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The Effect Of Project-Based Learning And Self-Directed Learning Models On Critical Thinking Skills In Economics Learning Through The Use Of Artificial Intelligence As A Mediating Variable Among Generation Z Students

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Abstract

This study aims to obtain broader knowledge and understanding of the effect of project-based learning, self-directed learning, and critical thinking skills through the use of artificial intelligence (AI) among Generation Z students. The method used in this study is quantitative research with a descriptive research type. The population consisted of Generation Z students from the Department of Economics, Faculty of Economics and Business, Universitas Negeri Makassar, totaling 1,225 respondents. The sample used in this study consisted of 124 respondents. The data analysis technique used was Partial Least Squares Structural Equation Modeling (PLS-SEM). The results show that project-based learning has a significant effect on critical thinking skills. Self-directed learning has a significant effect on critical thinking skills. Project-based learning has a significant effect on the use of artificial intelligence. Self-directed learning has a significant effect on the use of artificial intelligence. Artificial intelligence has a significant effect on critical thinking skills. Artificial intelligence mediates the effect of project-based learning on critical thinking skills. Artificial intelligence also mediates the effect of self-directed learning on critical thinking skills.

Keywords: ***Project-Based Learning, Self-Directed Learning, Critical Thinking Skills, Artificial Intelligence*.**

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INTRODUCTION

Education is one of the important aspects in creating human resources who are able to think broadly and possess good attitudes and skills so that they can compete in the future. A learning model is a plan or pattern used to form a curriculum or long-term learning plan, design learning materials, and guide classroom learning. Learning models can be used as alternative patterns; therefore, it is important to choose appropriate and efficient learning models to achieve educational goals.

In the educational context, critical thinking is one of the main focuses of competency-based learning. This skill is not only useful for students' academic life, but also contributes to their readiness to face the world of work and make complex decisions in the future (Dominguez-Salazar & Ward, 2020). Therefore, various learning approaches have been developed to improve students' critical thinking skills. At the Faculty of Economics and Business, Universitas Negeri Makassar, critical thinking skills are prioritized. Students are expected to be able to analyze economic data, evaluate policies, and make rational business decisions. However, preliminary observations indicate that many students still face difficulties in developing this ability. This is largely caused by teaching methods that emphasize memorization more than in-depth analysis in learning.

Students involved in traditional learning processes tend to have limited exposure to analytical and evaluative activities. In contrast, learning approaches such as Project-Based Learning (PjBL) and Self-Directed Learning (SDL) have begun to be introduced to help students develop critical thinking skills through real-world and independent tasks. The faculty has also begun integrating technology into the learning process to support collaboration and student engagement. Project-Based Learning (PjBL) is a learning method that emphasizes the completion of real projects to encourage students to learn actively, collaboratively, and independently. This method is designed to help students connect theory with practice through challenging and contextual processes (Ferreira et al., 2023). Meanwhile, Self-Directed Learning is defined as a process in which a person takes the initiative, with or without the help of others, to analyze learning needs, formulate learning goals, identify resources, select and implement appropriate learning strategies, and evaluate learning outcomes.

The preliminary survey showed that students who were actively involved in project-based learning and independent learning tended to have better critical thinking skills. Therefore, identifying factors that influence critical thinking skills, such as learning methods and the use of technology, is important for improving the quality of learning in this faculty. Research conducted by Calavia et al. (2023) found that the Project-Based

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Learning (PjBL) model can improve students' thinking skills, and through contextual project-based learning, students' cognitive abilities also improve compared with learning without projects. Previous research by Xiaolei and Teng (2024) stated that self-directed learning supported by digital technology is effective in sharpening critical analysis in the economic context.

Although many studies have examined the role of project-based learning and self-directed learning methods in supporting the learning process, few have examined the direct effect of AI use on the development of students' analytical abilities in economics learning. This study aims to explore how AI can serve as a mediator in the relationship between project-based learning and self-directed learning and the improvement of critical thinking skills among Generation Z students studying economics (Narmaditya et al., 2024).

This study offers two main contributions. First, it deepens the discussion of AI implementation in economics education, a topic that remains limited in previous research, particularly regarding how AI can serve as a tool to sharpen students' critical thinking skills (Hwang et al., 2023). Second, by using a theoretical approach, this study aims to broaden understanding of how project-based learning and self-directed learning methods involving AI technology can help students develop the skills needed to address challenges in economics learning (Rajam et al., 2021). Thus, AI does not merely function as a supporting tool, but also as an effective connector in strengthening students' critical thinking skills in the digital era.

RESEARCH METHODS

This study employed a quantitative approach to examine the effect of Project Based Learning (X1) and Self Directed Learning (X2) on Critical Thinking Skills (Y) through Artificial Intelligence (AI) as a mediating variable. The population consisted of 1,225 Generation Z students from the Department of Economics, Faculty of Economics and Business, Universitas Negeri Makassar. A total of 124 respondents were selected using the Cochran formula and purposive sampling technique, based on the following criteria: students born between 1996 and 2012, students from the Department of Economics, Faculty of Economics and Business, Universitas Negeri Makassar, and students who had experience using AI/ChatGPT in economics learning. The research instrument consisted of 36 statements divided into four variables, with 9 statements each for Project Based Learning, Self Directed Learning, Critical Thinking Skills, and Artificial Intelligence. Each construct was measured using a four-point Likert scale. The data were

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analyzed using Structural Equation Modelling Partial Least Squares (SEM-PLS) with SmartPLS version 4.0, following the approach proposed by Hair et al. (2020).

RESULTS AND DISCUSSION

Results

This study applied four indicators to assess the outer model, namely convergent validity, discriminant validity, composite reliability, and construct reliability.

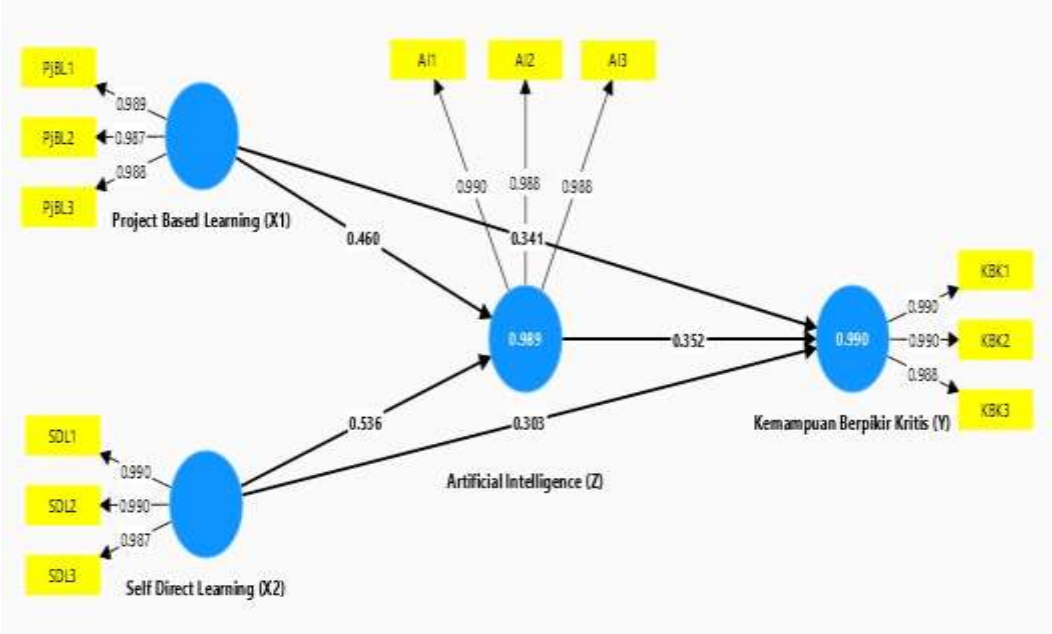


Figure 1. Measurement Model Test Results
Source: Data Processing Results, 2026

Table 1. Measurement (Outer) Model Calculation

Variable	Item	Loading	a(>=0.7)	CR(>=0.7)	AVE(>=0.5)
X1 (Project-Based *Learning)*	PJBL1	0.989	0.988	0.992	0.976
	PJBL2	0.987			
	PJBL3	0.988			
X2 (Self-Directed *Learning)*	SDL1	0.990	0.989	0.993	0.979
	SDL2	0.990			
	SDL3	0.987			

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Y2 (Critical Thinking Skills)	CTS1	0.990	989	0.993	0.978
	CTS2	0.990			
	CTS3	0.988			
Z (Artificial Intelligence)	AI1	0.990	0.989	0.992	0.978
	AI2	0.988			
	AI3	0.988			

Source: Data Processing Results, 2026

Table 3. Discriminant Validity

Variable	DL	CTS	CRTS	AI
Artificial Intelligence (AI)	0.989			
Critical Thinking Skills (CTS)	0.993	0.989		
Project-Based Learning (PjBL)	0.993	0.993	0.988	
Self-Directed Learning (SDL)	0.993	0.993	0.994	0.989

Source: Data Processing Results, 2026

Furthermore, the hypothesis testing results can be seen in Table 5 below:

Table 5. Hypothesis Testing Results

Hypothesis	Relationship	Standard Deviation	T statistic	P values	Remarks
H_1	PJBL→KBK	0.150	2.277	0.023	Sig.
H_2	SDL→KBK	0.145	2.100	0.036	Sig.
H_3	PJBL→AI	0.112	4.125	0.000	Sig.
H_4	SDL→AI	0.112	4.802	0.000	Sig.
H_5	AI→KBK	0.150	2.343	0.019	Sig.
H_6	PJBL→AI→KBK	0.082	1.971	0.049	Sig.
H_7	SDL→AI→KBK	0.090	2.106	0.035	Sig.

Source: Data Processing Results, 2026

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DISCUSSION

1. The Effect of the Project-Based Learning Model on Critical Thinking Skills in Economics Learning

The results of this study found that the project-based learning model has a significant effect on the critical thinking skills of Generation Z students in the Department of Economics, Faculty of Economics and Business, Universitas Negeri Makassar, in economics learning. This is in accordance with the proposed first hypothesis. This finding indicates that the more intensive the use of the Project-Based Learning model, the more students' critical thinking skills improve. This finding is consistent with previous research by Murat Genc (2015), which stated that students who are actively involved in Project-Based Learning tend to be better able to analyze and critically evaluate information.

The results show that the significant effect of the Project-Based Learning (PjBL) model on students' critical thinking skills in economics learning cannot be separated from the role of three main PjBL indicators: driving question, in-depth inquiry, and public product (Bytyqi, 2021). The driving question indicator functions as the main trigger for critical thinking because students are directed to answer essential questions that are open-ended and contextual, such as actual economic problems in society. These questions require students to analyze problems, identify issues, and formulate solutions based on economic concepts and data, thereby significantly developing their analytical and evaluative abilities (Ash, 2020).

The in-depth inquiry and public product indicators continuously strengthen the critical thinking process. The in-depth inquiry indicator has a moderate effect on students' critical thinking skills because the process of investigating or examining material in depth in economics learning helps students analyze economic problems, interpret data, and construct logical arguments based on the information obtained (John et al., 2019). Through concept exploration, case analysis, and review of various sources, students are trained to understand economic phenomena more comprehensively. Through activities such as case analysis, information gathering, and review of various sources, students are trained to understand economic concepts more comprehensively and develop data-based arguments (Caprara et al., 2023). However, the effect is in the moderate category because the effectiveness of in-depth inquiry is also influenced by other factors, such as student involvement in discussions and students' ability to interpret information (Condliffe et al., 2017).

The public product indicator has a relatively lower effect. This indicator has a relatively lower effect on critical thinking skills because it is the final stage of the learning

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process, which is preceded by driving questions and in-depth inquiry. Students' critical thinking skills develop more during the stages of formulating problems and conducting in-depth investigation (Grace Leggett, 2021). Meanwhile, at the public product stage, students focus more on preparing and presenting the results of their thinking. Therefore, its contribution to the development of critical thinking tends to be lower than indicators that emphasize analysis and inquiry processes.

2. The Effect of the Self-Directed Learning Model on Critical Thinking Skills in Economics Learning

The results show that the self-directed learning model has a significant effect on the critical thinking skills of Generation Z students in the Department of Economics, Faculty of Economics and Business, Universitas Negeri Makassar, in economics learning because it emphasizes learning independence and individual responsibility in managing the learning process. This is in accordance with the proposed second hypothesis. This finding is consistent with Markova (2014), who stated that students who are able to manage their own learning process tend to be more active in analyzing phenomena, evaluating data and information, and drawing conclusions based on logical reasoning (Ariyatun, 2021).

The results show that the significant effect of the Self-Directed Learning (SDL) model on Generation Z students' critical thinking skills in economics learning is closely related to three main indicators: planning, implementing, and evaluating (Mentz & Zyl, 2018). The planning indicator has a small effect in the self-directed learning variable on critical thinking skills because at this stage students begin to determine learning goals, plan strategies, and select learning resources to be used (Cappucio et al., 2023). This planning process encourages students to think in a directed manner and consider the steps needed to achieve learning objectives. This planning process also encourages students to think critically from the beginning, as they must analyze their learning needs, prioritize information, and formulate appropriate strategies to understand economic concepts in depth. However, the effect is in the small category because critical thinking skills develop more when students directly analyze information, solve problems, and reflect on their learning outcomes.

Meanwhile, the implementing indicator has a moderately high effect in the self-directed learning variable. At this stage, students not only plan learning goals and strategies but also execute the steps that have been established and complete tasks or projects in a structured manner. In addition, students are able to face obstacles that arise

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during the learning process and find solutions independently. Thus, the implementing indicator shows the extent to which students transform learning plans into real actions, which is the core of independent learning and supports the development of critical thinking skills (Dias & Brantley-Dias, 2017).

The evaluating indicator has a moderate effect in the self-directed learning variable on critical thinking skills because at this stage students reflect on and assess the learning process and outcomes that have been achieved (Dupri et al., 2021). Through evaluation activities, students not only assess whether learning objectives have been achieved, but also analyze the strengths, weaknesses, and effectiveness of the learning strategies used. This reflection and assessment process encourages students to think more analytically and objectively, so that critical thinking skills can develop more optimally than at the planning or implementing stages.

3. The Effect of the Project-Based Learning Model on the Use of Artificial Intelligence (AI)

Based on the research results, the project-based learning (PjBL) model has a significant effect on the use of artificial intelligence (AI) among Generation Z students in the Department of Economics, Faculty of Economics and Business, Universitas Negeri Makassar, because students are encouraged to use technology to analyze real and contextual economic problems. This is in accordance with the proposed third hypothesis. Previous research by Moti and Abigail (2010) supports this study by stating that the implementation of PjBL encourages students to actively explore problems, search for information, and formulate solutions (Condliffe et al., 2017).

This result is influenced by three main PjBL indicators: driving question, in-depth inquiry, and public product (Bytyqi, 2021). At the driving question stage, students are faced with contextual economic learning problems that are open-ended and challenging, encouraging them to use ChatGPT as an initial tool to explore concepts, formulate hypotheses, and obtain a quick and systematic overview of possible solutions. Therefore, the driving question indicator becomes an indicator with a strong effect in the project-based learning variable (Ge & Lai, 2023).

The indicator with a moderate effect in the project-based learning variable is in-depth inquiry. At this stage, students are required to deepen their understanding of material, analyze data, and develop critical arguments, which makes the use of ChatGPT more intensive as a tool for searching information, clarifying economic concepts, and developing frameworks of thought (Gill et al., 2024). Meanwhile, the indicator with a small

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effect is public product. At the public product stage, students are directed to produce and present project products to the public, so ChatGPT is used to improve output quality, such as formulating reports, presenting logical arguments, and improving academic language structure (Hwang et al., 2023).

4. The Effect of the Self-Directed Learning Model on the Use of Artificial Intelligence (AI)

The results show a significant relationship between the self-directed learning (SDL) model and the effectiveness of artificial intelligence (AI) use among Generation Z students in the Department of Economics, Faculty of Economics and Business, Universitas Negeri Makassar, in economics learning projects. This is in accordance with the proposed fourth hypothesis. This finding is consistent with Zuckerman (2022), who stated that students with a high level of learning independence tend to be able to choose appropriate learning strategies and make optimal use of digital technology.

The study found that the use of AI by Generation Z students in the context of self-directed learning improves the quality of economics project outcomes. Students are not only able to complete tasks more quickly, but also produce deeper and more accurate analyses (Zakharova & Andrushchenko, 2014). Critical skills sharpened through self-directed learning enable students to evaluate AI outputs more effectively, distinguish valid information from less relevant information, and integrate AI findings into realistic economic strategies. These findings confirm that the combination of Self-Directed Learning and the use of AI synergistically strengthens Generation Z students' economic competencies, making them better prepared to face challenges in a technology-based world of work (Imjai et al., 2024).

The results show that the significant effect of Self-Directed Learning (SDL) on AI use is closely related to three main indicators: planning, implementing, and evaluating (Mentz & Zyl, 2018). The planning indicator has a small effect in the self-directed learning variable. The planning indicator in self-directed learning related to the use of AI such as ChatGPT describes students' ability to plan their learning process independently by utilizing AI technology (Hassani & Silva, 2023). At this stage, students set learning goals, determine the material or topics to be studied, and design strategies and steps to achieve these goals. In the context of ChatGPT use, students also plan how and when AI will be used, for example to search for information, create summaries, or evaluate ideas (Imjai et al., 2024). The planning indicator emphasizes students' ability to prepare a systematic

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and directed learning process, so that the use of AI can run effectively and support improvements in critical thinking skills and learning independence.

The implementing indicator has a strong effect in the self-directed learning variable. The implementing indicator related to the use of AI such as ChatGPT describes the extent to which students are able to execute the learning process independently by utilizing AI technology (Surameery & Shakor, 2023). At this stage, students not only plan learning goals and strategies, but also use ChatGPT to search for information, explore concepts, and complete tasks or projects effectively. In addition, students are able to use AI to overcome difficulties or information gaps that arise during the learning process, and to assess and verify the answers or suggestions provided by ChatGPT. Thus, the implementing indicator shows students' ability to transform learning plans into real actions with AI support, while also improving learning independence and critical thinking skills.

Meanwhile, the indicator with a moderate effect is evaluating, which describes students' ability to assess and reflect on learning outcomes obtained with AI support. At this stage, students evaluate the accuracy, relevance, and quality of information or suggestions provided by ChatGPT, as well as assess the effectiveness of the learning strategies applied. In addition, students reflect on the achievement of learning goals, identify strengths and weaknesses in the independent learning process, and determine improvements or follow-up actions (Michel et al., 2023). Thus, the evaluating indicator emphasizes students' ability to control and improve the learning process independently, use AI critically, and support the development of critical thinking skills.

5. The Effect of Artificial Intelligence (AI) Use on Critical Thinking Skills in Economics Learning

Based on the research results, the use of artificial intelligence is proven to have a positive and significant effect on the critical thinking skills of Generation Z students in the Department of Economics, Faculty of Economics and Business, Universitas Negeri Makassar, in economics learning; therefore, the fifth hypothesis is accepted. This finding is consistent with Pavlik (2023), who showed that the use of AI in the learning process can encourage students to be more active in analyzing economic problems, evaluating information, and drawing rational conclusions. The presence of AI provides easy access to diverse information, rapid data presentation (Rice et al., 2024), and real-time feedback, so students do not merely act as recipients of information but also as processors and critics of that information.

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This positive effect can be explained through three main indicators of critical thinking skills: the ability to identify problems, the ability to solve problems, and the ability to draw conclusions (Dupri et al., 2021). The mechanical intelligence indicator in the context of ChatGPT use refers to students' ability to use AI to complete routine, technical, or operational tasks. Examples include searching for information, creating simple summaries, or carrying out procedural instructions. Although this indicator helps improve learning efficiency and productivity, its effect on critical thinking skills is relatively small (Rice et al., 2024). This is because mechanical intelligence focuses more on performing mechanical tasks, so it provides limited encouragement for students to analyze, evaluate, or make decisions that require deep reflection and reasoning. In other words, mechanical intelligence supports the learning process, but its contribution to the development of critical thinking is limited compared with indicators such as analytical or intuitive intelligence. The intuitive intelligence indicator in the use of ChatGPT helps students develop conceptual understanding and make creative connections among ideas (Perez-Mercado et al., 2023).

This indicator encourages students to recognize patterns, draw conclusions, and build new insights based on information obtained from AI. Its effect on critical thinking skills is categorized as moderate because, although it supports decision making and creative problem solving, its contribution is subjective and depends on the individual's ability to interpret and integrate information (Pavlik, 2023). In other words, intuitive intelligence helps improve critical thinking, but not as strongly as analytical intelligence, which directly encourages logical analysis and evaluation. The analytical intelligence indicator in ChatGPT use has a strong effect on students' critical thinking skills. This indicator enables students to analyze information, assess evidence, compare alternative solutions, and draw logical conclusions (Surameery & Shakor, 2023). By using ChatGPT, students can evaluate data and arguments more deeply, identify errors or inconsistencies in information, and formulate accurate, evidence-based solutions because these activities directly involve reasoning, evaluation, and information synthesis processes (Pradana et al., 2023).

6. The Effect of Digital Literacy on Critical Thinking Skills in Economics Learning through the Use of Artificial Intelligence (AI)

Based on the analysis results, the Project-Based Learning model has a positive and significant effect on the critical thinking skills of Generation Z students in the Department of Economics, Faculty of Economics and Business, Universitas Negeri

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Makassar, in economics learning through the use of artificial intelligence; therefore, the sixth hypothesis is accepted. This finding is consistent with previous research by Grace Leggett and Ingrid Harrington (2019), which stated that PjBL encourages students to be actively involved in solving real problem-based projects, while AI serves as a supporting tool in the process of searching for information, analyzing data, and making decisions. Through the integration of PjBL and AI, students become more trained in systematically identifying economic problems, as well as formulating and evaluating various alternative solutions based on data obtained through AI. Thus, artificial intelligence acts as a mediating variable that strengthens the effect of the PjBL model on students' critical thinking skills in economics learning.

In the implementation of PjBL, the use of AI, especially ChatGPT, acts as a cognitive tool that supports the construction of knowledge through three main indicators: mechanical intelligence, intuitive intelligence, and analytical intelligence. The mechanical intelligence indicator in the AI variable is one of the most dominant indicators in the mediation pathway because it is directly related to students' ability to use intelligent technology effectively to support the learning process (Rice et al., 2024). Mechanical intelligence refers to the ability of AI such as ChatGPT to search for information, analyze data, and organize knowledge quickly and accurately (Ray, 2023). In the context of Project-Based Learning, this indicator enables students to explore ideas, test hypotheses, and obtain instant feedback from AI, thereby improving the efficiency and quality of problem solving. Thus, mechanical intelligence becomes an indicator that strengthens the relationship between PjBL and critical thinking skills; intelligent use of AI can strengthen students' reflection, analysis, and synthesis processes in economics learning projects (Surameery & Shakor, 2023).

The intuitive intelligence indicator reflects the ability of AI, such as ChatGPT, to understand context, recognize patterns, and provide naturally relevant responses to users. Unlike mechanical intelligence, which focuses on logical and analytical data processing (Surameery & Shakor, 2023), in Project-Based Learning (PjBL), this indicator facilitates students' critical thinking skills because they can ask questions, receive alternative solutions, or explore new perspectives with AI support (Rodriguez-Garcia et al., 2021). The dominance of this indicator emerges because the intuitive ability of AI strengthens students' reflection and decision-making processes, making interaction with AI not merely mechanical, but also helping students develop analysis, synthesis, and critical evaluation more effectively. Thus, intuitive intelligence becomes an indicator that strengthens the relationship between PjBL implementation and the improvement of critical

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thinking skills, because AI provides guidance and insights that are contextual, adaptive, and responsive to students' learning needs (Surameery & Shakor, 2023).

The analytical intelligence indicator in the AI variable strengthens the relationship between PjBL implementation and critical thinking skills because students can use AI to structure data, compare various sources of information, and validate hypotheses or project solutions more accurately (Wilkie, 2024). Analytical intelligence makes AI not only a passive supporting tool but also an active mediator that helps students filter information, solve complex problems, and develop logical arguments (Surur et al., 2023).

7. The Effect of Digital Literacy on Creative Thinking Skills in Economics Learning through the Use of Artificial Intelligence (AI)

Based on the analysis results, the Self-Directed Learning model has a positive and significant effect on the critical thinking skills of Generation Z students in the Department of Economics, Faculty of Economics and Business, Universitas Negeri Makassar, in economics learning through the use of artificial intelligence; therefore, the seventh hypothesis is accepted. This finding is consistent with Zuckerman (2022). In the context of self-directed learning, students have autonomy to determine learning goals, strategies, and learning evaluation, while the use of AI, especially ChatGPT, acts as a learning facilitator and cognitive tool that supports the independent learning process (Vankov & Wang, 2024).

This result is influenced by three main AI indicators: mechanical intelligence, intuitive intelligence, and analytical intelligence. Mechanical intelligence functions as the initial stage, in which students use AI such as ChatGPT to search for information quickly and accurately. Students with high SDL are more active in using AI to obtain various sources of information as a basis for independent learning (Xia et al., 2024). In the practice of Self-Directed Learning, AI helps students formulate clear learning goals, select relevant topics or problems, and determine the necessary sources of information (Vankov & Wang, 2024).

In addition, AI facilitates the design of learning steps, such as sequences of exploration activities, data analysis, or experiments, so that students can follow a logical and systematic learning process. Intuitive intelligence describes students' ability to understand information quickly and practically with AI support. At this stage, students not only collect information but also begin to interpret it and relate it to the concepts being studied. This ability develops because independent students tend to interact more frequently with AI, making the understanding process more efficient and in-depth (Wang

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& Siau, 2019). Analytical intelligence is the most influential stage in improving critical thinking skills. Students use AI to analyze information, compare various sources, and draw conclusions logically and systematically (Xia et al., 2024). Thus, the three indicators form a continuous sequence from searching for information, understanding, and analyzing, which explains how SDL through the use of AI has the strongest effect on improving critical thinking skills (Wilkie, 2024).

CONCLUSION

Based on the analysis and discussion, it can be concluded that Project Based Learning and Self Directed Learning have a positive and significant effect on Generation Z students' critical thinking skills in economics learning. Both learning models also have a positive and significant effect on the use of Artificial Intelligence. In addition, the use of Artificial Intelligence has been proven to have a positive and significant effect on critical thinking skills and is able to mediate the effect of Project Based Learning and Self Directed Learning on the critical thinking skills of Generation Z students in the Department of Economics, Faculty of Economics and Business, Universitas Negeri Makassar.

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