Attitudes Towards Mathematics, Motivational Persistence, and AI-Based ChatGPT usage: A Structural Model on Critical Thinking Disposition of Private Senior High Schools in Davao Region

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ABSTRACT

This study determined the best model that predicts critical thinking disposition of the senior high school students using the Structural Equation Modeling. It was conducted among private senior high school institutions in Region XI focusing on the Grade 11 using descriptive-correlational design, employing the cluster random sampling method in the selection of respondents. The results showed a moderate level of attitudes towards mathematics and AI-based ChatGPT usage, along with a high level of motivational persistence and a critical thinking disposition. Moreover, a significant relationship exists between attitudes towards mathematics, motivational perseverance, and critical thinking disposition, while it revealed a not significant relationship between AI-based ChatGPT usage and critical thinking disposition.

The hypothesized model generated in the study came up with marginal to poor fit which requires model modification. The best-fit model demonstrated a causal link of motivational persistence to critical thinking disposition, while attitudes towards mathematics directly influence CTD when mediated by motivational persistence. This pathway underscores that CTD is most effectively cultivated not merely by favorable attitudes but with motivational persistence that enable them to achieve mathematical pursuits amidst difficulties.

Keywords: Education, attitudes towards mathematics, motivational persistence, AI-based ChatGPT usage, critical thinking disposition, private senior high school, structural equation model, Philippines

INTRODUCTION

Critical thinking disposition refers to the consistent internal motivation or behavioral inclination to engage in purposeful, self-regulatory judgment, reasoning, and problem-solving within mathematical contexts. Critical thinking disposition is a behavioral tendency to engage in critical thinking, and people who think critically always act based on disposition (Kurniati et al., 2020; Salviejo et al., 2024). Critical thinking disposition is vital in learning mathematics because it promotes systematic problem-solving, analytical reasoning, and creative approaches to challenges (Silwana & Widayanti, 2024).

However, students often struggle to maintain a self-reflective and critical attitude toward their math education and have conflicting ideas about it (Sachdeva & Eggen, 2021; Er, 2024). Critical thinking disposition impairments have a direct impact on academic achievement, critical thinking skills and decision-making in real-life situations (Celik & Ozdemir, 2020; Sachdeva & Eggen, 2021).

A study in Turkey found that students were low in critical thinking disposition, which shows how important it is to improve traits like analytical skills, open-mindedness, cognitive maturity, curiosity, self-confidence, systematic thinking, and a search for truth (Cansoy & Türkoğlu, 2017). Similarly, Boonsathirakul and Kerdsomboon (2021) also added on their research on Thailand universities indicates that academic progression does not enhance critical thinking disposition.

This is corroborated by the research conducted by Ng et al. (2022) in China, which also discovered that students exhibited an ambivalent critical thinking disposition especially in truth-seeking. In Indonesia, Hidayanto et al. (2022) also observed that only high-achieving students have critical thinking disposition features. Moreover, being open-minded and able to think critically are two traits that affect how well students do in school (Bell & Loon, 2015). Without critical thinking disposition, students may have difficulties in observing, analyzing, or make important decisions, leading to erroneous conclusions and shallow reasoning, according to Fianingrum et al. (2023).

In the Philippines, a study conducted in Central Luzon found that students demonstrated weak reflective thinking and attentiveness, only a fair level of open-mindedness, and moderate organization, perseverance, and intrinsic goal motivation (Salviejo et al., 2024).

Moreover, a noticeable decline in these 21st-century skills was reported among Filipinos, reflecting a low critical thinking disposition among students. This decline is further substantiated by the 2019 TIMSS results, in which the Philippines ranked the lowest in mathematics out of 58 participating countries (CNN Philippines Staff, 2020). Low critical thinking disposition among students negatively impacts learning outcomes, as Futalan and Pagente (2024) showed that it significantly predicts critical thinking skills and mathematical achievement. Underdeveloped critical thinking disposition often hinders students' ability to think critically and solve mathematical problems systematically and logically (Benedicto & Andrade, 2022).

Critical thinking disposition plays a vital role in teaching mathematics and in developing skills that apply to real-world contexts. However, most previous research has focused more on critical thinking abilities rather than dispositions (Rauscher & Badenhorst, 2021).

As Rauscher and Badenhorst (2021) emphasize, further studies are needed to identify which dispositions should be prioritized to meet the demands of the modern world. This gap is evident in the Davao Region, where critical thinking disposition has not been thoroughly investigated, particularly in the context of emerging technologies such as AI (Futalan & Pagente, 2024). To address this, the present study examines how attitudes toward mathematics, motivational persistence, and AI-based ChatGPT usage influence CTD among private senior high school students in the area.

Research Objectives

To determine the level of attitudes towards mathematics of the students in terms of:

1.1 self-confidence;
1.2 value;
1.3 enjoyment;
1.4 motivation

To determine the level of motivational persistence of the students in terms of:

2.1 recurrence of unattained purposes;
2.2 long-term purposes pursuing;
2.3 current purposes pursuing

To determine the level of AI-based ChatGPT usage of the students terms of:

3.1 usage and engagement;
3.2 perceptions of effectiveness;
3.3 challenges and reservation;
3.4 preferences and suggestions

To determine the level of critical thinking disposition of students in terms of:

4.1 truth-seeking;
4.2 open-mindedness;
4.3 analyticity;
4.4 systematicity;
4.5 CT self-confidence;
4.6 inquisitiveness;
4.7 cognitive maturity

To determine the significant interrelationship between attitudes towards mathematics, motivational persistence, AI-based ChatGPT usage and critical thinking disposition.

To determine the best fit model of critical thinking disposition among Grade 11 private senior high school students in Region XI.

To determine the underlying implications of the significant causal links in critical thinking disposition.

METHODOLOGY

This study employed quantitative descriptive-correlational design to describe the characteristic of data and examine the degree and direction of relationships among variables without establishing causality (Creswell & Creswell, 2017; Mohajan, 2020).

Meanwhile, the study used structural equation modeling (SEM) to assess the influence of attitudes towards mathematics, motivational persistence, AI-based ChatGPT usage on critical thinking disposition. According to Hoyle (2011), structural equation modeling may also explained as a comprehensive statistical approach to test hypotheses and exploring relations between observed and latent variables.

Population and Sample

A total of 380 was computed based on raosoft calculator, 5% margin of error and 95% confidence level. The raosoft sample size calculator has been widely utilized in academic research to ensure representatives and validity of findings (Khan et al., 2019; Santos, 2020).

Cluster random sampling was employed in this study to select respondents in a manner that ensured representativeness while maintaining feasibility. This method has been widely used in educational research to reach large or remote populations where surveying individuals directly would be impractical (Thomas, 2023). Schools or places are easier to survey than persons and remain statistically valid (Ahmad et al., 2025). The population was grouped into clusters based on provinces within Region XI, with schools serving as the primary units.

The six provinces with the largest student populations were identified, and each province was treated as a cluster for analysis. To ensure that schools of varying sizes were adequately represented, probability-proportional-to-size (PPS) sampling was applied, meaning that provinces and schools with larger student enrollments had a higher probability of selection.

This approach eliminated bias and ensured sample representation when cluster sizes varied (Lee et al., 2024; Pamplona, 2019). By matching the sample distribution to the actual population structure, PPS strengthened the internal validity of the study (Kiran et al., 2021).

The researcher secured all the necessary documents, asking approval from the schools including the ethical clearance to guarantee compliance with policies and standards to conduct the study. Informed Consent Forms (in Filipino) were given to identified respondents' parents by school instructors or class advisers.

This had informed them about their children's participation, emphasized its voluntary nature, and assured them of the freedom to withdraw of their child without sanctions. Parents were instructed to affix their signatures to

the consent forms if they agreed to their children's participation. Once parental consent forms were collected, an Assent Form was distributed to the student respondents.

The researcher explained the purpose of the study, highlighted the significance of their contribution, and reiterated that participation was voluntary with the freedom to withdraw at any time without sanctions.

Statistical Tool

The following statistical tools were utilized for the data analysis and interpretation.

Mean was used to measure the level of attitudes towards mathematics, motivational persistence, AI-based ChatGPT usage, and critical thinking disposition of private senior high schools.

Standard Deviation was used to measure set of data's dispersion from the mean of attitudes towards mathematics, motivational persistence, AI-based ChatGPT usage, and critical thinking disposition. The larger the SD and the more important the magnitude of the mean value deviation, the higher the variability distribution.

Pearson Product Moment Correlation was utilized to ascertain the significant correlation between the dependent variable, critical thinking disposition, and the independent variables, attitudes towards mathematics, motivational persistence, AI-based ChatGPT usage.
Structural Equation Modeling was used to explore the best fit-model of critical thinking disposition. Is a multivariate statistical analytic technique for investigating structural relationships. This approach combined multiple regression analysis and component analysis to investigate the structural relationship between measurable variables and latent constructs

RESULTS

Level of Attitude towards Mathematics

It is shown in Table 1 that the level of attitudes towards Mathematics among Grade 11 private secondary school students has an overall mean of 3.20 described as moderate which means that attitude towards mathematics is sometimes manifested.

This results indicates that their emotional, cognitive, and behavioral inclinations regarding the subject are not consistently strong, but rather manifest occasionally or at a moderate level. In addition, considering the degrees of dispersion in this variable, standard deviation is .66 indicating that the responses are clustered around the mean.

Table 1. Level of attitudes towards mathematics of the students

Indicators	Mean	SD	Descriptive Equivalent
Self-confidence	2.98	0.84	Moderate
Value	3.85	0.65	High
Enjoyment	3.05	0.81	Moderate
Motivation	2.92	0.84	Moderate
Overall	**3.20**	**0.66**	**Moderate**

Level of Motivational Persistence

The motivational persistence among Grade 11 private secondary students has an overall mean of 3.56 described as high. This means that the motivational persistence of students is oftentimes manifested.

Also, the standard deviation of 0.56 is less than one, which means that the individual replies are quite near to the mean. This means that students always show a strong and unwavering commitment to their goals.

Table 2. Level of Motivational persistence

Indicators	Mean	SD	Descriptive Equivalent
Recurrence of Unattained Purposes	3.53	0.62	High
Long-term Purposes Pursuing	3.55	0.68	High
Current Purposes Pursuing	3.60	0.72	High
Overall	**3.56**	**0.56**	**High**

Level of AI-based ChatGPT Usage

The overall status of AI-based Chat GPT usage in mathematics is 3.04 described as moderate. It means that AI-based Chat GPT usage is sometimes observed. Considering the degrees of dispersion in this variable, the standard deviation is .52 indicating that the responses are clustered near the mean. This suggests that students do not merely rely on using AI, but instead use it occasionally as an additional tool to aid in enhancing their understanding mathematical concepts

Table 3. Level of AI-based ChatGPT Usage

Indicators	Mean	SD	Descriptive Equivalent
Usage and engagement	2.92	0.88	Moderate
Perceptions of effectiveness	3.02	0.90	Moderate
Challenges and Reservations	3.12	0.68	Moderate
Preferences and Suggestions	3.10	0.68	Moderate
Overall	**3.04**	**0.52**	**Moderate**

Level of Critical Thinking Disposition

In table 4, it is shown that the overall level of critical thinking disposition of Grade 11 private secondary school student is 3.74, which is high. It means that critical thinking disposition of the students is oftentimes exhibited. Grade 11 students in private secondary schools are often inclined to engage in reflective, analytical, and evaluative thinking. This implies that they are intellectually curious, open-minded, and systematic in their approach to learning and problem-solving.

Table 4. Level of Critical Thinking Disposition

Indicators	Mean	SD	Descriptive Equivalent
Truth-seeking	3.98	0.66	High
Open-mindedness	3.67	0.73	High
Analytically	3.77	0.65	High
Systematically	3.72	0.63	High
CT-self confidence	3.44	0.69	High
Inquisitiveness	3.68	0.71	High
Cognitive Maturity	3.88	0.64	High
Overall	**3.74**	**0.51**	**High**

Significance of the Relationship among Attitude towards Mathematics, Motivational Persistence, AI-based Chat GPT Usage to Critical Thinking Disposition

The nature of the relationship between the exogenous variables: attitude towards mathematics, motivational persistence, and AI-based Chat GPT usage, and the endogenous variable, critical thinking disposition is reflected in Table 5. In Table 5, it is shown that two of the exogenous variables have a significant relationship with critical thinking disposition ($p<.05$).

There is a significant positive relationship between attitude towards mathematics and critical thinking disposition ($r=.34$, $p<.05$). The strength of correlation between the two variables is low, as revealed by the coefficient of .34. Because the two factors are intimately related, a positive attitude toward math leads to better critical thinking.

Table 5.1 Significance of the Relationship among Attitude towards Mathematics, Motivational Persistence, AI-based Chat GPT Usage to Critical Thinking Disposition

Variables	**Critical Thinking Disposition**		
	r	p-value	Remarks
Attitude towards Mathematics	.34	.00	Significant
Motivational Persistence	.65	.00	Significant
AI-based Chat GPT Usage	.08	.14	Not Significant

Significance of the Influence of Attitude towards Mathematics and Motivational Persistence to Critical Thinking Disposition

In Table 5.2 below, the results of the regression analysis are presented. One exogenous variable was deleted from the model because it was found to be insignificant in the initial analysis (Table 5.1). This deletion was performed to check for potential changes in the predictive effect of the other two exogenous variables (attitude towards mathematics and motivational persistence) on the endogenous variable, critical thinking disposition. The results indicate that two of the exogenous variables, attitude towards mathematics ($\beta=.09, p< .05$) and motivational persistence ($\beta=.62, p< .05$) are significant positive predictors of critical thinking disposition.

Table 5.2 Significance of the Influence of Attitude towards Mathematics and Motivational Persistence to Critical Thinking Disposition

Exogenous Variable	**Coefficients**	**t**	**p**	**Remarks**
Attitude towards Mathematics	.09	2.18	.03	Significant
Motivational Persistence	.62	14.62	.00	Significant
Dependent Variable: Critical Thinking Disposition				

Best-Fit Model of Critical Thinking Disposition of Students

To achieve a best-fit model, the researcher applied targeted modifications guided by AMOS modification indices in identifying potential correlated errors or removing paths that are insignificant to improve the model fit. The exogenous variable, AI-Chat GPT usage was removed from the modified hypothesized model because its direct path going to CTD was not significant. This approach is supported by Akinwande et al. (2015), stating that model specification may include omitting a variable to attain a good fit. As a result, all indices' goodness of fit values changes, notably achieving the desired range for a good fitting model.

In table 6.1, it is shown that the goodness-of-fit indices as basis for overall model evaluation. The SEM analysis revealed that absolute fit is good CMIN/df is (GFI = .943) which is greater than ≥0.90 supporting that the model reproduces the observed data well. Meanwhile the following incremental fit indices: CFI (.961), TLI (.949), IFI (.961), and NFI (.942) had all exceeded the .90 threshold indicating that Incremental fit is excellent.

Moreover, the parsimony fit indices: CMIN/DF (2.888) is below 3.0 described as acceptable while PNFI (0.728) and PCFI (0.742) which are greater than the criterion of 0.5 described as acceptable implying that model achieves a balance between simplicity and fit. Though PCLOSE (0.006) is low indicating not a close fit, but the RMSEA (0.071) is acceptable (below 0.08) according to Sathyanarayana & Mohanasundaram (2024). It means that the

model fits the empirical data well and implies that though the model is not a perfect fit, but it is still acceptable by most SEM standards.

Table 6.1 The Goodness of Fit Measures of Hypothesized Model of the Study

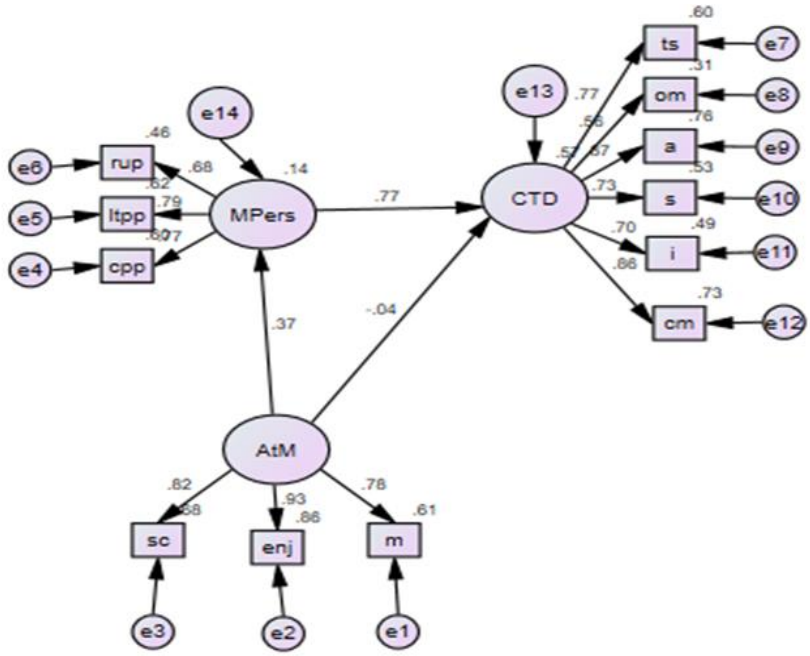
INDEX	CRITERION	Hypothesized Model	Remarks
CMIN/df	<3	2.888	Acceptable
NFI	≥0.90	.942	Good
TLI	≥0.90	.949	Good
CFI	≥0.90	.961	Excellent
GFI	≥0.90	.943	Good
PNFI	>..50	.728	Acceptable
PCFI	>.50	.742	Acceptable
RMSEA	≤0.08	.071	Acceptable
p-CLOSE	>0.05	.006	Low

Underlying the Significant Causal Link in the Critical Thinking Disposition of Students

Presented in Figure 1 are the standardized path estimates of the best-fit model. It shows the standardized path estimates between the latent variables and between latent and observed variables as well as the direct, indirect, and total effects of the variables portrayed in the best-fit model of critical thinking disposition of students. In scrutinizing the data, Table 6 shows that all path estimates are significant at p<.05 except AtM to CTD.

Specifically, the path from MPers to CTD yielded a strong positive standardized coefficient (β = .77), representing the most substantial effect on the endogenous variable.

Figure 1 The Best Fit Model of Critical Thinking Disposition of Students



DISCUSSIONS

Level of Attitude towards Mathematics

The moderate level results of attitudes towards mathematics corroborates the study of Quimbo (2025), who asserted that a moderate attitude toward mathematics signifies a favorable perception of the discipline, while

still allowing for enhancement to cultivate a more enthusiastic engagement. In addition, Syamsuri and Bahtiar (2023) noted that even students with high mathematical proficiency sometimes exhibit moderate attitudes, highlighting the complexity of fostering both sustained proficiency and consistent disposition toward mathematics. Similarly, Yasar (2016) and Andamon and Tan (2018) observed that students' attitudes occasionally fall within a neutral range, often shaped by their perceived relevance of mathematics to future careers.

Moreover, Braho (2025) reported moderate attitudes toward mathematics across various disciplines reinforcing the notion that such dispositions are common and not confined to contexts. Correspondingly, Umac et al. (2025) emphasized that high school students frequently acknowledge the utility of mathematics yet struggle with motivation and positive thinking, which aligns with the current identification of moderate attitudes.

Level of Motivational Persistence

The motivational persistence among Grade 11 private secondary students described as high which means that students always show a strong and unwavering commitment to their goals.

This result corroborates evidence showing that motivational persistence is characterized by sustained effort and resilience despite setbacks, which directly supports the strong commitment observed in the present study (Thalib et al., 2018; Bostan et al., 2021). It also aligns with findings in mathematics education, where high persistence has been linked to grit and perseverance, enabling students to spend more time engaging with challenges and thereby improving mastery skills (DiNapoli, 2023).

The high observed in this study further corroborated by reports that students can adhere to long-term goals even after experiencing failures, reflecting self-control and consistency in their pursuit of academic objectives (Ertem & Arı, 2022). This is consistent with findings that highly persistent learners with disciplined and goal-oriented behavior reflected in the present results (Dascalu et al., 2025).

Moreover, the outcome aligns with evidence that persistence is often driven by the value students place on tasks, suggesting strong persistence and recognition of the importance of academic goals (Ogbaekirigwe et al., 2025). Likewise, Harum (2024) corroborating results confirm that high level of motivational persistence showing consistency in pursuing current goals and demonstrating determination in academics.

High motivational persistence shows that students can work toward both short-term and long-term goals in all of its dimensions. The high level of persistence seen in students shows that they can balance their long-term goals with their short-term discipline and stay strong when things go wrong.

This is in line with research motivation persistence lowers dropout rates and boosts academic engagement (Bostan et al., 2021). Thus, practices like reflecting, setting goals, and getting help from a mentor are still very important for keeping these high levels of motivation.

Level of AI-based ChatGPT Usage

The overall status of AI-based Chat GPT usage in math described as moderate. This suggests that students do not merely rely on using AI but instead use it occasionally as an additional tool to aid in enhancing their understanding mathematical concepts (Sánchez-Ruiz et al.,2023).

This result is like the study conducted by Egara et al. (2025), which found that students exhibited moderate to high usage of AI. Students primarily use it to understand, solve problems, and review mathematical concepts. In addition, this finding was also supported by the study of Muktar (2025), which found that students generally agree that AI is useful for learning mathematics but expressed partial reliance due to its impact on conceptual understanding, problem-solving skills, motivation, and engagement.

This aligns with the notion that while AI supports learning, it cannot be fully relied upon because its reliability for complex problem-solving is still limited (Dao & Lee, 2023). The moderate usage of AI-ChatGPT is also align with the study of Auna and Hamzah (2024), who noted that despite high satisfaction among students, actual usage within formal school environments remained only moderate due to contextual barriers.

Level of Critical Thinking Disposition

It is shown that the overall level of critical thinking disposition of Grade 11 private secondary school student is high. This implies that they are intellectually curious, open-minded, and systematic in their approach to learning and problem-solving.

The study corroborates the findings of Futalan and Pagente (2024), which indicated that senior high school students in private institutions frequently demonstrate high levels of critical thinking disposition, particularly in truth-seeking and analyticity. This result is supported by the study which reported that higher education students consistently demonstrated strong engagement and reflective in their academic pursuit, reflecting high levels of critical thinking disposition (Alvarez-Huerta et al., 2023). This corroborates the study of Redhana et al. (2017), where university students achieved high level of critical thinking disposition, particularly in open-mindedness, truth-seeking and systematicity. This result is further supported by the study which highlighted resilience and maturity among undergraduates, consistent high level of critical thinking disposition (Chen et al., 2020). Similar report was also observed in the study of Safitri and Syahfitri (2023), showing high level of critical thinking disposition among students particularly truth-seeking and inquisitiveness.

Significance of the Relationship among Attitude towards Mathematics, Motivational Persistence, AI-based Chat GPT Usage to Critical Thinking Disposition

The significant but low correlation between attitudes towards mathematics and critical thinking disposition aligns with Salviejo et al. (2024), who demonstrated that intrinsic motivation and reflective thinking predicted critical thinking disposition among students. Similarly, Garcia and Santos (2021) confirmed that mathematical attitudes such as confidence was directly linked to stronger critical thinking disposition, while Cagulada and Ucang (2025) found that positive mathematical attitudes predicted higher levels of critical thinking disposition among high school students.

These findings concur with those of De-la-Peña et al. (2021), who demonstrated that positive mathematical attitudes foster creativity and cognitive flexibility, thereby enhancing reasoning and problem-solving abilities. Likewise, Kamid et al. (2021) further confirmed that persistence and enjoyment in mathematics cultivate intellectual curiosity and open-mindedness, both essential components of critical thinking disposition. Supporting this, Minarti et al. (2020) showed that mathematical knowledge equips students with the ability to analyze and engage in critical discourse, reinforcing mathematics as a foundation for higher-order thinking.

There is a strong positive relationship between motivational perseverance and critical thinking disposition ($r=.65$, $p<.05$). The coefficient of.65 indicates strong correlation between the variables. This also shows that their relationship is direct, meaning that students' critical thinking disposition grows with motivational perseverance.

This coefficient indicates that students exhibiting greater motivational persistence characterized by effort, consistency, and resilience are more inclined to possess a high critical thinking disposition. The p-value indicates that this relationship is statistically significant, demonstrating that the constructs are interconnected.

This result is supported by Minarti et al. (2020) and Arifuddin (2023), who found that motivational persistence enhances analytical thinking and mathematical motivation, improving critical thinking disposition among students. Moreover, Salviejo et al. (2024) discovered that the motivational persistence and motivation of students foster openness and reflective thinking, further supporting the conclusion that motivational perseverance has a strong association to critical thinking disposition. Likewise, Xu and Yang (2024) emphasized that motivation sustain persistence and creativity, which strengthens the connection between motivational persistence and critical thinking disposition characteristics. In addition, Harum et al. (2024) highlighted that students high motivational persistence exhibited strong truth-seeking and consistency in academic contexts.

However, there is no significant relationship between AI-based Chat GPT usage and critical thinking disposition ($r=.08$, $p>.05$). The strength of correlation between the two variables is very weak as revealed by the coefficient of .08. It implies that the relationship is very weak relationship is directed which means that as the level of AI-based Chat GPT usage increases, the level of critical thinking disposition does not significantly increase.

The observed non-significant correlation between AI-based ChatGPT usage and critical thinking disposition aligns with cautionary studies emphasizing the risks of unstructured or excessive reliance on AI like Guo and Lee (2023) reported that frequent dependence on ChaTGPT hindered logical reasoning and comprehension. Moreover, Abbas et al. (2024) similarly noted weakened analytical skills due to over-reliance. Similarly, Hao et al. (2026) further confirmed low critical thinking disposition among undergraduates heavily dependent on AI, particularly in truth-seeking.

This result contrasts with studies of Qawqzeh (2024) who observed that the increase of CTD were associated with varying amounts of ChatGPT use, whereas Barana et al. (2023) and Pepin et al. (2025) found that collaborative ChatGPT use increased intellectual curiosity and systematic thinking. This also contradicts Nasr et al. (2023), who asserted that ChatGPT in collaborative and reflective learning contexts might stimulate students to interrogate, synthesize, and enhance their ideas. Accordingly, structured and purposeful AI use supports CTD attributes including inquisitiveness, independence, and systematicity.

Likewise, Akastangga et al. (2023) found that without reflective scaffolding there will decrease self-confidence and analytical curiosity. This also supported by Egara and Mosimege (2024) discovered that some students got more involved, but others lost interest and effort. These conflicting results show that ChatGPT's effect on CTD depends on instructional design, scaffolding, and context.

Overall, the results confirm the explanatory strength of Social Cognitive Theory and Expectancy-Value theory in accounting for the positive associations observed. Bandura's (1986) Social Cognitive Theory validated by the finding that confidence, perseverance, and goal orientation enhance motivational persistence, which in turns fosters reflective reasoning and systematic problem-solving a characteristic of having a critical thinking disposition. Likewise, Wigfield and Eccles' (2000) Expectancy-Value Theory is affirmed, as students value mathematics and expect success demonstrate stronger persistence and engagement, aligning with higher-order thinking abilities.

In contrast, the lack of significant association between AI use and critical thinking disposition is explained by Cognitive Offloading Theory (Risko & Gilbert, 2016), which posits that reliance on external systems reduces effortful reasoning and reflective monitoring. This is further substantiated by Gerlich (2025) and Akastangga et al. (2023), who emphasize that AI-driven offloading weakens analytical process, truth-seeking and reflective judgment.

Significance of the Influence of Attitude towards Mathematics and Motivational Persistence to Critical Thinking Disposition

The regression coefficient of 0.09 indicates that attitudes towards mathematics has a positive direct effect on student's critical thinking disposition, suggesting that increases in attitudes towards mathematics lead only a 0.09 unit increase in critical thinking disposition, reflecting small but a direct influence. Such findings are consistent with Salviejo et al. (2024), who demonstrated attitudes towards mathematics significantly predicted critical thinking disposition among students. Similarly, Cagulada and Ucang (2025) confirmed that mathematical attitudes highly influence critical thinking disposition among high school students.

Supporting evidence further emphasizes this influence, as De-la-Peña et al. (2021) found that attitudes towards mathematics influence enhanced analytical and reflective reasoning, strengthening critical thinking disposition. Moreover, findings also corroborate in the study of Sari and Juandi (2023), demonstrating that students who has a positive attitude towards mathematics are more likely to engage in analytical thinking and problem solving. Also, Kamid et al. (2021) highlighted that attitudes towards mathematics are predictors with students' cognitive engagement, reflecting intellectual curiosity and open-mindedness, which are attributes of critical thinking disposition.

On the other hand, the coefficient of 0.62 indicates that motivational persistence emerged as strongest predictors on student's critical thinking disposition. This suggests that increases in motivational persistence lead a 0.62 unit increase in critical thinking disposition, reflecting a large direct influence. This finding aligns with the study of Arifuddin (2023), who demonstrated that motivational persistence significantly improved learners' critical thinking disposition. In addition, Xu and Yang (2024), who emphasized that motivational persistence fosters openness and reflective thinking, Similarly, Dascalu et al. (2025) highlighted that students with high motivational

persistence consistently demonstrated stronger critical thinking disposition, particularly in fulfilling academic tasks.

This study supports Social Cognitive Theory (Bandura, 1986), which highlights the importance of personal beliefs and self-regulation in academic involvement. The findings show that attitudes towards mathematics significantly contribute to students' critical thinking disposition, reflecting how confidence and positive views shape engagement in problem-solving tasks (Laranang & Bondoc, 2020; De-la-Peña et al., 2021; Kamid et al., 2021; Minarti et al., 2020). At the same time, motivational persistence emerged as the strongest predictor, reinforcing SCT's principle that sustained effort and resilience enhance self-analysis and reflective reasoning (Minarti et al., 2020; Arifuddin, 2023). This is further supported by Valenzuela et al. (2023) and Firdaus et al. (2025), who found that persistence strengthens students' analytical and critical thinking skills.

These results also align with Expectancy-Value Theory (Eccles & Wigfield, 2000), which posits that students persist in academic tasks when they perceive them as valuable and believe they can succeed. Motivational persistence reflects this expectancy-value dynamic, as students who recognize the worth of their academic goals and expect achievement demonstrate deeper cognitive engagement and processing. The study of Salviejo et al. (2024) further emphasized that internal motivation enables learners to overcome challenges, fostering openness and reflective thinking. Overall, the results highlight that both attitudes towards mathematics and motivational persistence are vital in enhancing students' critical thinking disposition, consistent with the theoretical perspectives of SCT and EVT.

Best-Fit Model of Critical Thinking Disposition of Students

The result of the best-fit model implies that motivational persistence is the key mechanism that connects attitudes toward mathematics with critical thinking disposition. In the model, it demonstrates that attitudes toward mathematics significantly predict motivational persistence (.37), and motivational persistence strongly predicts critical thinking disposition (.77), while the direct effect of attitudes on critical thinking disposition (–.04) is weak and nonsignificant. This pattern highlights that positive attitudes towards mathematics alone are not enough to foster critical thinking disposition, instead, they must be enacted through sustained motivational persistence.

Grounded in Social Cognitive Theory (SCT), this finding reinforces Bandura's principle of triadic reciprocity, where attitudes toward mathematics (AtM) represent the personal cognitive beliefs of learners, motivational persistence (MPers) reflects the behavioral regulation of effort, and critical thinking disposition (CTD) emerges as the cognitive outcome. SCT emphasizes that personal factors, behaviors, and cognitive outcomes interact reciprocally (Bandura, 1986). The nonsignificant direct path from AtM to CTD underscores SCT's principle that beliefs must be operationalized through self-regulated behaviors to produce meaningful outcomes. Thus, persistence mediates the translation of attitudes towards mathematics into critical thinking dispositions, showing that motivational persistence is the bridge between attitudes and cognitive development.

Underlying the Significant Causal Link in the Critical Thinking Disposition of Students

The path from MPers to CTD yielded a strong positive standardized coefficient ($\beta = .77$), representing the most substantial effect on

the endogenous variable. The findings supported by Minarti et.al (2020) who reported that students with strong motivational persistence are significantly more likely to exhibit higher levels of critical thinking disposition. Also, Arifuddin (2023) similarly found that students with stronger motivational persistence exhibited better critical thinking disposition. Furthermore, Li et al. (2024) demonstrated that motivational persistence increased cognitive processing directly tied to critical thinking disposition, while Dascalu et al. (2025) and Harum (2024) showed that students with high motivational persistence displayed stronger critical thinking disposition. Motivational persistence predicts critical thinking, according to expanding research of Firdaus et al., (2025) found that motivational persistence improves students' critical thinking by sustaining cognitive engagement and self-regulation. According to their structural equation modeling, students who are academically persistent are more likely to critically reflect, assess, and analyze material.

These studies demonstrate that motivational persistence enhances critical thinking perseverance and metacognition (Salviejo et al., 2024). The significant impact of this study underscores the importance of educational motivation. Setting goals, having freedom, and valuing tasks might help pupils stick with it and think about things in a more analytical and reflective way (Xu & Yang, 2024).

So, the straight path from AtM to MPers had a standardized path coefficient (β = .371), which showed a moderate and beneficial influence. This was supported by Odani and Orongan (2020), who emphasized that students' favorable attitudes towards mathematics are more likely to persevere in their studies. In alignment, Thalib et al. (2018) corroborated that positive attitudes towards mathematics encourage purposeful effort, such as sustained engagement in mathematics learning. Similarly, Salviejo et al. (2024) and Minarti et al. (2020) confirmed that positive attitudes increase both intrinsic and extrinsic motivation, which translates into persistence in mathematical tasks.

This implication is further contextualized by Bandura's Social Cognitive Theory (1986), which explains that personal beliefs and attitudes influence motivation and behavior through self-efficacy and goal setting. Supported by this framework, Priniski et al. (2018) and Rodríguez et al. (2021) reinforced that when students perceive mathematics as valuable and achievable, they are more inclined to persevere and regulate their learning. The results also corroborate Valenzuela et al. (2023), who found that favorable attitudes forecast motivational persistence, particularly when assignments are perceived as significant and attainable. Likewise, Firdaus et al. (2025) aligned with this result by showing that positive mathematical attitudes foster self-regulation and sustained involvement. Karakuş (2024) further supported this by highlighting that students with favorable attitudes toward mathematics demonstrate flexibility and persistence, both essential for academic resilience and critical thinking.

When examining motivational persistence, the negligible direct effect from AtM to CTD (β = -.041, p = .415) indicates that attitude towards mathematics does not directly influence critical thinking disposition. There is a positive and significant indirect effect (β = 0.29), which shows that AtM affects CTD through MPers. This indicates that favorable mathematical attitudes enhance motivated perseverance and critical thinking orientation.

This indicates that motivational persistence serves as a mediator in the relationship between attitude and critical thinking among students. To support this, Salviejo et al. (2024) and Minarti et al. (2020) confirmed that motivational persistence enhances reflective thinking and self-analysis, thereby linking attitudes toward mathematics indirectly to critical thinking disposition. Likewise, Arifuddin (2023) and Xu & Yang (2024) showed that sustained motivation reduces negative traits and fosters originality, reinforcing the mediating role of motivational persistence. In addition, Li et al. (2024), Dascalu et al. (2025), and Harum et al. (2024) corroborated that motivational persistence strengthens CTD, particularly in truth-seeking and consistency. Also, Firdaus et al. (2025) further emphasized that affective components such as attitude towards mathematics require motivational scaffolding through motivational persistence to evolve into higher-order cognitive outcomes like critical thinking disposition.

The cumulative impact of AtM on CTD is positive (β = 0.25) and not statistically significant, encompassing both direct and indirect effects. Thus, motivated persistence fully mediates the association between arithmetic attitudes and critical thinking. The mediation is characterized as full or complete since the direct effect (AtM → CTD) is not substantial, but the indirect effect (AtM → MPers → CTD) is considerable. Mathematical mindset influences critical thinking only through motivating persistence. According to Karakuş (2024), motivational constructs are crucial links between emotional attitudes and cognitive dispositions. Moreover, Sari et al. (2023) found that persistent effort and engagement to like and confidently learn arithmetic indirectly improve critical thinking.

The best-fit model shows three indicators for attitudes towards mathematics (self-confidence, enjoyment, and motivation) and three indicators for motivational persistence (recurrence of unattained purposes, long-term purposes, and current purposes) as significant positive determinants (p <.05). The six indicators of the endogenous variable, critical thinking dispositions, (truth-seeking, open-mindedness, analytically, systematically, inquisitiveness, and cognitive maturity) are also significant positive measures with p-values below.05.

The findings support Nasr et al., (2025), who stressed the role of motivation and metacognition in student critical thinking. The instructional design must link emotional and motivational dimensions to promote critical thinking (Nasr et al., 2025). The results confirm the applicability of Social Cognitive Theory (SCT) in explaining the best-fit model, where attitudes toward mathematics significantly predict critical thinking disposition through the mediating role of motivational persistence. SCT posits that personal factors such as attitudes, behavioral mechanisms like persistence, and cognitive outcomes interact reciprocally (Bandura, 1997). In this model, students with positive attitudes toward mathematics develop stronger self-efficacy and value beliefs, which in turn sustain their persistence in learning tasks. This persistence becomes the behavioral channel that transforms attitudes into deeper cognitive engagement, ultimately fostering dispositions toward critical thinking. The findings imply that while favorable attitudes are essential, they must be reinforced by motivational persistence to yield meaningful cognitive outcomes.

CONCLUSION

The level of attitudes towards Mathematics among Grade 11 private secondary school students is moderate which means that attitude towards mathematics is sometimes manifested. This implies that students know how important math is, their confidence varies and feel motivated. Furthermore, the high level of motivational persistence of private senior high school in Region XI is oftentimes manifested. Students do not get easily discouraged and continues to complete their tasks despite difficulties or setbacks. This shows that students are resilient, they keep on working toward their goals even when faced with challenges. They pursue long term goals and current goals suggesting a robust desire to succeed in overcoming difficulties. Moreover, the moderate level of AI-based ChatGPT usage of private senior high school in Region XI is sometimes observed. This means that students use AI to enhance their understanding of complex, while remaining cautious about generating mathematical content and avoiding full reliance on it. They value ChatGPT's usefulness, yet prefer customizable tools tailed to their needs. Additionally, the high level of critical thinking disposition of private senior high school in Region XI is oftentimes exhibited. Students often inclined to engage in reflective, analytical, and evaluative thinking. There is a significant positive relationship between attitudes towards mathematics, motivational persistence and critical thinking disposition. However, there is no significant relationship between AI-based ChatGPT usage and critical thinking disposition. This suggests that while students utilize AI occasionally, AI alone may not necessarily help them develop deeper thinking or analytical skills which are essentials for critical thinking disposition. The hypothesized structural model generated in the study came up with marginal to poor fit. The model required modification by removing paths that are insignificant to improve the model fit. Moreover, the revised model shows acceptable goodness of fit indices. Hence, attitudes towards mathematics, motivational persistence are crucial in developing critical thinking disposition among senior high school students. The findings highlight that motivational persistence serves as a crucial mediator in the development of students' critical thinking disposition. Positive attitudes toward mathematics, when sustained through persistence, are transformed into consistent engagement and deeper cognitive processing. This pathway underscores that critical thinking disposition is most effectively cultivated not merely by favorable attitudes, rather, it is driven by motivational persistence which enables students to continue their mathematical pursuits despite challenges.

RECOMMENDATION

Further research is recommended using qualitative methods or mixed-methods approaches to substantiate the generated best fit model with field experiences of students. This would provide a more vivid scenario about the dynamics of attitudes towards mathematics, motivational persistence, AI-tools in fostering critical thinking disposition among students.

REFERENCES

1. Abbas, M., Jam, F. A., & Khan, T. I. (2024). Is it Harmful or Helpful? Examining the Causes and Consequences of Generative Ai Usage Among University Students. International Journal of Educational Technology in Higher Education, 21(1). https://doi.org/10.1186/s41239-024-00444-7
2. Ahmad, N., Alias, F. A., & Mohamed, S. A. (2025). Cluster sampling in educational research: a practical approach. Beyond Boundaries: The Multidimensional Horizons of E-Learning, 9, 76-81. https://appspenang.uitm.edu.my/sigcs/2025-1/Articles/2025V1_PAPER12.pdf

3. Akastangga, M. D. F., Harmonis, S., & Al Hafidz, R. A. (2023). The impact of ChatGPT on the critical thinking ability of UIN Sunan Kalijaga students. Matrix: Jurnal Manajemen Teknologi dan Informatika, 13(3), 157-165.
4. Akinwande, M. O., Dikko H. G., & Gulumbe S. U (2015). Identifying the Limitation of Stepwise Selection for Variable Selection in Regression Analysis. American Journal of Theoretical and Applied Statistics, 4, 414-419. https://10.11648/j.ajtas.20150405.22
5. Álvarez-Huerta, P., Muela, A., & Larrea, I. (2023). Disposition towards critical thinking and student engagement in higher education. Innovative Higher Education, 48(2), 239-256.
6. Andamon, J. C., & Tan, D. A. (2018). Conceptual understanding, attitude and performance in mathematics of grade 7 students. International Journal of Scientific & Technology Research, 7(8), 96-105. https://www.nature.com/articles/s41599-022-01449-1
7. Auna, H. S. A., & Hamzah, N. (2024). Studi Perspektif Siswa Terhadap Efektivitas Pembelajaran Matematika Dengan Penerapan Chatgpt. HINEF : Jurnal Rumpun Ilmu Pendidikan, 3(1), 13–25. https://doi.org/10.37792/hinef.v3i1.1160
8. Bandura, A. (1989). Social cognitive theory. In R. Vasta (Ed.), Annals of child development. Vol. 6. Six theories of child development (pp. 1-60). Greenwich, CT: JAI Press. https://www.scirp.org/reference/referencespapers?referenceid=1174203
9. Barana, A., Marchisio, M., & Roman, F. (2023). Fostering Problem Solving and Critical Thinking in Mathematics through Generative Artificial Intelligence. International Association for Development of the Information Society.
10. Bell, R., & Loon, M. (2015). The impact of critical thinking disposition on learning using business simulations. The International Journal of Management Education, 13(2), 119-127. http://dx.doi.org/10.1016/j.ijme.2015.01.002
11. Benedicto, P. N., & Andrade, R. (2022). Problem-based learning strategies and critical thinking skills among pre-service teachers. International Journal of Science, Technology, Engineering and Mathematics, 2(2).
12. Boonsathirakul, J., & Kerdsomboon, C. (2021). The Investigation of Critical Thinking Disposition among Kasetsart University Students. Higher Education Studies, 11(2), 224-232.
13. Bostan, C. M., Ticu, C., Vrabie, T., Stanciu, T., & Andronic, R. L. (2021). Supporting motivational persistence in the personality system in early academic stages through educational strategies. Revista Romaneasca pentru Educatie Multidimensionala, 13(2), 223-242. https://doi.org/10.18662/rrem/13.2/419
14. Braho, D. (2025). An overview of attitudes toward mathematics across different disciplines, gender and STEM. International Journal of Current Science Research and Review, 8(7), 3294–3304. https://doi.org/10.47191/ijcsrr/V8-i7-18
15. Cagulada, J. B. P., & Ucang, J. T. THE RELATIONSHIP BETWEEN MATHEMATICAL DISPOSITION AND ACADEMIC PERFORMANCE AMONG JUNIOR HIGH SCHOOL STUDENTS. https://doi.org/10.5281/zenodo.15389178
16. Cansoy, R., & Türkoglu, M. E. (2017). Examining the Relationship between Pre-Service Teachers' Critical Thinking Disposition, Problem Solving Skills and Teacher Self-Efficacy. International Education Studies, 10(6), 23-35.
17. Celik, H. C., & Ozdemir, F. (2020). Mathematical Thinking as a Predictor of Critical Thinking Dispositions of Pre-Service Mathematics Teachers. International Journal of Progressive Education, 16(4), 81-98.
18. Chen, Q., Liu, D., Zhou, C., & Tang, S. (2020). Relationship between critical thinking disposition and research competence among clinical nurses: A cross-sectional study. Journal of Clinical Nursing, 29(7-8), 1332-1340. DOI: 10.1111/jocn.15201
19. CNN Philippines Staff. (2020, December 10). Students worst in math and science proficiency: Study. CNN Philippines. https://www.cnnphilippines.com/news/2020/12/10/PH-Grade-4-students-worst-in-math-and-science-proficiency--study-.html
20. Creswell, J. W., & Creswell, J. D. (2017). Research design: Qualitative, quantitative, and mixed methods approaches. Sage publications.
21. Dao, X. Q., & Le, N. B. (2023). Investigating the effectiveness of chatgpt in mathematical reasoning and problem solving: Evidence from the vietnamese national high school graduation examination. arXiv preprint arXiv:2306.06331.

22. Dascalu, C. G., Topoliceanu, C., & Antohe, M. E. (2025). Relations Between Medical Students' Motivational Persistence Skills and Their Acceptance of Specific Blended Learning Tools. European Journal of Investigation in Health, Psychology and Education, 15(4), 45. https://doi.org/10.3390/ejihpe15040045
23. De-la-Peña, C., Fernádez-Cézar, R., & Solano-Pinto, N. (2021). Attitude toward mathematics of future teachers: how important are creativity and cognitive flexibility?. Frontiers in Psychology, 12, 713941.
24. DiNapoli, J. (2023). Distinguishing between grit, persistence, and perseverance for learning mathematics with understanding. Education Sciences, 13(4), 402. https://doi.org/10.3390/educsci13040402
25. Egara, F. O., & Mosimege, M. (2024). Exploring the integration of artificial intelligence-based ChatGPT into mathematics instruction: Perceptions, challenges, and implications for educators. Education Sciences, 14(7), 742.
26. Egara, F. O., Mosimege, M., & Mosia, M. (2025). Secondary school students' perceptions of their usage of artificial intelligence-based ChatGPT in mathematics learning. Journal of Education (University of KwaZulu-Natal), (98), 124-146. http://dx.doi.org/10.17159/2520-9868/i98a07
27. Er, Z. (2024). Examination of the Relationship between Mathematical and Critical Thinking Skills and Academic Achievement. Pedagogical Research, 9(1).
28. Ertem, Z. S., & Ari, A. (2022). Investigation of the Relationship between Motivational Persistence, Procrastination Tendency and Achievement Orientation. Anatolian Journal of Education, 7(1), 17-30. https://files.eric.ed.gov/fulltext/EJ1332533.pdf
29. Fianingrum, F., Pujiastuti, H., & Fathurrohman, M. (2023). Disposisi Berpikir Kritis Matematis dalam Pembelajaran Matematika: Systematic Literature Review. JIIP-Jurnal Ilmiah Ilmu Pendidikan, 6(1), 543-548.
30. Firdaus, T., Nurohman, S., Wilujeng, I., & Rahmawati, L. (2025). Exploring Motivational, Cognitive, and Instructional of Critical Thinking Disposition in Science Learning: The Mediating Role of Student Self-Regulation. International Journal of Science Education and Teaching, 4(1), 12-25.
31. Futalan, M. C. Z., & Pagente, F. F. (2024). Unveiling Minds: Investigating Critical Thinking Traits of Students in Private Catholic Schools in Siquijor Province. Journal of Interdisciplinary Perspectives, 2(7), 1-1.
32. Gerlich, M. (2025). AI Tools in Society: Impacts on Cognitive Offloading and the Future of Critical Thinking. Societies, 15(1), 6. https://doi.org/10.3390/soc15010006
33. Guo, Y., & Lee, D. (2023). Leveraging chatgpt for enhancing critical thinking skills. Journal of Chemical Education, 100(12), 4876-4883.
34. Harum, A. (2024). Profile of Student Learning Persistence in South Sulawesi: Analysis of Age, Education Level, and Grade Level. JCOSE Jurnal Bimbingan dan Konseling, 6(2), 1-6. https://doi.org/10.24905/jcose.v6i2.159
35. Hao, L., Piaw, C. Y., & Yusoff, S. M. (2026). Factors affecting critical thinking disposition of English major undergraduates using artificial intelligence (AI) learning tools. International Journal of Instruction, 19(1), 749-774.
36. Hidayanto, E., Cahyowati, E. T. D., & Ummah, A. H. (2022). Students' critical thinking disposition in working on numeration problems. Jurnal Pendidikan MIPA, 23(3), 1224-1240.
37. Hoyle, R. K. (2011). Structural equation modeling for social and personality psychology. Structural Equation Modeling for Social and Personality Psychology, 1-120. https://doi.org/10.4135/9781446287965
38. Kamid, K., Huda, N., Syafmen, W., Sufri, S., & Sofnidar, S. (2021). The relationship between students' mathematical disposition and their learning outcomes. Journal of Education and Learning (EduLearn), 15(3), 376–382. https://files.eric.ed.gov/fulltext/EJ1312226.pdf
39. Karakuş, İ. (2024). University students' cognitive flexibility and critical thinking dispositions. Frontiers in Psychology, 15, 1420272.
40. Kiran, S., Kamath, A., Bellur, R., & Krishnan, G. (2021). 745 Probability-proportional-to-size cluster sampling as an effective methodology for large-scale participant recruitment. International Journal of Epidemiology, 50(Supplement_1), dyab168-353.
41. Kurniati, D., Purwanto, P., As' ari, A. R., & Sa'dijah, C. (2020). Changes of the students' truth-seeking behaviour during the infusion mathematics learning. TEM Journal, 9(4), 1711.

42. Laranang, J. A. I., & Bondoc, J. M. F. (2020). Attitudes and self-efficacy of students toward mathematics. International Journal of English Literature and Social Sciences, 5(5), 1392-1423. https://dx.doi.org/10.22161/ijels.55.11
43. Lee, G. S., Hong, K. H., & Son, C. K. (2024). A Probability Proportional to Size
44. estimation of a Rare Sensitive Attribute Using a Partial Randomized Response Model with Poisson Distribution. Mathematics, 12(2), 196.
45. Li, S., Wang, Z., & Sun, Y. (2024). Relationship between thinking dispositions, working memory, and critical thinking ability in adolescents: A longitudinal cross-lagged analysis. Journal of Intelligence, 12(6), 52.
46. Minarti, E. D., Alghadari, F., & Hutajulu, M. (2020, October). Mathematical disposition ability and critical thinking: Evaluation of middle school students. In Journal of Physics: Conference Series (Vol. 1657, No. 1, p. 012017). IOP Publishing.
47. Mohajan, H. K. (2020). Quantitative research: A successful investigation in natural and social sciences. Journal of economic development, environment and people, 9(4), 50-79.
48. Muktar, R. (2025). Impact of Artificial Intelligence on Mathematics Learning among Stem Students of Grade 11 Senior High School at MSU-Sulu. Psychology and Education: A Multidisciplinary Journal, 38(5), 1-1. doi:10.70838/pemj.380508
49. Namaziandost, E., Rezai, A., Heydarnejad, T., & Kruk, M. (2023). Emotion and cognition are two wings of the same bird: insights into academic emotion regulation, critical thinking, self-efficacy beliefs, academic resilience, and academic engagement in Iranian EFL context. Thinking Skills and Creativity, 50, 101409.
50. Nasr, N. R., Tu, C. H., Werner, J., Bauer, T., Yen, C. J., & Sujo-Montes, L. (2025). Exploring the Impact of Generative AI ChatGPT on Critical Thinking in Higher Education: Passive AI-Directed Use or Human–AI Supported Collaboration?. Education Sciences, 15(9), 1198. https://doi.org/10.3390/educsci15091198
51. Neil L. Umac, Dennies S. Panara-Ag & Carlito P. Yurango. (2025). The Relationship between Students' Attitudes towards Mathematics and Academic Performance in the Subject. Asian Journal of Education and Social Studies, 51(8), 709–719. https://doi.org/10.9734/ajess/2025/v51i82271
52. Ng, S.-Y., Cheung, K., & Cheng, H.-L. (2022). Critical Thinking Cognitive Skills and Their Associated Factors in Chinese Community College Students in Hong Kong. Sustainability, 14(3), 1127. https://doi.org/10.3390/su14031127
53. Nordito S. Quimbo (2025). A Correlational Study Between the Attitudes towards Mathematics of Senior High School Students and their Performance in Mathematics. International Journal of Research and Innovation in Social Science (IJRISS), 9(03), 4899-4903. https://doi.org/https://dx.doi.org/10.47772/IJRISS.2025.903SEDU0353
54. Odani, A. O., & Orongan, R. C. (2020). Critical thinking, mathematical dispositions, and metacognitive awareness of students: A causal model on performance. International Journal of Science and Research, 10(7), 698-709. DOI:10.21275/sr21707180858
55. Ogbaekirigwe, C. O., Ubah, I. M., Azubuike, A. S., Igwe, U. A., & Okolie, U. C. (2025). Understanding the motivational predictors of students' persistence in work placement learning tasks. Education+ Training, 67(1), 37-55. https://doi.org/10.1108/ET-02-2023-0059
56. Pagente, F., & Futalan, M.C. (2024). Unveiling Minds: Investigating Critical Thinking Traits of Students in Private Catholic Schools in Siquijor Province. Journal of Interdisciplinary Perspectives. https://doi.org/10.69569/jip.2024.0215
57. Pamplona, D. D. M. Sampling with Probability Proportional to Aggregate Size in Heterogeneous Populations: A Study of Design and Efficiency. https://www.psai.ph/docs/publications/tps/tps_2019_68_2_2.pdf
58. Pepin, B., Buchholtz, N., & Salinas-Hernández, U. (2025). "Mathematics Education in the Era of ChatGPT: Investigating Its Meaning and Use for School and University Education"—Editorial to Special Issue. Digital Experiences in Mathematics Education, 11(1), 1-8.
59. Priniski, S. J., Hecht, C. A., & Harackiewicz, J. M. (2018). Making learning
60. personally meaningful: A new framework for relevance research. The Journal of Experimental Education, 86(1), 11-29. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6191053/

61. Rauscher, W., & Badenhorst, H. (2021). Thinking critically about critical thinking dispositions in technology education. International Journal of Technology and Design Education, 31(3), 465-488. https://link.springer.com/article/10.1007/s10798-020-09564-3
62. Redhana, I. W., Karyasa, I. W., & Atrisa, N. P. F. (2017, August). Development of critical thinking disposition inventory. In 2nd International Conference on Innovative Research Across Disciplines (ICIRAD 2017) (pp. 195-198). Atlantis Press.
63. Risko, E. F., & Gilbert, S. J. (2016). Cognitive offloading. Trends in cognitive sciences, 20(9),676-688. https://discovery.ucl.ac.uk/id/eprint/1508770/1/gilbert_TiCS_OFFLOADING_RPS.pdf
64. Rodríguez, S., Estévez, I., Piñeiro, I., Valle, A., Vieites, T., & Regueiro, B. (2021). Perceived competence and intrinsic motivation in mathematics: Exploring latent profiles. Sustainability, 13(16), 8707. https://doi.org/10.3390/su13168707
65. Sachdeva, S., & Eggen, P.-O. (2021). Learners' critical thinking about learning mathematics. International Electronic Journal of Mathematics Education, 16(3), em0644. https://doi.org/10.29333/iejme/11003
66. Safitri, D., & Syahfitri, J. (2023). Analysis of Critical Thinking Dispositions as a Predictor of Students' Critical Thinking Skills in Biology Learning. AL-ISHLAH: Jurnal Pendidikan, 15(4), 5859-5869.
67. Salviejo, K. M., Ibañez, E., & Pentang, J. (2024). Critical thinking disposition and learning approach as predictors of mathematics performance. DOI: 10.11591/edulearn.v18i4.21386
68. Sánchez-Ruiz, L. M., Moll-López, S., Nuñez-Pérez, A., Moraño-Fernández, J. A., & Vega-Fleitas, E. (2023). ChatGPT challenges blended learning methodologies in engineering education: A case study in mathematics. Applied Sciences, 13(10), 6039. https://doi.org/10.3390/app13106039
69. Sari, R. N., & Juandi, D. (2023). Improving student's critical thinking skills in mathematics education: a systematic literature review. Jurnal Cendekia: Jurnal Pendidikan Matematika, 7(1), 845-861. https://doi.org/10.31004/cendekia.v7i1.2091
70. Sathyanarayana, S., & Mohanasundaram, T. (2024). Fit indices in structural equation modeling and confirmatory factor analysis: reporting guidelines. Asian Journal of Economics, Business and Accounting, 24(7), 561-577. https://doi.org/10.9734/ajeba/2024/v24i71430
71. Silwana, A., & Widayanti, E. (2024). The Urgency Of Critical Thinking Disposition In Mathematics Learning In The Independent Curriculum. Jurnal Lebesgue: Jurnal Ilmiah Pendidikan Matematika, Matematika dan Statistika, 5(2), 1295-1303. DOI Issue: 10.46306/lb.v5i2
72. Syamsuri; Bahtiar, Ramlan. (2023). Determining the Relationship Between 11th Students' Attitude Towards Mathematics and Their Achievement in Mathematics. Technium Soc. Sci. J., 39, 148.
73. Thalib, T., Hanafi, S., Aufar, M. F., Irbah, S., & Eduardus, J. S. (2018). The academic persistence scale. Science And Education For Improving Learning Quality In Moluccas Archipelago, May 2019, 122-130.
74. Thomas, L. (2023, June 22). Cluster sampling: A simple step-by-step guide with examples. Scribbr. https://www.scribbr.com/methodology/cluster-sampling/
75. Valenzuela, J., Nieto, A., Ossa, C., Sepúlveda, S., & Muñoz, C. (2023). Relationships between motivational factors and critical thinking. European Journal of Education and Psychology, 16(1), 1–18. https://doi.org/10.32457/ejep.v16i1.2077
76. Wigfield, A., & Eccles, J. S. (2000). Expectancy–value theory of achievement motivation. Contemporary educational psychology, 25(1), 68-81.
77. Xu, Z., & Yang, F. (2024). Effect of critical thinking disposition on employee innovative behavior: A meta-theory of personality perspective. Journal of Pacific Rim Psychology, 18, 18344909241231847.
78. Yasar, M. (2016). High school students' attitudes towards mathematics. Eurasia Journal of Mathematics, Science and Technology Education, 12(4), 931-945.