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Analysis of the Relationship Between Project-Based Outcome and Critical Thinking Skills on the Concept of Student Computational Ability

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A R T I C L E I N F O

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A B S T R A C T

This study aims to understand the influence of planning, project management, evaluation, cooperative thinking, and algorithmic thinking skills on the development of critical thinking ability. Using a structural equation modeling approach with path analysis, this study analyzed the relationship between these skills and critical thinking. The research method used an inferential quantitative approach by examining active students. The population is undergraduate students of Commerce Education, State University of Malang. Samples were taken from all students who fell into the population category. The results show that skills in planning, project management, and evaluation have a significant influence on critical thinking ability. The practical implications of the results of this study can be a guideline for developing student skills that are integrated with unique learning methods in higher education so that they can compete in the business world as professional workers.

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INTRODUCTION

Critical thinking refers to an individual's intellectual capacity to analyze and assess information objectively and rationally. This skill goes beyond the mere possession of knowledge; it demands the judicious and efficient application of that knowledge. In this context, individuals are required not only to collect data, but also to critique various viewpoints, distinguish between substantive and non-substantive arguments, and conclude with evidence-based logic. Within the educational environment, this capacity is crucial in facilitating a deeper understanding of teaching materials, developing problem-solving skills, and enhancing the capacity for argumentation and discussion. Critical thinking is not only relevant in educational settings but also in everyday life. Beyond the academic realm, this ability is important in shaping individuals who can think independently, make informed decisions, and adjust to diverse life situations. Therefore, the development of critical thinking is essential not only for academic achievement but also for success in various aspects of life.

Based on the educational context, critical thinking provides substantial benefits to the learning process, including increased in-depth understanding of the material. Students who develop critical thinking are better able to analyze and assess information, changing from passive recipients to active participants in learning (Sokhanvar et al., 2021). It also enhances problem-solving skills, allowing students to systematically identify and analyze problems, and formulate practical and innovative solutions. Finally, critical thinking strengthens students' self-learning ability. In today's information age, critical thinking skills are crucial in finding, evaluating, and applying information independently (van Laar et al., 2019). Students with critical thinking tend to be proactive in learning, use information sources effectively, and apply them in real situations. These skills form independent and continuous learners, who continue to develop knowledge throughout life, rather than relying solely on formal education. Critical thinking is also essential in dealing with change, complexity, and decision-making in a fast-changing world (Svensson et al., 2022).

The urgency of applying critical thinking to students, especially in a higher education environment, does not seem to go hand in hand with the conditions observed in students of the Commerce Education study program at the State University of Malang. An initial study conducted on 60 students in the study program, through the administration of a questionnaire to assess critical thinking capacity, revealed surprising results. The answers from the majority of students were on a scale of 2 to 3 points out of a maximum total score of 4 points. This indicates that, at an early stage, the student's critical thinking skills have not been optimally developed. This raises concerns about the effectiveness of the learning methods applied, as well as highlighting the need for strategic changes in the curriculum and teaching approaches that are more supportive of the development of critical thinking skills. These observations revealed a stark difference between the expectations of students' critical thinking skills and the actual conditions. This has significant implications, raising questions about how effective the current curriculum and teaching methods are in developing and sharpening the critical thinking skills that are so important for students. In response to these findings, it is imperative to conduct a critical review of the teaching strategies and learning content currently in use, with the primary aim of improving the standard and effectiveness of teaching critical thinking to students. This step is crucial to ensure that students are not only academically successful but also skilled in dealing with various practical challenges in the real world with a critical and analytical approach.

Universitas Negeri Malang (UM) has integrated the Project Based Learning (PjBL) method into its teaching strategy. PjBL, which focuses on active student engagement through projects, is implemented in various courses. The process includes problem identification, working group formation, project planning and implementation, and presentation of results. PjBL at UM increases students' motivation, critical skills, problem-solving, communication, collaboration, creativity, and innovation, despite challenges such as extensive preparation and extra resources. Its implementation improved student learning outcomes. Project Based Learning (PJBL) is an educational method that places students as the main actors in learning. (Hotapeti et al., 2020). Through PJBL, students are actively involved in practical projects with specific objectives, appropriate challenges, and measurable outcomes. The main characteristic of PPA is the empowerment of students to explore, process, and apply knowledge in solving real problems. This method enhances students' critical thinking skills, with a focus on developing analysis, evaluation, and forming logical conclusions (Li et al., 2022).

Besides that, PJBL also encourages students to look at problems from multiple perspectives, promoting open and objective thinking. Ultimately, students not only learn to solve problems effectively, but also develop the ability to ask critical questions, distinguish between facts and opinions, and build solid arguments based on evidence. This approach has been proven through research which shows that students who engage in PPA tend to achieve higher scores in critical thinking tests compared to those who follow conventional learning methods. Thus, PPA not only improves students' general academic ability but also strengthens important life skills such as problem-solving, creativity, and collaboration. Students become better prepared to face real-world challenges in both academic and professional environments. PJBL is recognized as a memorable and relevant learning strategy for the modern era, which not only focuses on academic knowledge but also on developing holistic competencies required for success in the 21st century. All of these indicate the urgency of PjBL to have a positive impact on critical thinking skills (Yamashita & Yasueda, 2017).

LITERATURE REVIEW

The theoretical underpinnings of computational thinking involve several key aspects (Amoore, 2019). Creativity, in this context, is about innovative problem-solving, which goes beyond conventional methods to find unique solutions (Prikshat et al., 2020; Yong et al., 2020). Algorithmic thinking, another important component, involves structuring the problem-solving process in an orderly and stepwise manner, like a computer algorithm (Özmutlu et al., 2021). This approach is essential for systematically tackling complex problems. Critical thinking plays a central role in computational thinking, which requires individuals to analyze problems logically and evaluate solutions based on their effectiveness and efficiency (Akpur, 2020). This aspect is crucial in making reasoned and informed decisions in computational tasks. Problem-solving, which is a core element, revolves around identifying the essence of the problem and methodically working towards a solution, which often utilizes a combination of different computational thinking skills (M. Y. Huang et al., 2017; Joseph et al., 2024). The cooperative aspect of computational thinking underscores the importance of collaborative problem-solving. Individuals combine their various skills and knowledge to find solutions, highlighting teamwork and effective communication. Good communication skills are indispensable in this process, as they enable clear expression of complex computational concepts and encourage productive collaboration (Bos van den Hoek et al., 2023; Zhang et al., 2023).

Several studies delve deeper into how students' involvement in research can improve their critical thinking skills. The practical research conducted provides new insights into how students develop analytical skills and critical attitudes while engaged in research projects, particularly in the context of undergraduate education (Apanovich et al., 2018; Montuori et al., 2024). The main focus is on the development of critical thinking which includes students' cognitive abilities and dispositional attitudes. Added to an analysis of the integration of critical thinking in learning materials, this research reveals various challenges faced by students during learning (Riza et al., 2019). From there, various studies also highlighted the importance of transferring acquired critical thinking skills into professional learning settings (Ongardwanich et al., 2015). In addition, efforts provide insight into the importance of balanced teaching methods in university settings (Ahmed & Indurkhya, 2020). These methods emphasize the recognition of diverse learning styles among students and the importance of creating a supportive and positive learning environment (Verbree et al., 2021). Finally, this study offers recommendations for the integration of critical thinking approaches in university curricula, emphasizing the importance of learning experiences that focus not only on knowledge but also on developing critical life skills.

In an academic context, studies on the impact of algorithmic thinking on social and economic students fall into two main focuses (van Laar et al., 2019). First, evaluate how algorithmic thinking contributes to the improvement of academic skills such as problem-solving, critical thinking, and creativity. Research in this area has shown encouraging results (Park et al., 2023). Second, the research assessed the correlation between algorithmic thinking and essential 21st-century skills, including collaboration and communication (Lee et al., 2016). The results underscored the significant benefits of algorithmic thinking in developing these abilities (Bilbao et al., 2021). Based on these findings, it was concluded that algorithmic thinking is highly beneficial for enhancing academic abilities and 21st-century skills of social and economic students (Shakeel et al., 2023). So it is important to integrate algorithmic thinking into the higher education curriculum. Some recommendations include the development of relevant algorithmic thinking learning modules, training for lecturers, and evaluation of the effectiveness of integrating this method into the curriculum.

Cooperative skills are an important aspect of student character building, especially in achieving common goals efficiently and effectively. Recent research shows that there are still deficiencies in communication, cooperation, problem-solving, and conflict management among university students. Difficulties in effective communication and productive cooperation are areas that require improvement. In addition, students also often face obstacles in solving problems together and managing conflict in teams. This indicates the need for more guidance in these aspects. Improving these cooperative skills can be achieved through curriculum development that focuses more on these skills, the use of cooperative learning methods, and structured exercises and practices. In this improvement effort, group activities, simulations, and collaborative exercises can be effective tools. based on this approach, it is expected that students will be better prepared to face the world of work and daily social challenges.

Based on the context of this research, other components of computational ability are implemented in the ability in the learning output in higher education (Y. M. Huang et al., 2022). Critical thinking and planning skills are two important elements that support each other in decision-making and achieving efficient outcomes (Montuori et al., 2024). Critical thinking facilitates in-depth evaluation of information, which is crucial in developing action plans (Hu et al., 2023; Sokhanvar et al., 2021). This includes problem recognition, collection of relevant data, and making appropriate decisions based on that analysis. In the context of planning, critical thinking is required to develop practical and realistic solutions. After gathering the necessary information, individuals must be able to assess the options available and choose the best strategy (Graciano et al., 2023). The ability to evaluate and adjust plans is also very important. This requires individuals to continuously monitor the effectiveness of the plan and make adjustments based on feedback and changing conditions (Motta & Galina, 2023). Therefore, the integration between critical thinking and planning is essential. Through the combination of these skills, one can increase the likelihood of success in achieving desired goals.

Creativity and project management skills are two aspects that support each other in the process of idea creation and realization (Yuliati & Lestari, 2018). Creativity plays a role in generating new ideas and innovative solutions, while project capability ensures that these ideas are implemented successfully (Shraddha et al., 2020; Zikargae et al., 2022). Examples of applications of synergy between these two skills include product design, research, and business projects, where creativity inspires innovation, while project capability guarantees its efficient execution. In art, music, or film projects, project skills are also crucial to achieve the desired goal. These two skills complement each other and are necessary for the success of a project. Communication and evaluation skills are two critical skills that support each other. Communication facilitates the communication and explanation of evaluation criteria, data collection, and presentation of evaluation results. These two skills when combined can increase the effectiveness of communication and evaluation (Ismail & Edi, 2023; Korkmaz et al., 2017). Based on this, there are implicative variables for the components of computational ability, namely planning ability, project ability, and evaluation ability as a substitutive form of critical thinking, creativity, and communication ability.

Based on the literature review above, the hypotheses in this study are as follows:

H1: There is a positive and significant correlation between the Planning Skills variable and the Evaluation Skills variable.

H2: There is a positive and significant correlation between the Project Skills variable and the Evaluation Skills variable.

H3: There is a positive and significant correlation between Planning Skills variables and Cooperative Thinking Variables.

H4: There is a positive and significant correlation between the Evaluation Skills variable and the Algorithmic Thinking variable.

H5: There is a positive and significant correlation between the Algorithmic Thinking variable and the Critical Thinking variable.

H6: There is a positive and significant correlation between the Cooperative Thinking variable and the Critical Thinking variable.

H7: There is a positive correlation between Planning Skills variables and Algorithmic Thinking variables through Evaluation Skills variables.

H8: There is a positive correlation between the Project Skills variable and the Algorithmic Thinking variable through the Evaluation Skills variable.

H9: There is a positive correlation between the Evaluation Skills variable and the Critical Thinking variable through the Algorithmic Thinking variable.

H10: There is a positive correlation between the Planning Skills variable and the Critical Thinking variable through the Evaluation Skills variable and the Algorithmic Thinking variable.

H11: There is a positive correlation between the Project Skills variable and the Critical Thinking variable through the Evaluation Skills variable and the Algorithmic Thinking variable.

METHODOLOGY

This study used a population of all-semester UM Cosmetology Education students who underwent an assessment course with a PjBL approach. The sample was taken from the entire population of 90 respondents. This study uses structural equation modeling (SEM) analysis techniques using SPSS 26 and AMOS tools. This study tests the model hypothesis (see Figure 1), how exogenous variables affect endogenous variables directly and indirectly. Table 1 shows the operational variables in this study. Table 1 explains the practical definitions ranging from variables and indicators to the description of each indicator. The following is a complete explanation of the variables and indicators used in this study:

Table 1. Research Variables and Indicators

Variable	Indicators code	Question/Statement Item (Score)
Critical Thinking (CT)	CT1	I am good at preparing regular plans regarding the solution of complex problems.
	CT2	It is fun to try to solve complex problems
	CT3	I am willing to learn challenging things
	CT4	I pride myself on being able to think with great precision
	CT5	I use systematic methods when comparing the options in my hands and when reaching a decision
Algorithmic Thinking (AL)	AL1	I can immediately build equity that will provide a solution to a problem.
	AL2	I think I have a special interest in mathematical processes
	AL3	I think I learn better instructions with the help of mathematical symbols and concepts
	AL4	I believe that I can easily grasp the relationship between numbers
	AL5	I can mathematically expressways of solving problems that I face in everyday life
	AL6	I can digitize mathematical problems expressed verbally
Cooperative Thinking (CO)	CO1	I like to experience cooperative learning together with my group mates
	CO2	In cooperative learning, I think that I achieve/will achieve more successful results because I work in groups
	CO3	I like solving problems related to group projects together with my friends in cooperative learning
	CO4	More ideas happen in cooperative learning
Planning Skills	Planning Skills	Students' ability to plan the project together
Project Skills	Project Skills	Students' ability to organize and complete the project
Evaluation Skills	Eva Skills	Students' ability to evaluate the results and implementation of the project

In addition, testing whether the statement items used can reflect the variables built with the CFA technique (Ji et al., 2021). For this reason, the model fit test in this study uses the criteria of good fit and/or acceptable fit. (Schermelleh-Engel et al., 2003) with the components Chi-square (CMIN & DF) relative Chi-square ($\chi 2/df$), Root Mean Square Error of Approximation (RMSEA), Normed Fit Index (NFI), Comparative Fit Index (CFI), Goodness-of-

Fit (GFI), and Adjusted Goodness-of-Fit Index (AGFI). Table 2 describes the criteria that must be met for the model to be categorized as a good or fit model. These criteria will be used to interpret the processed data results in this study.

RESEARCH RESULT

Table 2. Model Fit Criteria

Fit Measure	Good Fit	Acceptable Fit
χ^2	$0 \le \chi^2 \le 2\ df$	$2df < \chi^2 \le 3df$
p-value	$0.05 < p \le 1.00$	$0.01 \le p \le 0.05$
χ^2/df	$0 \le \chi^2/df \le 2$	$2 < \chi^2/df \le 3$
RMSEA	$0 \le RMSEA \le 0.05$	$0.05 < RMSEA \le 0.08$
p-value for test of close fit (*RMESA* < .05)	$0.10 < p \le 1.00$	$0.05 \le p \le 0.10$
Confidence interval (CI)	close to *RMESA,* left boundary of CI = 0.00	close to *RMSEA*
SRMR	$0 \le SRMR \le 0.05$	$0.05 < SRMR \le .10$
NFI	$0.95 \le NFI \le 1.00$[a]	$0.90 \le NFI < 0.95$
NNFI	$0.97 \le NNFI \le 1.00$[b]	$0.95 \le NNFI < 0.97$[c]
CFI	$0.97 \le CFI \le 1.00$	$0.90 \le DFI < 0.97$[c]
GFI	$0.95 \le GFI \le 1.00$	$0.90 \le GFI < 0.95$
AGFI	$0.90 \le AGFI \le 1.00$, close to *GFI*	$0.85 \le AGFI < 0.90$, close to *GFI*

After the model is declared a good fit and/or acceptable fit, the resulting output uses a parameter format in the form of a standardized estimate, to see the results that have been standardized with different types of data between ordinal and interval. In addition, in resampling the number of samples that are not too large and obtaining better parameter estimates, the Bootstrap Maximum Likelihood (Bootstrap ML) technique is used. To determine the feasibility of item factors, the standard loading factor developed by Costello & Osborne (Costello & Osborne, 2005) is used with a standard loading factor that must be met in social research at least > 0.32. Furthermore, Standardized regression wights use a significance of 5% ($p<0.05$), the significance level is used to measure the direct effect of the measured variables. In the direct effect analysis, after the significance level is met, the standard deviation value will be analyzed to determine how much the endogenous/dependent variable changes if the exogenous/independent variable is either directly or through the variable that mediates the change (Kline, 2011).

RESEARCH RESULT

Equation

Figure 1 shows the research path map through previously defined variables. The sequence of paths in the model in Figure 1 shows the path to answer the hypothesis of this study. The path relationship can be explained through correlation as follows: 1) PlanningSkills variable correlates with EvaSkills, 2) ProjectSkills variable correlates with EvaSkills, 3) PlanningSkills correlates with CO, 4) EvaSkills variable correlates with AL, 5) AL correlates with CT, 6) CO variable correlates with CT. Figure 1 also shows indirect relationships, namely 7) the correlation of PlanningSkills variables to AL through EvaSkills, 8) ProjectSkills correlates to CT through EvaSkills, 9) EvaSkills correlates to CT through AL, 10) PlanningSkills correlates to CT through EvaSkills and AL, 11) ProjectSkills correlates to CT through Evaskills and AL.

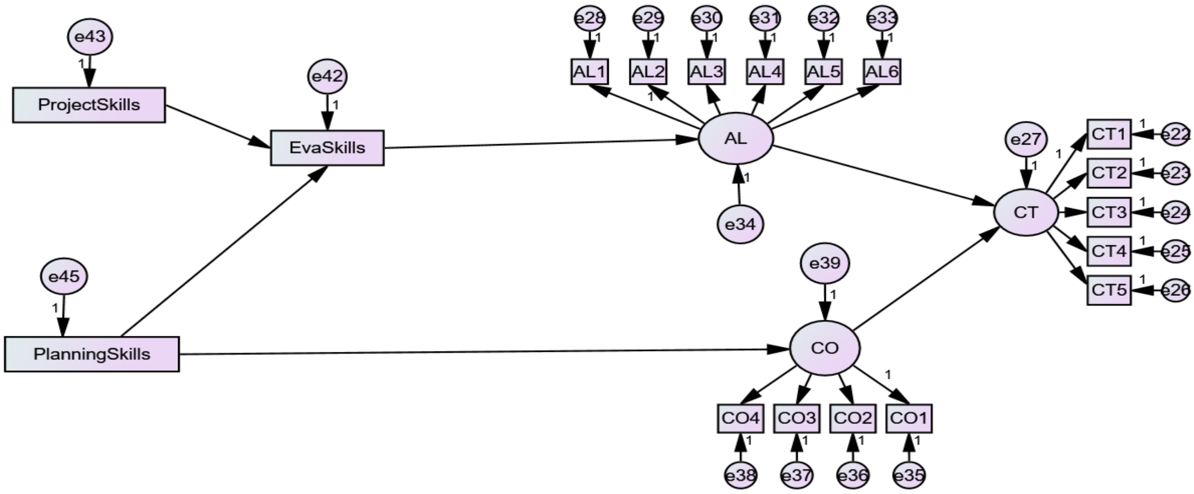

Figure 1. Research Design Model

Model Fit Analysis

Table 3 shows the results of the fit model analysis with specific results as follows:

Table 3. Model Fit Test Results

P	CMIN	DF	CMIN/DF	GFI	AGFI	NFI	CFI	RMSEA
0,612	110,103	115	0,957	0,891	0,838	0,888	1,000	0,000
AF	GF	GF	GF	AF	AF	AF	GF	GF

Description:
AF: Acceptable Fit
GF: Good Fit

Table 3 shows the results of the model fit test. Based on the results obtained, the probability value (P) is 0.612. The Chi-Square (CMIN) value obtained is 110.103

with a degree of freedom (DF) of 115, resulting in a CMIN/DF ratio of 0.967. This indicates that the model has a relatively good fit because the ideal CMIN/DF ratio usually ranges from 0 to 2. Furthermore, for the global fit indices, the global fit index (GFI) showed a value of 0.891 and the adjusted goodness-of-fit index (AGFI) had a value of 0.838. Both indices indicate an acceptable fit (AF) with the proposed model. The Normed Fit Index (NFI) value was 0.888, indicating a good fit with the data. The high Comparative Fit Index (CFI) of 1.000 indicates an excellent fit between the model and the data. Finally, the Root Mean Square Error of Approximation (RMSEA) value was 0.000, which also indicated a good fit with the data as it was less than 0.08. The overall results show that the proposed model is a good fit with the data obtained.

Factor Loading Analysis

Table 4 shows the results of the factor loading analysis. This analysis determines the correlation between variables (indicators) and their latent constructs (factors). Several methods for estimating factor loading are the principal component method, the maximum likelihood method, and the principal factor method.

Table 4. Analysis of Loading Factor

		variable	Estimate	S.E.	C.R.	P
CT2	<---	CT	1,113	0,187	5,942	0,000
CT3	<---	CT	0,885	0,174	5,092	0,000
CT4	<---	CT	0,890	0,146	6,079	0,000
AL2	<---	AL	4,623	1,195	3,869	0,000
AL3	<---	AL	3,567	0,944	3,779	0,000
AL4	<---	AL	3,334	0,951	3,506	0,000
AL5	<---	AL	2,911	0,697	4,178	0,000
CO1	<---	CO	1,000			0,000
CO2	<---	CO	0,950	0,102	9,313	0,000
CO3	<---	CO	0,946	0,099	9,589	0,000
CO4	<---	CO	0,672	0,105	6,416	0,000
CT1	<---	CT	1,000			0,000
CT5	<---	CT	0,776	0,153	5,071	0,000
AL1	<---	AL	1,000			0,000
AL6	<---	AL	3,335	0,775	4,302	0,000

The CT variable has items with high loading factors. Item CT1 has a loading factor of 1.000 with a p-value of 0.000. Furthermore, CT2 has a loading factor of 1.113 with a C.R. value of 5.942 and a p-value of 0.000. CT3 and CT4 each have a loading factor value of 0.885 and 0.890 with the same p-value of 0.000. The AL variable also has a high loading factor. Items AL1 to AL5 have the same p-value of 0.000 with a loading factor value of 1.000, 4.623, 3.567, 3.334, 2.911, and 3.335, respectively. Finally, the CO variable also has a high loading factor value of 1.000, 0.950, 0.946, and 0.672, respectively. Then all of them have the same p value of 0.000 which shows that all items have a significant loading factor. The loading factor value shows positive results which illustrates that everything is positively correlated with a strong relationship.

SEM Analysis

Table 5 shows the results of the SEM analysis. Each correlation value across variables is explained and categorized into direct effects in this table.

Table 5. SEM Analysis Results - Direct Effect

Effects			Estimate	P value
PlanningSkills	→	EvaSkills	0.525	0,000
ProjectSkills	→	EvaSkills	0,277	0,012
PlanningSkills	→	CO	0.094	0,003
EvaSkills	→	AL	0.183	0,036
AL	→	CT	1,371	0,001
CO	→	CT	0,298	0,000

The results in Table 5 above show the direct effect on the path relationship that has been made in the model. The PlanningSkills variable has an effect of 0.525 on the EvaSkills variable with a p-value of 0.000. This result shows that PlanningSkills has a positive and significant effect on the EvaSkills variable (H1). Furthermore, the ProjectSkills variable has an effect of 0.277 on the EvaSkills variable with a p-value of 0.012. This result shows that ProjectSkills has a positive and significant effect on the EvaSkills variable (H2) although not as great as the effect of PlanningSkills. The PlanningSkills variable has an effect of 0.094 on AL with a p-value of 0.003. This result shows a positive and significant effect in the relationship between the two (H3) although the magnitude is the smallest among other direct relationships. Fourth, the EvaSkills variable has an effect of 0.183 and a p-value of 0.036 on AL. This result also shows a positive and significant correlation in both variables (H4) but with the smallest significance value among other paths. Furthermore, the AL variable has an effect of 1.371 with a p-value of 0.001 on the CT variable. This result shows that the AL variable has a positive and significant correlation with the CT variable (H5) with the highest correlation value. Finally, the CO variable has an effect of 0.298 with a p-value of 0.000 on the CT variable. This result shows that the CO variable has a positive relationship with the CT variable (H6). The next table, table 6, shows the indirect relationship between variables in the model:

Table 6. Indirect Effects

Efek	Estimate
PlanningSkills → EvaSkills → AL	0,091
ProjectSkills → EvaSkills → AL	0,225
EvaSkills → AL → CT	0,286
PlanningSkills → EvaSkills → AL → CT	0,151
ProjectSkills → EvaSkills → AL → CT	0,145

Based on the output of indirect effects, all correlations between variables have positive results. First, PlanningSkills has a positive effect on AL through EvaSkills (H7). Then ProjectSkills also has a positive effect on AL through EvaSkills (H8). EvaSkills variable has a positive effect on the CT variable through AL (H9). Furthermore, PlanningSkills has a positive effect on CT through EvaSkills and AL variables (H10). Finally, the ProjectSkills variable has a positive effect on the CT variable through the EvaSkills variable and the AL variable (H11).

DISCUSSION

Theoretically, there is a positive relationship between Planning Skills and Evaluation Skills. These two abilities are intertwined in many aspects. Planning Skills, which refer to the ability to plan an activity or project, include aspects such as setting goals, strategizing, identifying risks, and allocating resources (Robledo-Castro et al., 2023). This ability is not only important for starting a project but also for ensuring that all steps are carried out efficiently and effectively (Liu et al., 2021). On the other hand, Evaluation Skills relate to the ability to assess the outcome of an activity or project. This ability involves data analysis, interpretation of results, and performance assessment (Anderson et al., 2017). With strong Evaluation Skills, one can determine whether the goals set in the planning stage were achieved successfully, as well as identify areas for improvement in the future. The link between Planning Skills and Evaluation Skills becomes clear when considering how good planning can facilitate the evaluation process. Effective planning helps in creating clear parameters and performance indicators, which then form the basis for evaluation. Conversely, effective evaluation provides important feedback that can be used to refine and optimize plans.

The existence of a synergistic relationship between project management skills and evaluation skills is significant. Project Skills play an important role in the management of all aspects of a project, including planning, executing, and controlling it, which is essential for the success of the project itself. These skills involve a broad understanding of project objectives, the development of effective strategies, and wise use of resources (Hotapeti et al., 2020). These capabilities are not only important for achieving the expected results but also support an efficient evaluation process. The possibility of a strong relationship between Project Skills and Evaluation Skills has far-reaching implications. In the work environment, developing these two skills together can increase effectiveness and efficiency in project management (Janse van Rensburg & Goede, 2020; Sulistiobudi & Kadiyono, 2023). In education, the integration of these two skills in the curriculum can help students prepare to tackle real-world challenges (Gundry et al., 2014). Moreover, improvement in one area can strengthen performance in the other, suggesting a mutually beneficial relationship between the two skills.

From a theoretical perspective, there is a close connection between Planning Skills and Cooperative Thinking. Planning skills involve setting up and organizing a task or project, and this is directly related to the ability to collaborate and work with teams. It requires an understanding of how to bring together different individual contributions to achieve a common goal. Good planning ability includes aspects such as task organization, team coordination, and the ability to deliberate, all of which are important parts of Cooperative Thinking (van Leeuwen & Janssen, 2019). Thus, people who have strong planning skills are usually also effective in teamwork and collaboration. Overall, this hypothesis emphasizes the importance of combining planning ability with cooperative thinking. In both work and educational settings, the effective integration of these two abilities not only improves individual performance but also strengthens teamwork outcomes and group dynamics (Chu et al., 2017; Hu et al., 2023).

From a theoretical perspective, evaluation skills, which involve critical appraisal and analysis of information, are closely correlated with algorithmic thinking ability (H. Huang et al., 2022). This is because, in algorithmic thinking, one often has to sort and evaluate data to determine the most effective problem-solving steps. Moreover, the process of iteration and refinement is a hallmark of both evaluation and algorithmic thinking, where feedback is used to optimize the process or outcome. In an empirical context, research in various fields such as education and technology can show how evaluation skills affect one's ability in algorithmic thinking. There is a strong and positive relationship between algorithmic thinking and critical thinking skills. Algorithmic Thinking, which is concerned with solving problems through logical and structured steps, is naturally closely related to Critical Thinking, which is an objective process of analyzing and evaluating information (Amoore, 2019). Through the development of Algorithmic Thinking, one also sharpens their Critical Thinking skills. This is because the process of Algorithmic Thinking involves clearly defining the problem, creating hypotheses, and testing those hypotheses with systematic methods (Bilbao et al., 2021). These skills are particularly relevant in Critical Thinking, which requires structure and logic in the analysis and evaluation of information. Correspondingly, expertise in Critical Thinking provides strong support for the development of Algorithmic Thinking. Individuals who have good Critical Thinking skills will better understand the value of a logical and systematic approach to solving problems (Richado et al., 2023). Based on a theoretical perspective, the positive relationship between Cooperative Thinking and Critical Thinking is explained. Cooperative Thinking, which involves teamwork to achieve a common goal, contributes to the development of Critical Thinking, the process of analyzing and evaluating information. Collaboration enriches understanding and appreciation of different perspectives, building strong arguments, and resolving conflicts, all key in Critical Thinking. Conversely, Critical Thinking, with its understanding of the logic of arguments and the importance of evidence, enhances the efficiency of teamwork. These two skills reinforce each other, advancing team capabilities and critical analysis (Young et al., 2021).

Planning skills relating to goal setting, plan development, and resource management, have a significant relationship with algorithmic thinking, i.e. the ability to solve problems using algorithms (Peng et al., 2023). Evaluation skills are also important, enabling reflection and improvement of the algorithmic process. Planning skills support a structured approach to algorithm thinking, while evaluation helps to improve the effectiveness of algorithms. The development of planning and evaluation skills is essential to effectively improve algorithmic thinking. Project management skills, which include planning, organizing, and completing projects, are related to algorithmic thinking, i.e. solving problems using algorithmic methods. Evaluation skills are also important in this connection, reinforcing algorithmic thinking. Proficiency in managing projects supports an algorithmic approach to problem-solving (López et al., 2019).

Evaluation skills, which relate to the ability to assess work or products, are closely related to critical thinking skills, which is the ability to think objectively, rationally, and logically in dealing with problems or situations (Goyal et al., 2022; Kłeczek et al., 2020). Meanwhile, algorithmic thinking skills involve using algorithms in problem-solving. There is a mutually beneficial relationship between these three skills where evaluation skills play a role in strengthening critical thinking skills through algorithmic thinking skills (Tangahu et al., 2021). Evaluation skills allow one to observe and assess a problem or situation from multiple points of view, objectively and rationally. This is important in identifying key elements of a problem or situation. This ability also supports the critical thinking process, allowing individuals to critically consider all aspects before making a decision (Finlay et al., 2022). On the other hand, algorithmic thinking skills support individuals in tackling problems logically and systematically. Applying an algorithmic approach, one can formulate an effective solution to a problem or situation (Bilbao et al., 2021). These skills help in processing information and coming up with logical conclusions, which is the essence of critical thinking (Au-yong-Oliveira et al., 2018). Thus, evaluation skills play a key role in developing critical thinking ability, especially through strengthening algorithmic thinking skills. Therefore, it is important to start training evaluation skills early, both in formal education settings such as schools and through learning activities outside of school. The development of these evaluation skills not only helps in improving critical thinking but also in honing problem-solving abilities more effectively and efficiently. Planning skills include the ability to set goals, formulate plans, and organize resources, which is closely related to critical thinking skills, namely the ability to think objectively, rationally, and logically in dealing with problems or situations (Serrano & Kazda, 2020). Algorithmic thinking skills, which relate to problem-solving using algorithmic methods, are also an important aspect of this relationship. Planning skills support critical thinking by focusing on clear goals, creating effective plans, and carefully managing information and resources, aiding in more informed and efficient decision-making. The role of evaluation skills and algorithmic thinking in critical thinking is equally important. Evaluation skills enable an objective assessment of the work or product, as well as the situation or problem at hand. On the other hand, algorithmic thinking skills help in solving problems logically and systematically. Both of these skills contribute to improving critical thinking ability by providing tools for deeper analysis and effective solution discovery (Janssen et al., 2019; Mcharek et al., 2019; Mursid et al., 2022; H. Zhang et al., 2024).

The ability to manage projects, including planning, organization, and completion, is related to critical thinking and algorithmic thinking. Managing projects supports critical thinking through clear goal-setting and effective resource management. Meanwhile, evaluation skills and algorithmic thinking facilitate objective analysis and logical problem-solving. The combination of these abilities strengthens the critical thinking process, making it important to be trained early in formal education as well as out-of-school activities. These results discuss the link between Planning Skills and Evaluation Skills, emphasizing their importance in project management and professional development (Mali et al., 2023). The discussion of the relationship between Project Skills and Evaluation Skills highlights their synergistic effects on work and educational effectiveness. Theoretical perspectives on the interaction between Planning Skills and Cooperative Thinking, and how these skills enhance team dynamics and individual performance, are also presented (Martín-Núñez et al., 2023). In addition, an assessment of the correlation between Evaluation Skills and Algorithmic Thinking, shows that these skills collectively improve problem-solving ability (Khalaf et al., 2022). The relationships between Algorithmic Thinking and Critical Thinking, and Cooperative Thinking and Critical Thinking are also explored, showing how these skill sets reinforce each other. Finally, the text discusses the importance of integrating these skills in educational and professional settings to enhance problem-solving and critical-thinking abilities (Ceulemans et al., 2021; Permansah et al., 2023; Tao et al., 2023).

CONCLUSIONS AND RECOMMENDATIONS

This study examines the impact of various skills such as planning, project management, evaluation, cooperative thinking, and algorithmic thinking on the development of critical thinking ability. The method used was structural equation modeling to analyze the correlation between these skills. The results showed that skills in planning, project management, and evaluation had a significant effect on critical thinking ability. This research emphasizes the synergy between these skills and their collective impact in enhancing critical thinking, suggesting the need for an integrated approach in education and professional environments to foster these competencies. The results of this study make a significant contribution to educational and professional development. In the education sector, the findings can be applied to create curricula that focus more on the incorporation of planning, project management, and evaluation skills, with the ultimate goal of strengthening students' critical thinking abilities. In the professional context, training programs that focus on these skills can improve critical analysis and decision-making among employees. The implications are also useful in leadership development and research and development activities, where the application of these skills supports more innovative and effective solutions.

ADVANCED RESEARCH

Further research can be directed and designed in the big theme of the usefulness of computational thinking in study more broadly. The results of this research are expected to be able to become the basis for developing students' computational thinking, especially in the fields of social studies and education.

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