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Unveiling the role of critical thinking in education: regional analysis and predictive factors

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ABSTRACT

Despite its recognized importance, the role of critical thinking (CRIT) in promoting authentic problem-solving (APS), collaborative learning (COL), creative thinking (CRET), and knowledge creation efficacy (KCE) in different regional contexts still needs to be investigated. This study uses partial least squares-structural equation modeling (PLS-SEM) and partial least squares-multi group analysis (PLS-MGA) to evaluate the effect of CRIT on these skills and compare the effect between municipality and regency, using data from 431 high school students in Indonesia. The Ranger algorithm identified the main predictors of the impact of CRIT on the other skills. The findings revealed that CRIT significantly improved the impacts of these skills, with no significant differences between regions. The ability to provide sound reasoning and consider diverse perspectives were the main predictors. This study contributes to the relatively under-attended area of CRIT in Indonesian education by highlighting its important role in skills development.

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1. INTRODUCTION

Current educational reforms emphasize the development of competencies across disciplines, recognizing the close links between contemporary global challenges [1], [2]. Preparing students to face the complexity of societal challenges requires a more holistic approach than mere memorization and subject-specific knowledge. Higher-order cognitive skills, such as critical thinking (CRIT), authentic problem-solving (APS), creative thinking (CRET), collaborative learning (COL), and knowledge creation efficacy (KCE), are now vital in education [3], [4]. However, while the importance of these abilities is recognized, there still needs to be a research gap regarding the complex impact of CRIT practices on students' overall skill development, especially in different regional contexts.

The diversity of regional contexts, such as differences in educational infrastructure, academic culture, and social environment, may affect the effectiveness of applying CRIT skills in learning. More comprehensive research is still needed to investigate the specific impact of CRIT practices on acquiring and developing such skills. Although many studies have emphasized the importance of CRIT in facilitating learning outcomes [5]–[8], research in Indonesia tends to neglect a comprehensive examination of the role of CRIT in the formation of other skills or how its impact may differ in different regions, as well as the key factors that influence it [9]–[12]. It suggests that research on CRIT in Indonesia has not been well explored.

Although Hidayatullah *et al.* [13] research highlighted CRIT as a skill to focus on at the senior high school level, attention to regional differences, especially at the municipality and regency levels, has yet to be fully explored in this study. In contrast, the study by Daga *et al.* [14] showed no significant differences in CRIT skills across regency. However, the study has yet to investigate how CRIT explicitly affects the development of other skills and the predictors that influence it. Recent research by Wibowo *et al.* [15] found that CRIT significantly influences knowledge skills on environmental awareness, but the factors that may influence it have yet to be thoroughly examined.

This research addresses the need for broader knowledge by thoroughly analyzing how CRIT affects students' skill development in Indonesia. The focus is on regional differences and the main factors that influence them. In Indonesia, regional divisions within a province include municipalities and regencies, which allows for educational disparities [16]–[18], raising the question of whether there are differences in CRIT between the two regions and what the main factors that influence it. As such, this research will fill the knowledge gap by providing a deeper understanding of the relationship between CRIT and other skill development, considering the diverse regional contexts and key factors involved.

2. MODEL AND RESEARCH QUESTIONS

CRIT is intricately linked with various cognitive abilities and is pivotal in assessing, evaluating, and fostering other skills [12], [19]–[22]. However, the extent of CRIT's influence on learning in Indonesia, particularly concerning regional dynamics, still needs to be explored. Moreover, research focusing on CRIT and its key predictors must be clarified. This study seeks to fill this gap by investigating the impact of CRIT in student learning experiences on other skills, such as APS, COL, CRET, and KCE. It aims to consider regional variations and overlooked predictors integral to understanding CRIT's significance, as shown in Figure 1. Thus, the research question guiding this study is as:

i) Does CRIT affect APS, COL learning, CRET, and KCE?
ii) Does the effect of CRIT differ by region (municipality vs. regency)?
iii) What are the most important predictors of CRIT on APS, COL learning, CRET, and KCE?

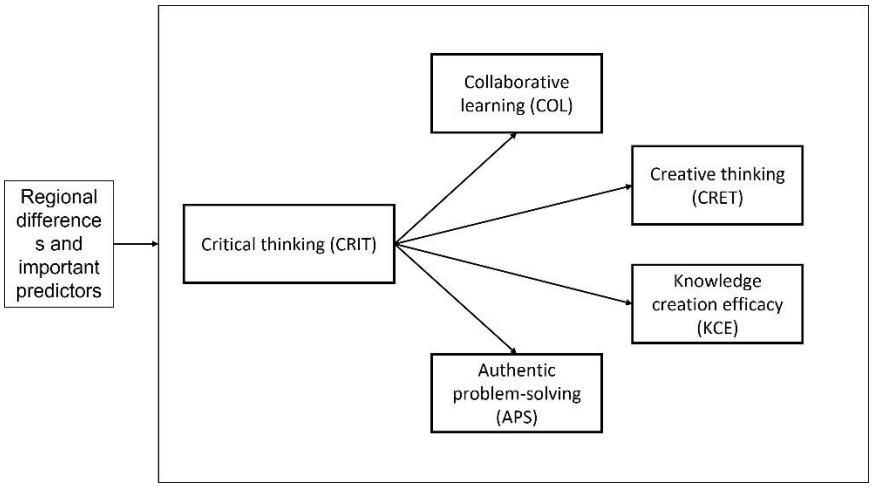

Figure 1. Research model

3. METHOD

In this study, we used two approaches to study the impact of CRIT in depth and to answer the research questions. First, partial least squares-structural equation modeling (PLS-SEM) was used to assess how CRIT affects other skills. We also used partial least squares-multi group analysis (PLS-MGA) to find out how the effect of CRIT differs across regions. Secondly, we used the Ranger machine learning algorithm to identify the main predictors of CRIT on other skills.

3.1. Measurement

We used an online questionnaire survey and consisted of two parts. The first part aims to collect students' socio-demographic information, such as gender and location. At the same time, the second part is a measurement scale that covers CRIT practices and other skills in learning. The scale was adapted from

Chai *et al.* [23] and contains 22 questions, as presented in Table 1. No questions were deleted as all their loadings passed the 0.5 threshold [24]. The questions in this survey reflect students' views on CRIT and other skills, such as APS, COL, CRET, and KCE. Students rated each aspect using a five-point Likert scale, from strongly disagree=1 to strongly agree=5.

Table 1. Scale of measurement

Constructs	Items	Outer loading	VIF
CRIT	CRIT1: I think of other possible ways to understand what I am learning	0.801	1.491
	CRIT2: I consider many different opinions to see which one makes more sense	0.819	1.617
	CRIT3: I provide many different reasons and evidence for my opinions	0.826	1.440
APS	APS1: I delve into the underlying causes of real-world dilemmas and seek resolutions	0.770	1.594
	APS2: I explore authentic societal issues and endeavor to devise remedies	0.786	1.592
	APS3: I confront various real-world challenges (e.g., water scarcity, social cohesion, environmental concerns) and strive for solutions	0.566	1.303
	APS4: I engage in practical problem-solving, devising my approaches	0.755	1.683
	APS5: I apply acquired knowledge to tackle real-life predicaments	0.796	1.665
COL	COL1: My peers and I actively collaborate in acquiring new knowledge	0.822	2.127
	COL2: My classmates and I engage in lively discussions, exchanging differing perspectives on our studies	0.873	2.621
	COL3: My peers and I collaborate effectively to accomplish tasks	0.820	2.109
	COL4: My classmates and I share and elucidate our understandings actively	0.828	2.105
	COL5: I receive commendations from my peers for my contributions	0.698	1.470
CRET	CRET1: I generate a multitude of novel concepts	0.809	1.702
	CRET2: I devise various strategies to address challenges	0.693	1.378
	CRET3: I propose innovative methods for task completion	0.844	1.888
	CRET4: I generate ideas with practical utility	0.812	1.824
KCE	KCE1: I construct theories or explanations pertinent to the subject matter I am studying	0.734	1.564
	KCE2: I synthesize disparate ideas to form innovative concepts	0.768	1.680
	KCE3: I independently generate valuable knowledge	0.750	1.690
	KCE4: I conceive fresh insights into the subject matter	0.816	1.967
	KCE5: I devise potentially beneficial designs	0.724	1.516

Note: Variance inflation factor (VIF)

3.2. Participants

The sample comprises purposively selected high school students from municipalities and regencies in North Sumatra Province, Indonesia. Student's demographic data is summarized in Table 2. About 214 students (49.65%) attended municipality schools, while 217 students (50.35%) attended regency schools. Regarding gender, 160 students (37.12%) were males, and 271 (62.88%) were females. Importantly, it is paramount to underscore that each student's involvement in our research endeavor was voluntary and un coercion, ensuring our study's integrity and ethical conduct.

Table 2. Demographic data of students (n=431)

Criteria	Item	Frequency	Percentage (%)
Region	Municipality	214	49.65
	Regency	217	50.35
Gender	Male	160	37.12
	Female	271	62.88

3.3. Minimum sample

In PLS-SEM, achieving high statistical power is possible even with small sample sizes [24]. However, Hair *et al.* [24] recommend procedures to determine the minimum sample size to ensure a power level of at least 80%. We used the inverse square root and gamma-exponential methods to determine a representative sample size. The minimum acceptable path coefficient is 0.197, with a significance level of 0.05 and a power level of 0.80 [25]. We targeted a greater power level of 0.95 to ensure robustness, resulting in a required sample size of 279 and 261. Therefore, our sample was adequate for reliable statistical analysis.

3.4. Common method bias and data analysis

Our study adopts a comprehensive approach to address common method bias (CMB) and conducts careful data analysis. One of the key focal points in our methodology is the use of VIF as a diagnostic tool to assess CMB, drawing on recommendations from Hair *et al.* [24] and Kock [26]. Per their guidelines, a VIF value below 3.3 indicates the absence of significant multicollinearity or CMB. This study carefully

scrutinized the VIF values well below this threshold, as carefully documented in Table 1, thereby confirming the absence of multicollinearity or CMB-related issues in our data set. In addition, we chose to use PLS-SEM to answer the first research question. PLS-SEM is a powerful statistical approach to overcoming complexities, such as small sample sizes and non-normally distributed data [24]. We carefully examined our collected data using SmartPLS version 4 software, renowned for its expertise in PLS-SEM analysis. To understand more about the relationships between different groups, we conducted a PLS-MGA, a technique for comparing relationships in diverse regional cohorts. In our quest to understand the important predictors of CRIT against other skills, we used the Ranger algorithm, operated through the R package "ranger". This algorithm, known for its fast execution in generating random forests, calculates the importance of variables using p values [27]. Our study reflects a commitment to careful research practices and robust data analysis, thus ensuring the reliability and validity of our findings.

4. RESULTS

4.1. PLS-SEM approach

4.1.1. Measurement model analysis

In the measurement model evaluation process, several key indicators become a critical foundation to ensure the validity and reliability of the model. One is average variance extracted (AVE), which assesses convergent and divergent validity. In this context, the expected AVE value is greater than 0.5, indicating an adequate level of validity. Furthermore, the reliability composite (CR) is also an important focus, indicating convergent validity with a minimum expected value of 0.6. In addition, the importance of Cronbach's alpha (CA) must be addressed, as it is used to assess internal consistency reliability. The range of CA values is from 0 to 1, and values above the minimum limit of 0.6 are considered an acceptable indicator of measurement reliability. Together, these metrics form an essential basis for assessing the validity and reliability of the model [24]. In Table 3, all of these indicators exceeded their respective thresholds, confirming the reliability and dependability of the developed model.

Table 3. Measurement of AVE, CR, and CA

Constructs	AVE	CR	CA
APS	0.547	0.856	0.796
COL	0.657	0.905	0.868
CRET	0.627	0.870	0.800
CRIT	0.665	0.856	0.750
KCE	0.576	0.872	0.816

In this study, the square root of the AVE was employed to assess the discriminant validity of the model. By the recommendations of Fornell and Larcker [28], a construct is deemed to exhibit satisfactory discriminant validity if the square root of its AVE exceeds the correlation with other constructs included in the study. Table 4 presents the square root value of the AVE for each construct in bold, with the diagonal values highlighted. This calculation demonstrates how much a construct can differentiate itself from other constructs within the model. Furthermore, it can be observed that the square root of the AVE for each construct consistently exceeds the correlation between constructs, indicating that each construct has sufficient discriminant validity and can be distinguished well from other constructs.

The heterotrait-monotrait ratio (HTMT) is a crucial indicator of discriminant validity. The HTMT evaluates the extent to which latent constructs diverge from one another, ensuring that the variables utilized to gauge causal relationships effectively differentiate between the domains of the represented concepts [29]. As illustrated in Table 5, all HTMT ratio values are below 0.85, thus satisfying the designated threshold and reinforcing the discriminant validity of the conceptual model [24]. It further reinforces the reliability of the measurement model and highlights the unique characteristics of the construct under investigation for students in Indonesia.

Table 4. Discriminant validation of Fornell-Larcker criterion

	APS	COL	CRET	CRIT	KCE
APS	0.739				
COL	0.439	0.810			
CRET	0.437	0.467	0.792		
CRIT	0.494	0.548	0.542	0.816	
KCE	0.569	0.477	0.642	0.568	0.759

Table 5. Discriminant validation of HTMT criteria

	APS	COL	CRET	CRIT	KCE
APS					
COL	0.491				
CRET	0.527	0.562			
CRIT	0.601	0.678	0.684		
KCE	0.682	0.571	0.792	0.717	

4.1.2. Structural model analysis

Structural model analysis was used to analyze the paths between the proposed constructs. The significance of the paths between constructs was investigated using a bootstrapping technique with 5000 resamples, following the best practices suggested by Hair *et al.* [24]. Table 6 presents the results of hypothesis testing, including path coefficients (β), standard deviation (SD), t-statistics, explanatory power (R-square), impact size (f-square), which indicates the magnitude of the impact if it is above 0.1, and p-values that illustrate the significance level of each path in the structural model.

Table 6. Structural model testing

Relationship	β	SD	t-statistics	R-square	f-square
CRIT→APS	0.494***	0.039	12.694	0.244	0.323
CRIT→COL	0.548***	0.041	13.270	0.301	0.430
CRIT→CRET	0.542***	0.041	13.236	0.294	0.416
CRIT→KCE	0.568***	0.033	17.163	0.323	0.476

Note: ***p<0.001

This study yielded significant insights into the influence of CRIT on other skills, as shown in Figure 2. CRIT significantly impacted APS (β=0.494, p<0.001). Similarly, CRIT significantly influenced COL (β=0.548, p<0.001). CRIT also influenced CRET significantly (β=0.542, p<0.001). Furthermore, CRIT influenced KCE significantly (β=0.568, p<0.001). The R-square, ranging from 29% to 33%, signifies the proportion of variance in the endogenous constructs explained by the exogenous constructs. Overall, CRIT, about other skills, showed a large impact as the f-square value was above 0.1 [30]. This result confirms that CRIT has a vital role in influencing other skills.

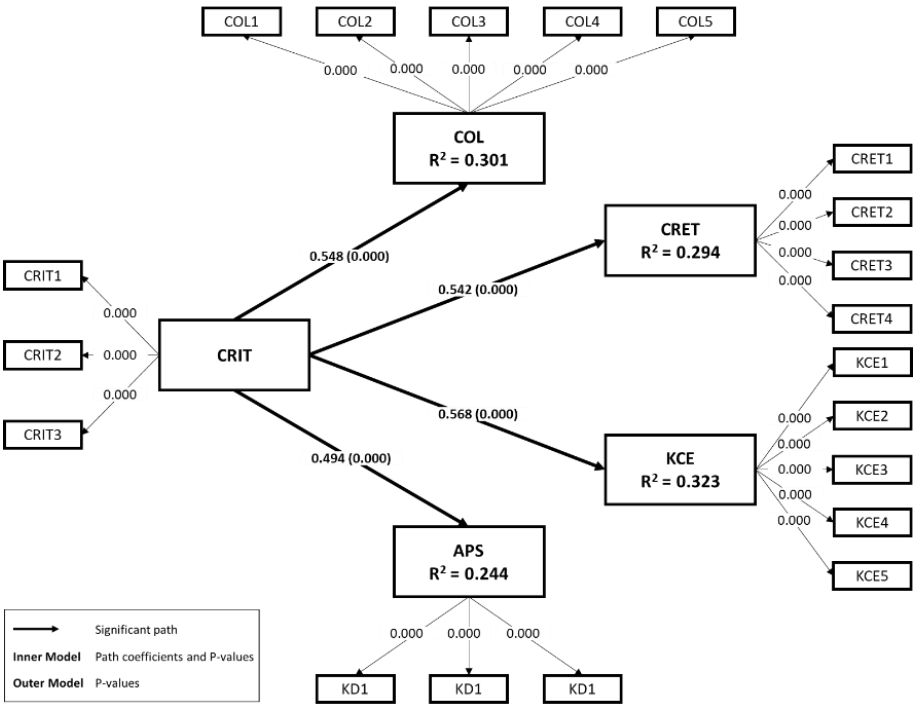

Figure 2. Structure model examination results

4.1.3. PLS-MGA

PLS-MGA is a PLS-based nonparametric approach that has been widely used for group comparison or cluster analysis [24]. It does not require any distributional assumptions. In addition, this approach is easy to implement because it uses bootstrap output generated by standard PLS implementations such as SmartPLS. This study used the PLS-MGA approach to determine the effect of CRIT differently based on region. A p-MGA value of less than 0.05 indicates a significant difference between the specific path coefficients of the two

subpopulations [24]. Table 7 displays the differences in path coefficients and p-MGA values for each relationship observed across regional groups (municipality vs. regency). The p-MGA values for the CRIT to APS, COL, CRET, and KCE relationships did not meet the significance threshold (p-MGA>0.05). These results show no significant group differences between regions, meaning that CRIT has the same influence on APS, COL, CRET, and KCE skills even though it is applied in municipality or regency.

Table 7. PLS-MGA test for municipality vs. regency

Relationship	β-municipality	β-regency	Diff	p-MGA
CRIT→APS	0.446***	0.545***	0.099	0.184
CRIT→COL	0.548***	0.552***	0.004	0.957
CRIT→CRET	0.552***	0.530***	0.022	0.790
CRIT→KCE	0.599***	0.539***	0.060	0.357

Note: path coefficient difference (Diff), ***p<0.001

4.2. Machine learning approach

Random forest represents a machine learning algorithm that belongs to the supervised learning techniques based on ensemble learning, combining multiple classifiers to solve problems and improve model performance [31]. Cutler *et al.* [32] explained that random forest is a powerful statistical classifier compared to other statistical classifiers because it can model complex interactions between predictor variables and has very high classification accuracy. In addition, determining the importance of features is important in interpreting random forests to explain machine learning prediction results accurately.

Various methods are available to select feature importance, each with its assumptions, algorithms, and limitations. If the goal is to identify the most important features overall, the Ranger method may be the most appropriate [33]. Therefore, we used the Ranger method, which is well-known for its speed and efficacy in implementing random forests, to investigate the intricate network of factors that influence the outcome of the model under study [27]. With careful attention to detail, the analysis centered on decomposing the significance of the CRIT predictors, namely "CRIT1-think of other possible ways to understand what has been learned," "CRIT2-consider different opinions to see which one makes more sense," and "CRIT3-provide reasons and evidence," on the model outputs, including APS, COL, CRET, and KCE.

Figure 3 presents the findings of the Ranger analysis. It can be observed that the lines and values displayed indicate that CRIT3 is the primary predictor for APS, CRET, and KCE. Its capacity to provide reasons and evidence exerts a significant influence over these dimensions, shaping their trajectories within the framework of the model. Additionally, it was discovered that CRIT1 emerged as the primary predictor driving COL. These results indicate encouraging students to consider alternative explanations for their learning outcomes can foster collaborative. The findings enhance our comprehension of the model outputs, particularly the pivotal predictors of CRIT on other skills.

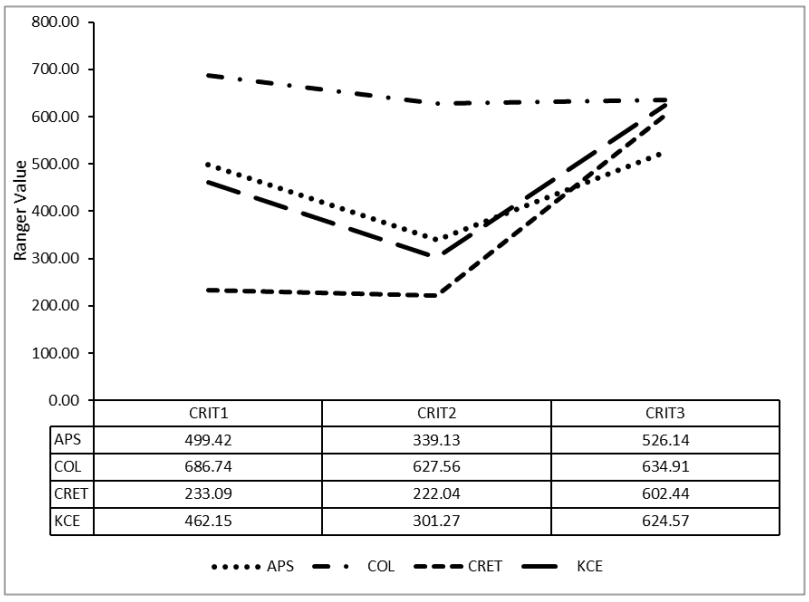

Figure 3. Ranger analysis results

5. DISCUSSION

Before discussing the results, it is essential to keep in mind the purpose of this study, which is to uncover the role of CRIT in APS, COL, CRET, and KCE, as well as to analyze regional differences and important predictors that influence them. In the following discussion, we will discuss the findings in the context of learning in Indonesia and relate them to the global situation so that the universality of the role of CRIT is seen.

5.1. Effect of critical thinking on authentic problem-solving, collaborative learning, creative thinking, knowledge creation efficacy

We used PLS-SEM to explore the relationship between CRIT and other essential skills. Firstly, the analysis showed that CRIT significantly influenced APS, and this confirmed that CRIT positively contributes to an individual's ability to confront and solve complex and authentic problems in daily life. This result is supported by previous research consistently highlighting the strong relationship between CRIT and problem-solving skills [34]. The positive relationship between CRIT and APS emphasizes the need to integrate CRIT into various educational curricula. Studies from regions such as Asia also highlight that CRIT skills are essential to address real problems effectively. For example, research by Alcantara and Bacsa [35] in the Philippines and Van and My [36] in Vietnam also found that CRIT skills positively correlate with problem-solving skills in students. Therefore, the emphasis on CRIT in the Indonesian context aligns with global education priorities, suggesting that CRIT skills can universally improve problem-solving abilities.

In addition, the strong evidence that CRIT positively influences COL suggests that CRIT supports effective collaborative in the learning process. COL supported by CRIT skills encourages the exchange of ideas and joint problem-solving, resulting in deeper understanding and more creative solutions, consistent with previous research [11], [37]. CRIT also supports COL learning and aligns with global education trends prioritizing teamwork and cooperative learning [38]. COL is increasingly seen as an essential component of the learning process in various educational settings. For example, research by Loes and Pascarella [39] in the United States and Liang and Fung [40] in Hong Kong found that CRIT fosters an environment where students are more willing to engage in meaningful discussions, consider different perspectives, and work towards a common goal. These findings suggest that integrating CRIT into a COL learning framework can be effective across various educational curricula, encouraging a culture of cooperation and mutual respect among students.

This study also found a positive relationship between CRIT and CRET, confirming that CRIT ability supports the development of CRET ability. CRIT opens the door to exploring new ideas and innovative problem-solving approaches, resulting in more creative and original outcomes [41]. This study's findings also confirm that CRIT enhances CRET, as supported by extensive literature from different regions. In Korea, for example, Suh *et al.* [42] has shown that CRIT facilitates the exploration of new ideas and innovative approaches to problems. Similarly, a study conducted by Patston *et al.* [43] across different curricula from 12 countries showed that CRIT provides a foundation for creativity by encouraging students to question assumptions and think beyond conventional boundaries. These consistent findings across different cultural contexts suggest that encouraging CRIT can universally enhance creative abilities, enabling students to produce original and innovative solutions.

Finally, this study highlights the importance of CRIT in enhancing the effectiveness of knowledge creation. It confirmed that CRIT ability significantly contributes to an individual's effectiveness in creating new knowledge. The ability to critically analyze information and structure thoughts systematically enables individuals to contribute valuable knowledge. This finding is supported by previous research that has consistently highlighted the strong relationship between CRIT and problem-solving skills among university students in Indonesia [44]. The significant impact of CRIT on knowledge creation effectiveness highlights its role in empowering individuals to make meaningful contributions to the creation of new knowledge. This relationship is supported by research in various educational settings. Studies by Van and My [36] in Vietnam and Ahmed and Ibrahim [45] in Saudi Arabia show that CRIT skills enable students to analyze information, synthesize ideas and construct new knowledge critically. These findings suggest that promoting CRIT can be a universal strategy to enhance knowledge creation, making it a valuable asset in educational contexts.

Overall, the findings emphasize the importance of integrating CRIT in education as a foundation for fostering crucial skills such as APS, COL, CRET, and KCE in Indonesia and globally. With CRIT skills, individuals can face complex challenges in various contexts, both academic and professional, while also encouraging effective collaborative, innovative creativity, and meaningful contributions to knowledge creation. Integrating CRIT into the curriculum can prepare students to become competitive and relevant members of society in this ever-evolving era.

5.2. The effect of critical thinking that differs by region (municipality vs. regency)

The differential influence of CRIT by region (municipality vs. regency) has been one of the foci of analysis in this study. We utilized a PLS-MGA approach to explore the differences in the influence of CRIT practices between the two subpopulations. Results from the PLS-MGA analysis showed that the p-MGA values for all observed path coefficients did not meet the significance threshold ($p<0.05$), indicating that there were no significant group differences between regions (municipality vs. regency) in the influence of CRIT practices on the variables tested.

The research finding that CRIT practices similarly influence APS, COL, CRET, and KCE across different regions (municipality vs. regency) in Indonesia suggests that the benefits of CRIT are not limited to specific local contexts. This finding highlights the universality of CRIT in developing essential cognitive and analytical skills, regardless of local differences affecting urban or rural areas. CRIT allows humans to make considered and informed decisions based on the information available to them, thus not being tied to a specific location [9], [19], [46], [47]. This universality is supported by global research showing that CRIT is essential across various socio-geographic backgrounds [48]. Research by Rear [49] in the context of Asian students emphasized the broad applicability of CRIT across various educational environments. These findings emphasize the importance of integrating CRIT into educational practice universally, ensuring that all students, regardless of their geographical location, have the opportunity to develop essential cognitive and analytical skills [50], [51]. It emphasizes the importance of integrating CRIT in learning approaches across all regions so that students can develop the necessary skills to face challenges in an increasingly complex and dynamic society [47].

5.3. The most important predictors of critical thinking on authentic problem-solving, collaborative, creative thinking, knowledge creation efficacy

The findings from our study used Ranger's algorithm to provide valuable insights into the factors that influence the output of the models tested in the context of CRIT and their relationship with APS, COL, CRET, and KCE. The analysis mainly focuses on identifying the most important predictors of these output variables. The findings indicate that students succeed tremendously in various educational settings by developing core competencies, such as providing reasons and evidence for their opinions (CRIT3) and considering different perspectives (CRIT1). The importance of CRIT3 as a predictor of APS, CRET, and KCE is in line with global education standards that emphasize CRIT as a fundamental skill, where students who can provide strong justifications tend to have more in-depth, creative, and accurate understanding [52]. Similarly, the identification of CRIT1 as a critical predictor for COL shows the value of teaching students to appreciate and interact with multiple viewpoints, which has been shown to enhance collaborative and innovation in various studies [39], [40]. These findings open up space for broader reflection on aspects of CRIT that are important in the Indonesian context and various educational settings.

The need to provide reasons and evidence for opinions highlights that thinking logically and analytically is crucial for addressing complex problems, not only in education but also in everyday life and the world of work. Mihail [53] underlines the importance of CRIT skills to participate in an increasingly complex and connected society, which not only gives information but must also receive information, go further and analyze problems, present solutions to identified problems and apply those solutions in real situations.

Meanwhile, identifying the ability to consider different perspectives as a critical predictor for COL highlights the importance of tolerance, empathy and appreciation of diversity in education. Teaching students to appreciate and interact with multiple viewpoints has increased collaborative and innovation, crucial in an increasingly globalized, and diverse work and social environment. O'Reilly *et al.* [46] emphasized the importance of CRIT skills in dealing with complex information challenges in the contemporary era. It has been shown that the ability to think critically enhances individual understanding and promotes better cooperation and effective conflict resolution [54]–[57]. Thus, the findings from this study provide valuable insights into the importance of CRIT in building APS, CRET, COL, and KCE. Encouraging students to develop the ability to provide solid reasons for their opinions and consider different opinions and viewpoints can be an effective strategy to improve the quality of their learning and skills in facing real-world challenges.

6. CONCLUSION

This research highlights the significant impact of CRIT on APS, COL, CRET, and KCE, emphasizing its role in fostering essential skills for students, particularly in Indonesia. The findings indicate no significant differences between municipality and regency areas in the influence of CRIT on these skills, underscoring the universal importance of integrating CRIT practices across all regions. Students' ability to provide solid reasoning and consider diverse viewpoints emerged as key predictors of these skills, making CRIT a cornerstone of effective educational practices. These results suggest the need for pedagogical

approaches that encourage real-world problem-solving, collaborative, and creativity while ensuring equitable access to learning environments. However, the study is limited by its focus on high school students in one province and the use of a specific CRIT scale, which may only capture some dimensions of this construct. Future research should involve broader populations, consider additional influencing factors like resource accessibility and individual characteristics, and refine assessment tools for CRIT. Additionally, developing localized curricula, training teachers to implement CRIT strategies, and continuously evaluating these efforts are essential for equipping students to face real-world challenges effectively.

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AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

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C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
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Fo : **Fo**rmal analysis
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R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

ETHICAL APPROVAL

The studies involving human participants were reviewed and approved by Universitas Negeri Padang. The participants agreed to take part in this study.

DATA AVAILABILITY

The data that support the findings of this study are available on request from the corresponding author [U]. The data, which contain information that could compromise the privacy of research participants, are not publicly available due to certain restrictions.

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