTION

Intrinsic barrier such as dislike of science is a major challenge to scientific progress worldwide (Hasanah & Tsukaoka, 2019). In Taiwan the number of students majoring in STEM fields has declined from 35.4% to 31.8% over the past decade (Ku & Lin, 2022). This was also found out in the Republic of Mauritius that the enrollment in scientific and technology education at the secondary school level, extending to the tertiary level, where fewer students are enrolled in science and technology programs (Ramsurrun *et al.*, 2024). In the Philippines, low ranking in science literacy on the 2018 Programme for International Student Assessment (PISA) highlights significant challenges faced by Filipino students in this subject. The results of structural equation modelling analysis of Xu & Zhou in 2022 revealed that students' science attitude, and engineering and technology attitude had positive effect on 21st century learning skills and improve learning.

Attitudes toward science play a vital role in shaping educational outcomes, influencing students' engagement and achievement in scientific disciplines (Robledo, 2020). In today's society, fostering scientific literacy and trust in scientific institutions is essential for enhancing public understanding and engagement with science (Besley *et al.*, 2021). Longitudinal research further highlights that high school students who maintain positive science attitudes report greater self-efficacy and are more likely to pursue STEM pathways beyond secondary education (Zhou & Shirazi, 2025). Philippine-specific research among senior high school learners further shows that strong science attitudes significantly relate to higher inquiry participation, scientific self-concept, and preparedness for STEM careers, highlighting the predictive power of attitude on future readiness (Ramos & Israel, 2023). The study of Sombilon *et al.* (2025), suggest that aligning instructional strategies with students' preferred learning styles can enhance their engagement, foster positive attitudes toward science, and potentially improve academic outcomes.

The need to examine the mediating role of study engagement in the relationship between critical thinking skills and attitudes towards science is increasingly apparent (Kamarrudin *et al.*, 2022). Understanding this dynamic is crucial for shaping educational practices that foster a more scientifically literate and engaged society (Dhaifi *et al.*, 2024). Research suggests a strong link between critical thinking abilities and student engagement, indicating that students who possess strong critical thinking skills are more likely to be interested in and engaged with their studies (Alpaslan, 2022). However, the specific mechanisms by which study engagement mediates the relationship between critical thinking and attitudes towards science require further investigation. Conducting research in this area will provide valuable insights into how to effectively cultivate a positive attitude towards science and promote active participation in learning (Alali & Al-Baraka, 2024).

The primary aim of this study is to examine the relationship between critical thinking skills, study engagement and attitude toward Science among secondary students. Specifically, it seeks to investigate the following objectives: first, level of critical thinking skills in terms of truth-seeking, open-mindedness, analytical ability, systematization ability and self-confidence; secondly, the level of study engagement in terms of student's active learning, teacher-student interaction, peer interaction, deep cognitive strategies, and enthusiasm for learning and lastly, the level of attitude toward Science in terms of perception of the teacher, anxiety toward science, value of science to society, self-confidence in science and the desire to do science. Additionally, it aims to investigate the significant relationship of critical thinking skills and attitude toward Science, ascertain the significant relationship between critical thinking skills and study engagement, and determine the significant relationship between study engagement and attitude towards Science. Finally, the researcher seeks to determine if study engagement significantly mediate critical thinking skills and attitude toward Science.

The null hypothesis was tested and verified at a 0.05 level of significance for no significant relationship between the following variables: critical thinking skills and attitude towards Science, critical thinking skills and study engagement, study engagement and attitude towards Science respectively. Lastly, the null hypothesis of no mediating effect of study engagement on the relationship between critical thinking skills and attitude toward Science.

The result of this study will help in ensuring inclusive, equitable, and quality education for all and promote lifelong learning opportunities by 2030 as outlined in Sustainable Development Goal 4. The findings of this study will promote research projects, instructional strategies, and policy choices that attempt to advance science literacy, improve science education, and stimulate creativity on a worldwide scale. This study could lead to a more knowledgeable and involved public that takes part in decision-making concerning matters related to science. Any sector in the government, particularly in the department of education, can establish an appropriate mechanism that may increase a positive attitude toward the Science subject. Moreover, the study's findings will assist academic staff and educators in modifying their pedagogical approaches and refining their instructional techniques in order to encourage critical thinking and raise student participation. Finally, future researchers may use the results of the study to acquire new knowledge that is useful and serves as a basis for further research, insights, and reference in the future.

2. LITERATURE REVIEW

Critical thinking is anchored to the Paul-Elder model (Paul & Elder, 2005), which is a disciplined process of actively and skillfully conceptualizing, applying, analyzing, synthesizing, and evaluating information to guide belief and action. It also provides a comprehensive framework for improving the quality of thinking by emphasizing the systematic use of intellectual standards and the analysis of the elements of thought. According to this model, critical thinking involves eight fundamental elements: purpose, question at issue, information, interpretation and inference, concepts, assumptions, implications and consequences, and point of view which serve as the foundation for evaluating reasoning and ensuring clarity, accuracy, relevance, and logical consistency in thought processes. By systematically applying these elements and standards, individuals can move beyond unreflective or biased

thinking and develop higher-order thinking skills that are essential for effective problem-solving and decision-making.

Study engagement is anchored on the Goal Theory which is a psychological framework that focuses on the role of goals in motivating human behavior (Locke & Latham, 1991). Goal Theory emphasizes the importance of goal setting, goal striving, and goal attainment in shaping behavior and performance. The theory posits that goals provide individuals with a sense of direction, purpose, and motivation, influencing their actions and efforts. Research shows that explicit achievement goals, particularly when aligned with students' personal aspirations, play a dominant role in fostering academic goal engagement and reducing disengagement in high school settings (Yau *et al.*, 2022). Additionally, goal directness having clear, specific academic goals has been found to exert the strongest influence on students' academic performance, with student engagement acting as a key mediator in this relationship (Sattar *et al.*, 2022). These findings underscore that both the context provided by teachers and the internal motivation of students are crucial for promoting sustained engagement and academic success in high school (Bardach *et al.*, 2020).

Furthermore, attitude toward science is anchored to the Theory of Planned Behavior (Ajzen, 1991) which is shaped by three main factors: attitude toward science (AS), subjective norms (SN), and perceived behavioral control (PBC). TPB emerged as a major framework for understanding, predicting, and changing human social behavior. According to the theory, intention is the immediate antecedent of behavior and is itself a function of attitude toward the behavior, subjective norm, and perceived behavioral control; and these determinants follow, respectively, from beliefs about the behavior's likely consequences, about normative expectations of important others, and about the presence of factors that control behavioral performance.

Studies carried out in the Philippines have demonstrated a favorable association between students' attitudes toward science and their critical thinking abilities. Research has indicated, for example, that students who have better levels of critical thinking also tend to have more positive views about science (Tan, 2019; Fidel & Santos, 2020). Furthermore, Tan (2021) highlights how crucial it is to incorporate critical thinking training into science curricula in the Philippines in order to promote scientific literacy and favorable attitudes toward science. The study of Borbon *et al.* (2025) also stated that critical thinking skills significantly influence academic success among senior high school students, emphasizing the importance of cultivating these skills to enhance students' educational outcomes. This correlation highlights how important it is to develop critical thinking skills in order to improve Filipino students' attitudes toward science.

Studies conducted in the Philippines by Reyes (2019) and Cruz (2020), consistently demonstrates a positive correlation between critical thinking skills and study engagement among Filipino students. Moreover, Chen *et al.* (2022) revealed in their study that the initial level and development of study engagement positively influenced the initial level and development of critical thinking. This was resonated with the study of Bordon *et al.* (2025) on senior high school students resulted a significant relationship between critical thinking skills and study skills which played a crucial role in achieving students' academic success. This correlation underscores the importance of integrating critical thinking instruction into educational curricula globally, including in the Philippines, to enhance student engagement and academic success.

There is a consistent positive correlation between study engagement and attitudes toward science among students. Study such as Lee *et al.* (2020) has found that students who are more engaged in their studies tend to exhibit more positive attitudes toward science. Moreover, study of Datu *et al.* (2024) revealed that science study engagement is facilitated by stronger connections between science teachers. The study of Mackenzie *et al.* (2024) further claimed that supports are important for supporting adolescents' attitudes towards science. Furthermore, the study of Mutya *et al.* (2020) involving Philippine secondary school students using self-learning modules, revealed that positive attitudes toward science were significantly linked to stronger study habits and higher academic engagement. Building on this, Guadalquiver and Ocdenaria (2023) confirmed a significant relationship not only between students' attitudes toward science and their academic performance in science but also with their level of engagement. Likewise, Adarlo *et al.* (2022) found that both students' attitudes toward science and their course engagement served as significant predictors of science literacy. This correlation highlights the importance of fostering study engagement to cultivate positive attitudes toward science globally, ultimately contributing to improved academic performance and scientific literacy

Figure 1 illustrates the key variables examined in this study, providing a visual representation of the conceptual framework and the relationships among the identified constructs. This framework guided the research design and data analysis, helping to clarify the mediating effect of study engagement in shaping student's science attitudes.

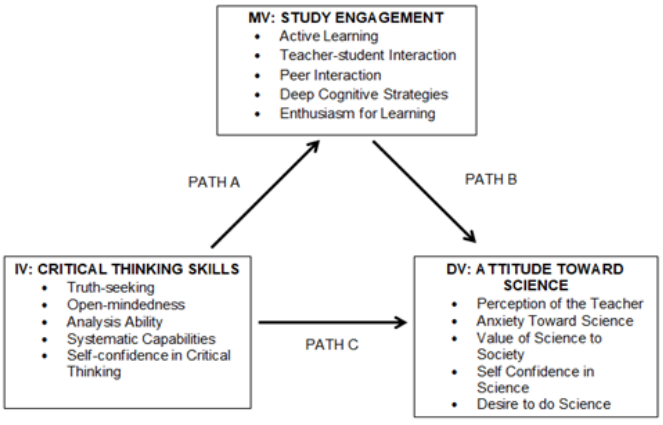

Figure 1. The conceptual framework showing the variables of the study

The independent variable is Critical thinking which is adapted the survey questionnaire in the study of Chen *et al.* (2022). In their study, they examined the developmental trajectories of and the interplay between study engagement and critical thinking. Additionally, critical thinking indicators are: truth-seeking, open-mindedness, analytical ability, systematization ability and self-confidence. Truth seeking refers to the disposition to actively pursue the best knowledge and evidence, even when it challenges personal beliefs. Open mindedness is the willingness to consider alternative perspectives and remain receptive to new ideas. Analytical ability involves logically examining information, arguments, and evidence. Systematization ability is the tendency to approach problems in an organized and methodical way. Self-confidence in critical thinking reflects trust in one's own reasoning and decision-making skills. These indicators are widely recognized and validated in recent studies as essential components of critical thinking dispositions among students, including high school and university population.

The mediating variable is Study engagement which is adapted the survey questionnaire in the study of Chen *et al.* (2022). In this study, the following indicators are: active learning, teacher-student interaction, peer interaction, deep cognitive strategies, and enthusiasm for learning. Active learning, refers to students' participation in hands-on, practical, or problem-solving activities that promote deeper understanding; teacher-student interaction, is defined as the quality and frequency of communication, support, and feedback exchanged between students and their teachers; peer interaction, which involves collaborative learning, discussion, and support among classmates; deep cognitive strategies, referring to the use of higher-order thinking skills such as analysis, synthesis, and critical evaluation to process and internalize information; and enthusiasm for learning which captures students' emotional investment, motivation, and positive attitudes toward their studies.

The dependent variable of this study is the Attitude Toward Science which is adapted from the study of Tai *et al.* (2022) In this study, the indicators are: perception of the teacher, anxiety toward science, value of science to society and self-confidence in science and the desire to do science. Perception of the teacher, which refers to students' views on their science teacher's effectiveness, supportiveness, and ability to make science engaging; anxiety toward science, which captures feelings of nervousness, worry, or discomfort when learning or performing in science; value of science to society, reflecting the extent to which students believe science is important and beneficial for society as a whole; self-confidence in science, which measures students' belief in their own ability to understand and succeed in science; and the desire to do science, indicating students' motivation and interest in participating in science-related activities or pursuing science further.

Table 1. Summary of related literature on critical thinking, study engagement, and attitude toward science

Author(s) and Year	Title / Focus	Methodology	Key Findings
Tan (2019); Fidel & Santos (2020)	Attitude toward science and critical thinking among Filipino students	Quantitative	Positive correlation between critical thinking and attitude toward science
Tan (2021)	Importance of integrating critical thinking in science education	Conceptual / Theoretical Review	Advocated inclusion of critical thinking in curricula to boost science literacy and attitude
Borbon *et al.* (2025)	Critical thinking and academic success among SHS students	Quantitative	Critical thinking strongly influences academic outcomes
Reyes (2019); Cruz (2020)	Critical thinking and study engagement correlation in the Philippines	Quantitative	Positive correlation between critical thinking and engagement
Chen *et al.* (2022)	Longitudinal effect of study engagement and critical thinking	Longitudinal Quantitative	Study engagement boosts development of critical thinking
Bordon *et al.* (2025)	Critical thinking and study skills among SHS students	Quantitative	Significant link between critical thinking and study habits
Lee *et al.* (2020)	Study engagement and attitude toward science	Quantitative	Engagement linked to more positive attitudes
Datu *et al.* (2024)	Influence of teacher-student connection on science engagement	Mixed Methods	Strong teacher connections facilitate science engagement
Mackenzie *et al.* (2024)	Teacher support and adolescent science attitudes	Quantitative	Support structures improve attitudes toward science
Mutya *et al.* (2020)	Attitude toward science and learning modules among Filipino secondary students	Quantitative	Attitude linked with study habits and engagement

Guadalquiver & Ocdenaria (2023)	Attitudes, performance, and engagement in science	Quantitative	Strong relationship between attitudes and academic engagement
Adarlo *et al.* (2022)	Predictors of science literacy	Quantitative	Attitude and engagement predict science literacy
Lv *et al.* (2022); Senina & Manguilimotan(2025)	Critical thinking, engagement, and attitudes toward science	Quantitative	Identified gap in examining the combined effect of these constructs

Despite significant research on critical thinking skills, study engagement, and attitudes toward science among secondary students, there is a notable research gap regarding the interplay of these constructs within the context of science education. While individual studies have explored the influence of critical thinking skills and study engagement on students' attitudes toward science independently, limited research has investigated the mediating effect of study engagement in the relationship between critical thinking skills and attitudes toward science. Existing studies often focus on either cognitive factors, such as critical thinking skills, or affective factors, like attitudes toward science, separately, failing to examine the potential synergistic effects of these constructs (Lv *et al.*, 2022; Senina & Manguilimotan, 2025). Moreover, although numerous studies have explored factors influencing students' attitudes toward science, such as teacher practices and classroom environment, few have specifically addressed the mediating role of study engagement in this relationship (Senina & Manguilimotan, 2025).

Understanding the mediating pathways through which critical thinking skills and study engagement impact attitudes toward science could provide valuable insights for educators and policymakers to develop targeted interventions and instructional approaches aimed at fostering positive attitudes and engagement in science education among secondary students. By addressing this research gap, future studies can contribute to a more comprehensive understanding of the factors influencing students' attitudes toward science and inform the development of effective strategies to promote science literacy and interest.

3. METHODOLOGY

3.1. Research design

The researcher utilized a non-experimental, descriptive-correlational quantitative research design to describe the levels of critical thinking, study engagement, and attitude towards science, examine the relationships between these variables, and investigate the mediating role of study engagement without manipulating any of the variables. This design is appropriate for exploring associations among constructs based on existing theories, such as the Paul-Elder Model (Paul & Elder, 2005) and Goal Theory (Locke & Latham, 1991) which emphasize the interconnectedness of cognitive and motivation factors in learning. Data collection was conducted in a span of one month from April 11 to 16, 2025.

3.2. Participants and sampling technique

Based on the calculations of Raosoft Software, a total of 301 Grade 11 Senior High School students was taken as a respondent to this study from the different public schools in the municipality of Pangantucan, Bukidnon which has a total population of 1361 as stipulated in the Department of Education Learner's Information System (LIS). This calculation is based on Barclay, as mentioned by Memon *et al.* (2020). This sample size calculator helps researchers determine the appropriate sample size based on factors like confidence level, margin of error, and population size. This calculator uses statistical formulas to calculate the minimum number of respondents needed for a study to achieve the desired level of accuracy. The researcher used a random sampling technique, which selects a sample from a larger group in such a way that every member of the population has an equal and independent chance of being chosen. This ensures the sample is representative of the population and minimizes bias.

The Grade 11 students were taken as the respondents since they have Science as one of their core subjects, which makes them more likely to engage with the research, providing thoughtful and complete responses, and increases the quality of the data collected. Additionally, their age is a crucial stage in their future science courses and career decisions. In addition, the researcher chose senior high students to be participants in the study because the researcher is confident that the senior high students already have enough knowledge to answer the high-level questions that were asked by the researcher. Respondents not taught science subjects in the target schools or who did not meet the researcher's status and subject teaching conditions were excluded from the research.

3.3. Research instrument

The research instruments for critical thinking and study engagement were adapted from an existing article by Chen *et al.*, 2022, and attitude towards science was adapted from the article by Tai *et al.*, 2022. All items for study engagement, critical thinking, and attitude toward science were measured on a 5-point Likert scale, ranging from 1 = absolutely disagree to 5 = absolutely agree.

The first and second questionnaires that was used in this study came from the article of Chen *et al.*, 2022 with the title The Relationship Between Study Engagement and Critical Thinking Among Higher Vocational College Students in China: A Longitudinal Study". The third research instrument of the study, the dependent variable was adapted questionnaire from the article of Tai *et al.* (2022) entitled "(Re-Designing a measure of student's attitudes toward science: A longitudinal psychometric approach. International Journal of STEM Education". The tentative draft of the inventory checklist was submitted for validation to a panel of jurors who are experts in the field of science. The adapted questionnaire underwent initial analysis and translation before being submitted to evaluators for review. Based on their feedback, necessary revisions were made, and

the instrument was refined for formal validation. To strengthen its credibility, an external validator was also consulted.

It was pilot-tested in order to determine the reliability of each item using Cronbach's Alpha. Based on the provided reliability statistics, the internal consistency of the three scales was assessed using Cronbach's alpha. The Critical Thinking Skill scale yielded a Cronbach's alpha of 0.705, indicating acceptable reliability. The Attitude toward Science scale demonstrated good reliability with a Cronbach's alpha of 0.850. The Study Engagement scale achieved excellent reliability, reflected by a Cronbach's alpha of 0.937. These results suggest that the items within each scale consistently measure their respective constructs, with higher alpha values indicating greater internal consistency.

After the questionnaire was revised and finalized, permission to conduct the study was secured from the campus administrator, and the instrument was distributed to the students. The researcher gathered the accomplished instruments as soon as the respondents finished answering them. The data obtained from this investigation were tallied, computer-processed, analysed, interpreted, and added to the literature.

3.4. Data gathering procedure

In conducting this research, the researcher adhered to all necessary standards to ensure a rigorous study. The adapted questionnaire was first analyzed, translated, and presented to evaluators for review. After incorporating feedback from validators and making necessary revisions, the researcher finalized the questionnaire for formal validation. To further enhance its credibility, an external validator was engaged. Once the questionnaire was prepared, the researcher organized all required materials for validation at UMERC. The researcher submitted a copy of the manuscript to UMERC, Protocol No. UMERC-2025-092, to review and provide recommendations and confirmation of ethical consideration. Additionally, a formal letter was submitted to the school principal requesting permission to conduct the study within the institution.

3.5. Data analysis procedure

This study employed different statistical tools to analyse the relationship between critical thinking, study engagement, and attitude toward science among secondary students. Firstly, weighted means were calculated to determine the levels of critical thinking, study engagement, and attitude toward science. Secondly, Pearson's r correlation was used to assess the significant relationships between critical thinking and study engagement, and attitude toward science. This statistical method was selected due to the continuous nature of the variables and the need to determine wether statistically significant linear associations existed among them. Finally, a path analysis was utilized to examine the mediating role of study engagement in the relationship between critical thinking and attitude toward science. Path analysis is particularly suitable for testing causal models and indirect effects in correlational data, as it allows the researcher to examine both direct and indirect pathways simultaneously. This analytic approach aligns with the study's conceptual framework, which hypothesizes that study engagement not only correlates with both critical thinking and attitude toward science but also acts as a mechanism through which critical thinking influences students' attitudes. Thus, the use of path analysis provided a deeper understanding of the structural relationships among the variables within the proposed model.

3.6. Ethical considerations

The researcher ensured that participants in this study fully understood that their participation was completely voluntary. They were informed, both in writing and verbally, that they have the absolute right to withdraw or leave the study at any stage of the research process at their discretion, without any consequences, particularly without any impact on their grades. For participants under the age of 18, assent was required, and informed consent was obtained from their parents or legal guardians before they could participate.

The researcher strictly followed privacy and confidentiality protocols to protect participants' data from potential risks, such as psychological distress, social consequences, and legal concerns. All collected data was securely stored in a password-protected digital file and a locked physical cabinet, accessible only to the researcher. Participants' identities remained anonymous, and no personally identifiable information was disclosed. If anonymized data is to be shared with school administrators or policymakers, it must occur with prior approval from the ethics review board and in accordance with data protection policies.

The researcher ensured that participants were well-informed about the study's purpose and that the inclusion and exclusion criteria were clearly communicated. Before engaging with respondents, the researcher obtained permission or a recommendation from the school administration or principal. Participant recruitment followed predefined selection criteria to ensure that only eligible individuals were included. With experience in educational research, the researcher worked closely with designated school personnel, such as teachers or academic coordinators, to identify potential participants who met the eligibility requirements. These school representatives assisted in the initial identification process while ensuring that recruitment remains voluntary and unbiased.

The researcher carefully assessed and minimized all potential risks, including physical, psychological, social, and economic risks. Since these factors may influence participants' decisions to join the study, they were fully disclosed before obtaining consent. Some questions may cause students to feel inadequate or anxious. To mitigate possible emotional discomfort, the researcher highlighted that there is no correct or incorrect responses and that the answers were gathered exclusively for research purposes. Participants were urge to take pauses if necessary and could omit any question that they find distressing. Additionally, the researcher collaborated with school guidance counselors to provide support for any participant who experienced emotional distress during or after the study.

The researcher ensured that respondents were among the primary beneficiaries of the study's findings. The potential advantages of their participation were clearly explained. Although participants did not receive direct financial compensation, they were given small tokens of appreciation to acknowledge their time and efforts. Furthermore, they gained

indirect advantages from the findings of the study, which could contribute to better educational practices, improve learning experiences, and enhance academic support.

In order to ensure originality and follow ethical research protocols, appropriate citations and paraphrasing were utilized in accordance with APA guidelines, thereby eliminating the necessity for tools like Grammarly, Turnitin, or other plagiarism checkers. Additionally, the manuscript was examined using a plagiarism detection tool to confirm its originality and guarantee adherence to academic integrity standards.

The researcher informed the committee that there was no conflict of interest related to this study. To maintain objectivity and meet ethical research standards, stringent measures were established to avoid any potential conflicts. The processes of data collection and analysis were conducted with transparency, ensuring that the results were grounded solely in objective evidence. Any personal relationships between the researcher and participants or facilitators were disclosed to the ethics committee, along with further steps taken to reduce bias. These steps may include the use of independent data collectors, anonymizing responses, and validating results independently to preserve the integrity of the research process.

4. RESULTS AND DISCUSSION

4.1. Level of critical thinking skills

Students' attitudes toward science of Grade 11 students of Pangantucan, Bukidnon, were examined in this section using the analyzed statistical data. As shown in Table 1, the results yielded an overall mean score of 3.02 with a standard deviation of 0.47, indicating a moderate level of critical thinking skills. Among the indicators, open-mindedness received the highest average score of 3.79, which is classified as high. In contrast, truth-seeking received the lowest average score at 3.36, placing it in the moderate range. The results of this study indicated that students exhibited a moderate level of critical thinking skills, with open-mindedness scoring the highest and truth-seeking the lowest. This implies that while students are generally open to new ideas and different viewpoints, they might show a limited tendency to actively seek out truth and verify information.

Table 1. The level of critical thinking skills of students

Indicator	SD	Mean	Descriptive Level
Finding the Truth (FT)	0.63	3.36	Moderate
Open-mindedness (OM)	0.55	3.79	High
Analysis Ability	0.47	3.68	High
Systematic Capabilities	0.55	3.45	High
Self-Confidence in Critical Thinking	0.40	3.60	High
Overall	0.47	3.02	Moderate

The findings were consistent with the research done by Lansangan and Orleans (2024), which indicated that junior high school students in the Philippines were very open to new ideas but struggled with organizing and planning information, hihglighting difficulties in more advanced analytical thinking. In a similar with the study of Pamaos *et al.* (2023) found that senior high school students demonstrated a high degree of critical thinking skills, while still calling attention to the ongoing need for the development of critical thinking abilities among different student groups. The study of Manassero-Mas and Vázquez-Alonso (2022) also found that students with a better understanding of how science works tend to have stronger critical thinking skills. Additionally, the study by Rohaida *et al.* (2024) demonstrated that external motivation, such as openness, positively influences both science literacy and critical thinking skills among elementary students. The study of Mangarin and Macayana (2024); Pacala and Cabrales (2023) supports the moderate level of critical thinking skills of students in Pangantucan, Bukidnon, where many schools, such as the municipality, lack formal laboratories due to budget constraints and infrastructure challenges, limiting students' opportunities for hands-on, inquiry-based learning, forcing them to depend on lecture-based instruction.

4.2. Level of attitude towards science

This section presents the students' attitudes toward science based on the statistical results. As shown in Table 2, the overall mean for attitude towards Science is 3.62 and has a standard deviation of 0.41, which is considered high. This indicates that the Grade 11 public school students of the municipality of Pangantucan, Bukidnon, generally possess a positive orientation toward science, valuing its role in society and feeling reasonably confident and motivated to engage with science-related content. The perception of the teacher showed a descriptor that was very high, with the highest mean rating of 4.26, while anxiety toward Science is the indicator with the mean rating of 2.76, or moderate.

Table 2. Level of attitude towards science

Indicator	SD	Mean	Descriptive Level
Perception of the Teacher	0.66	4.26	Very High
Anxiety toward Science	0.85	2.76	Moderate
Value of Science to Society	0.73	3.97	High
Self-confidence in Science	0.62	3.51	High
Desire to do Science	0.66	3.61	High
Overall	0.41	3.62	High

The results of this research revealed that students in the municipality generally have a strong positive attitude toward science, indicating an encouraging disposition towards learning in this field. This aligns with Palmes (2023), who found that although high school students demonstrated satisfactory performance in science and maintained high self-esteem, there was a notable link between science anxiety and self-esteem, implying that anxiety may undermine students' confidence in their science studies. Furthermore, the findings that indicated high appreciation for the societal value of science, self-assurance, and enthusiasm for engaging in science support the idea that students recognize the importance of science

and are typically eager to delve into scientific subjects. This is corroborated by the research of Alimbon *et al.* (2023), which showed that high school students held a very positive attitude towards science, especially regarding academic importance, participation in science activities, and the classroom environment. Additionally, Guadalquiver and Ocdenaria (2023) found that students with a pronounced positive attitude toward science were actively involved in science-related endeavors and showed strong academic performance in the subject, suggesting that affirmative attitudes toward science correlate with enhanced academic results. Nevertheless, the moderate score on anxiety related to science confirms the findings of Sabit *et al.* (2024) that it is crucial to tackle science anxiety in order to foster a more positive attitude and improve academic achievements in science.

Additionally, favorable perception from the teachers are associated with enhanced student results, as student view teacher communication positively tend to have increased enjoyment and succes (Wu & Wang, 2025). This was supported by the study of Barndmiller *et al.* (2020) that when teachers perceive students, these perceptions can positively influence students' academic achievement and classroom behavior, often mediating the relationship between student characteristics and perceived cognitive skills. A moderate level of anxiety towards science is a common experience among students and can be influenced by various factors. Recent studies indicate that science anxiety is not strongly linked to gender, but can be affected by grade level, family income, and type of school, with students from higher-income families and private schools generally reporting lower anxiety (Özbuğutu, 2021). The study of Degorio *et al.* (2023) also added that factors such as students' attitudes, their interactions with assessments and activities, and the overall learning environment contribute to the complexity of science learning anxiety. Although a certain level of anxiety can occasionally encourage students to study harder and enhance their performance, chronic anxiety can obstruct their involvement and success. This underlines the necessity for supportive teaching methods and inclusive classroom environments (Downing *et al.*, 2020).

4.3. Level of study engagement

This section of the research provides an overview of the engagement levels of Grade 11 public schools students from the municipality of Pangantucan, Bukidnon, based on the date gathered. Table 3 displayed a high descriptive level with an overall mean of 3.81 and a standard deviation of 0.51. This suggests that students generally exhibit strong engagement behaviours in their learning. The data showed that passion for learning was one of the indicators got the highest mean of 4.11 and active learning as the lowest mean of 3.45, respectively. The result showed that students demonstrated a signifocant degree of engagement on their studies, indicating a strong commitment to their learning experiences. Amon the various indicators assessed, "Passion for Learning" achieved the highest mean score and was classified as very high, inidcating that students possess a strong motivation enthusiasm for their academic pursuits. Active learning of students suggests that students frequently engage in active learning behaviors such as participation, collaboration, and hands-on activities, reflecting a positive but still improvable level of engagement.

Table 3. Level of study engagement

Indicator	SD	Mean	Descriptive Level
Active Learning	0.68	3.45	High
Teacher-student Interaction	0.65	3.79	High
Peer Interaction	0.66	3.87	High
Deep Cognitive Strategies	0.67	3.82	High
Passion for Learning	0.68	4.11	Very High
Overall	0.51	3.81	High

These results aligned with the study of Fredricks *et al.* (2019) that many students exhibit significant intrinsic motivation and a true enthusiasm for learning, which is demosntrated by their deep passion fot he subject matter. However, this internal drive doesn't consistently translate into observable active l;earning behaviors, such as posing questions, engaging in discussions, or collaborating with fellow students, pointing out a disconnect between motivation and actual behavioral engagement. Additionally, while passion can strongly motivate students, it must be supported by effective classroom practices, learning environments, and teaching methods that encourage active participation. To address this, schools should use strategies like student-led projects, inquiry-based learning, and collaborative activities to turn motivation into meaningful classroom engagement (Reeve *et al.*, 2020).

Recent studies revealed that students exhibit significant levels of active engagement when teaching methods and classroom settings foster collaboration and independence. A qusi-experimental investigation by Bishaw *et al.* (2024) indicated that cooperative learning teachniques greatly improved student engagement and academic success, showing moderate to large effects and highlighting the efficacy of peer-based teaching strategies in encouraging active involvement. In addition, Peng *et al.* (2022) explored the influence of active learning classroom designs and discovered that spatial elements such as adaptive setting arrangements and group oriented lay-outs played a crucial role in enhancing students learning experiences and levels of engagement. This results emphasize the significance of both teaching approaches amd physical classroom environements in maintaining active learning behaviors in students.

4.4. Correlation between critical thinking skills, attitude towards science, and study engagement

The statistical evaluation showed notable positvie correlations between critical thinking skills, attitude towards science, and level of study engagement among Grade 11 public schools of the municipality of Pangantucan, Bukidnon. As shown in Table 4, critical thinking skills were strongly correlated with attitude toward science and moderately correlated with study engagement.

Specifically, a significant positive relationship was found between critical thinking skills and attitude toward science, with a Pearson correlation coefficient (r) of .628 and a p-value of 0.01, which is less than the 0.05 level of significance. Thus, the null hypothesis is rejected. Additionally, critical thinking skills were positively correlated with study engagement (r-value of 0.513, p–value of 0.01). Hence, the null hypothesis was rejected. Similarly, a positive correlation was observed between attitude toward science and study engagement, with an r-value of 0.631 and a p-value of 0.01. Thus, the null hypothesis was rejected since the level of confidence is less than 0.05. All correlations were statistically significant at the 0.01 level, indicating a high level of confidence in the results.

Table 4. Overall significance of the relationship between levels of critical thinking skills, attitude towards science, and study engagement

	Critical Thinking Skills	Attitude Toward Science	Study Engagement
Critical Thinking Skills	1	.628**	.513**
Attitude Toward Science	.628**	1	.631**
Study Engagement	.513**	.631**	1

**. Correlation is significant at the 0.01 level (2-tailed).

The significant positive correlation between critical thinking skills and students' attitudes toward science conforms to the anchored proposition of the Paul-Elder critical Thinking Framework (Paul & Elder, 2005). This theory explained that critical thinking is not just about thinking skills but also about attitudes like curiosity, open-mindedness, and a desire to learn. Students who have a positive attitude toward science are more likely to ask questions, look for evidence, and think carefully about what they learn. These good attitudes help them develop stronger thinking skills. Thus, students in Pangantucan who enjoy science are also more likely to think critically.

The findings of this reserach align with those of Borbob *et al.* (2025), ehich indicate that critical thinking skills play a significant role in the academic achievement of senior high school students, highlighting the necessity of nurturing these skills to improve students' educational results. Likewise, Concha *et al.* (2024) in the Philippines identified a strong link critical thinking abilities of senior high school students when participating in computer-ssisted instruction. This showed that a positive attitude and interest in the subject empower students to analyze, evaluate, compare, and conceptualize within the relevant context.

The significant correlation between critical thinking skills and study engagement agrees with the proposition of Self-Determination Theory (SDT) by Deci and Ryan (1985). This theory explains that when students feel motivated—especially intrinsically motivated—they are more engaged in learning and more likely to use deep thinking strategies. Engaged students tend to focus, ask questions, and reflect on their learning, all of which help improve their critical thinking skills. In short, students who are more motivated and involved in their studies also tend to think more critically. The result is consistent with the research of Chen et. al. (2022) which indicated that the starting point and grwoth of study engagement had a positive effect on both the starting point and porgression of critical thinking. The research concluded that there exists a dynamic, reciprocal relationship between study engagement and critical thinking over time.

On the other hand, a correlation was observed between study engagement and attitude toward science. This result is congruent with the view of Eccles and Wigfield (2002) on Expectancy-Value Theory. This theory says that students are more engaged in learning when they enjoy the subject and believe it is important. Hence, if students have a positive attitude toward science, they are more likely to pay attention, participate, and stay focused in class. The more they enjoy science, the more engaged they become in studying it.

The result is similar to the study of Senina and Manguilimotan (2025) on the significant positive relationship between student engagement and attitudes toward science. This is supported by Adarlo *et al.* (2022) that both students' attitudes toward science and their course engagement were significant predictors of science literacy. The study of Guadalquiver and Ocdenaria (2023) further confirmed that there is a significant relationship not only between attitude toward science and both science achievement but also with student engagement. Similarly, a study involving Philippine secondary school learners using self-learning modules by Mutya *et al.* (2020), indicated that favorable views of science were notably linked to improved study habits and higher levels of academic involvement, suggesting that students who employ effective study techniques are more inclined to have a positive perception of science. Together, these studies support the current findings, highlighting the relationship between critical thinking abilities, attitudes toward science, and student engagement. Educational approaches that develop critical thinking and positive perspectives on science, while also promoting strong teacher-student relationships, could significantly boost student engagement and academic achievement.

4.5. Mediation analysis of the three variables

The path analysis depicted in Figure 2 indicated the following findings: the relationship of critical thinking skills (x) to study engagement (m); study engagement (m) to attitude towards science (y); criticial thinking skills (x) to attitude towards science (y) are all significant and maintian the same sign. Therefore, study engagement serves as a partial mediator in the connection between critical thinking skills and attitude towards science. The percent of total effect of critical thinking skills in attitude towards science that is mediated by study engagement is 51.39,

as shown in Table 5 on the estimates for partial mediation. This indicates that around fifty-two out of a hundred is the effect of factors of critical thinking skills on attitude towards science goes through its influence of study engagement, while the remaining 48 out of a hundred represents direct effects. Since partial mediation took place in this study, it can be understood that the study engagement is not the sole reason critical thinking can influence attitude towards science of the senior high school students in the municipality of Pangantucan.

The triangular diagram shown in Figure 2 illustrates that there is a corresponding 0.65-unit increase in m (study engagement) for every unit increase in critical thinking. Also, for every unit increase in study engagement, there is a 0.34 corresponding increase in attitude towards science. Moreover, for every unit increase in critical thinking skills, there is a corresponding 0.43 unit increase in attitude towards science. In summary, following the path critical thinking skills-study engagement-attitudes towards science of students, for every unit increase in critical thinking skills, there is a 0.43-unit increase in students' attitudes towards science. This implies that attitude towards science can be enhanced by teaching strategies, but should pass through study engagement. Hence, study engagement partially mediates critical thinking to strengthen students' attitude towards science.

Table 5. Estimates for partial mediation

			Estimate	S.E.	C.R.	P-value
Study Engagement	<---	Critical Thinking Skills	.653	.063	10.361	***
Attitudes towards Science	<---	Critical Thinking Skills	.428	.048	8.892	***
Attitudes towards Science	<---	Study Engagement	.342	.038	9.031	***

% Mediation=51.39

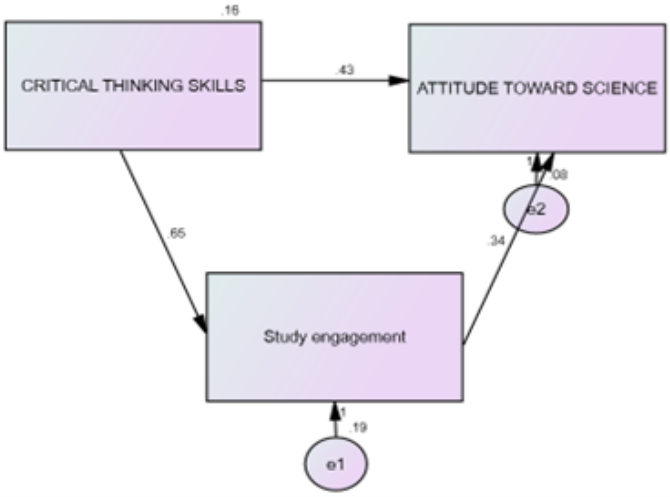

Figure 2. Mediation model
x=CRITICAL THINKING SKILLS,
y=ATTITUDE TOWARDS SCIENCE,
m=STUDY ENGAGEMENT

These findings aligned with the previous research conducted by Castillo *et al.* (2023) discovered a significant connection between and individual's study habits and the impact on their performance outcomes. Furthemore, Chen *et al.* (2022) presented compelling longitudinal data indicating yhat study engagement is not only related to critical thinking but also plays as a role in its advancement, emplying that encouraging engagement can result in lasting and progressively meaningful enhancements in critical thinking over time. Ramos and Israel (2024), also in the Philippine STEM setting, revealed a partial mediation of self-concept, a construct closely aligned with engagement between science inquiry and science-related attitudes. Specifically, self-concept, which overlaps with engagement, acted as a link through which inquiry influenced attitudes toward science.

In contrast, Guadalquiver and Ocdenaria (2023) examined Grade 11 students in Tagum City, Philippines, focusing on how student engagement affected the relationship between attitude towards science and academic performance in science. They discovered significant direct correlation between attitudes and angagement; however, their Sobel test inidctaed that engagement did not serve as a significant mediator between attitudes adn achievement, implying that the direct effects of attitudes are more influential than engagement by itself.

Additionally, Cabahug *et al.* (2024) emphasized that attitudes toward science have a considerable impact on both scientific knowledge and academic involvement among senior high school students in the Visayas region. Their research indicated that fostering positive scientific attitudes can increase student engagement, which in turn enhances academic performance. Likewise, Pagutayao *et al.* (2024) found a strong connection between psychological factors and critical thinking attitudes in Earth Science students who participated in computer-assisted instruction, indicating that psychological engagement can strengthen both critical thinking skills and favorable attitudes toward scientific education. The partial mediation model reveals that improving students' critical thinking abilities can not only enhance their attitudes toward science directly but also do so indirectly by promoting greater engagement. Consequently, educators should prioritize the development of teaching strategies that nurture critical thinking and encourage active student participation in the learning process. Techniques like the Socratic Method, as recommended by Pascual (2023), can foster critical thinking and encourage active involvement, which may lead to more positive attitudes toward science.

5. CONCLUSION

According to the study's findings, participants exhibit different levels across the assessed variables. The critical thinking skills displayed are at a moderate level, indicating a need for further enhancement in this cognitive area. Conversely, participants

show a high level of performance in their attitude towards Science, suggesting a favorable outlook and interest in the discipline. Furthermore, the degree of study engagement is high, indicating a strong commitment and involvement in academic pursuits. The results of the study reveal that students possess positive attitudes toward science and are actively engaged in their learning; however, their critical thinking abilities are only moderately developed. To tackle this issue, educators—including teachers, school leaders, and curriculum developers—should create lessons aimed at fostering deeper analytical skills. Employing strategies such as inquiry-based learning, problem-solving tasks, and promoting reflective questioning can improve students' critical thinking capabilities. Offering professional development for educators to implement these approaches will further aid this objective. Schools in rural areas such as Pangantucan, Bukidnon, are encouraged to prioritize the utilization of well-equipped science laboratories and purchase essential apparatus. Science teachers should also be trained to create engaging, hands-on activities using these resources. This approach can improve student engagement and help develop their critical thinking and attitude toward science. There is a significant correlation between students' critical thinking skills and their attitude towards science. Moreover, critical thinking skills are strongly correlated with study engagement, which is also notably linked to attitude towards science. Additionally, study engagement partially mediated the relationship between critical thinking skills and attitude toward science.

Thus, the conclusions support the idea that study engagement has a mediating effect on the relationship between critical thinking skills and attitude towards Science. Recognizing the strong connections between critical thinking skills, attitudes toward science, and study engagement, it is recommended that administrators support programs that integrate thinking skills with engaging science activities. Master teachers can develop learning plans that connect scientific concepts to real-life problems, fostering both engagement and critical analysis. Additionally, revising the curriculum to include more activities that encourage critical thinking—such as experiments, open-ended questions, and collaborative projects—can strengthen students' analytical skills and their interest in science. In Pangantucan, Bukidnon, where many students face limited access to learning resources, enhancing study engagement is especially important in linking critical thinking skills with positive attitudes toward science. Educators should focus on active learning strategies such as group work, real-life problem-solving, and student-led activities to make science lessons more interactive and meaningful. Training teachers to create dynamic and engaging learning environments can motivate students and encourage deeper thinking, aligning with UN Sustainable Development Goal 4 on promoting quality and inclusive education.

The finding of the study supports the Goal Theory of Locke and Latham (1991). This theory emphasizes the importance of goal setting, goal striving, and goal attainment in shaping behavior and performance. The theory posits that goals provide individuals with a sense of direction, purpose, and motivation, influencing their actions and efforts. For future researchers, it is recommended to explore further how study engagement affects the connection between students' critical thinking skills and their attitude towards Science. Since this study found that study engagement plays a mediating role, future studies can look deeper into what specific types of engagement—such as emotional, behavioral, or cognitive—have the strongest impact. Expanding the research to include different age groups, schools, or learning environments could also help provide a broader view and support the development of teaching strategies that improve both thinking skills and attitudes towards Science.

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