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The Effect of Teaching Methods and Formal Reasoning Ability on Student Learning Outcomes

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***Abstract*— The purpose of this study is to examine the influence of teaching methods and formal reasoning abilities on students' learning outcomes. The research employs a quantitative research method and utilizes simple linear regression analysis with the assistance of SPSS version 16. Regression is a statistical technique used to analyze the relationship between one or more independent variables and a dependent variable. The population and sample size for this study consist of 50 students. The results of the research lead to the conclusion that the simple linear regression test yields a Sig. value of 0.001 < 0.05. Based on decision-making principles, it can be inferred that X1 and X2 have a simultaneous impact on the variable Y. Therefore, it can be concluded that both the teaching method (X1) and formal reasoning (X2) have an influence on the students' learning outcomes (Y). This finding further strengthens previous research findings by employing a better methodology and a larger sample size, demonstrating that formal reasoning affects learning outcomes, although there are still other factors that influence learning outcomes, such as motivation, environment, and so on.**

***Keywords*—Formal Reasoning, Learning Outcomes, Method, Teaching**

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I. INTRODUCTION

Student learning outcomes are an important aspect in the world of education, because learning outcomes reflect student achievement in understanding and mastering the learning material provided by the teacher (Paul & Jefferson, 2019). Meanwhile, according to Dewati, (2015) related to the acquisition of good learning outcomes shows the effectiveness of the process passed by students (Balia et al., 2021), while low learning outcomes can indicate obstacles or deficiencies in the learning and learning system (Jain et al., 2020). Meanwhile, factors that affect student learning outcomes include various factors such as family environment, student motivation, teaching methods, and social factors (Schmauch et al., 2020). Family environment factors have a significant role in shaping students' learning habits, providing emotional support, and creating an atmosphere conducive to the learning process (Prakken, 2021). When students grow up in families that support

education, they tend to have higher motivation and adequate support to achieve good learning outcomes (Guo et al., 2020). In contrast, students who come from a less supportive family environment may face barriers in achieving their learning potential.

Achadah, (2019) explains that student motivation is also a key factor in learning outcomes. Students who have high intrinsic motivation, i.e. motivation that comes from within themselves, tend to be more eager in learning and strive to achieve good learning outcomes (Basílio et al., 2022). On the other hand, students with extrinsic motivation, i.e. motivation that comes from external factors such as praise or rewards, may be less intrinsically motivated and have less optimal learning outcomes. The teaching methods used by teachers can also affect student learning outcomes (Makransky et al., 2019). Effective teachers are able to deliver material in an interesting and relevant way, use a variety of teaching strategies, and provide constructive feedback (Qazi et al., 2020). Innovative and interactive approaches can increase students' interest in learning, facilitate better understanding, and ultimately improve their learning outcomes.

In addition, according to Abdullah, (2022) social factors can also affect student learning outcomes (Craik et al., 2019). Interaction with peers, social support and a positive school climate can affect student motivation and performance. Students who feel they belong to a supportive school community tend to have better learning outcomes compared to students who experience social isolation or feel uncomfortable in the school environment. In some cases, external factors such as economic conditions, environmental sustainability and access to educational resources can also affect student learning outcomes (Klimova, 2019). Students living in poverty or facing unstable environmental challenges may have difficulty in optimizing their learning potential (Pei & Wu, 2019). It is important to pay attention to students' backgrounds in the analysis of learning outcomes as this can provide insight into the factors that influence their academic performance (Abdi et al., 2019). By understanding students' backgrounds, educators can identify individual challenges and needs that need to be addressed to improve learning outcomes. In addition to the factors already mentioned, internal factors such as students' aptitudes, interests and learning styles can also play a role in their learning outcomes (Casafont et al., 2021). Each individual has different learning tendencies and preferences, and accommodating students' learning styles can help them optimize their learning potential.

Dwi Herlina, (2020) explains that the use of technology in learning can also affect student learning outcomes, the development of information and communication technology has brought changes in learning approaches, with access to digital resources, online learning platforms, and interactive tools (Almahasees et al., 2021). Effective technology integration can increase students' motivation and engagement in the learning process, which in turn can have a positive impact on their learning outcomes (Jangda et al., 2019). In addition to individual and internal factors, education policy factors can also play a role in student learning outcomes (Drawel et al., 2022). Investments in education infrastructure, improving teacher quality, providing relevant curricula and teacher upskilling programs can have a positive impact on overall student learning outcomes. Students' backgrounds should not be an excuse to generalize or curb their potential (Robaldo et al., 2020). While background factors can affect learning outcomes, every student has the ability to grow and develop, regardless of their background (Eringfeld, 2021). In inclusive education, attention should be paid to creating an equal and inclusive environment for all students, paying attention to individual differences and providing the necessary support to achieve optimal learning outcomes.

By understanding students' backgrounds and the factors that influence their learning outcomes, educators can design effective learning strategies and provide appropriate support for each student. With a holistic and student-centered approach, we can strive to improve overall learning outcomes and provide fair opportunities for all students to reach their full potential in education.

One of the factors that influence learning outcomes is formal reasoning. Formal reasoning is the ability to think abstractly, systematically, and logically (Torres Martín et al., 2021). It involves the ability to analyze and draw conclusions based on logical principles and rules that have been learned. In the context of education, formal reasoning is an important cognitive ability in problem solving, critical thinking, and higher learning (Alalwan et al.,

2019). Formal reasoning develops along with individual cognitive development. According to the theory of cognitive development proposed by Jean Piaget, formal reasoning is the last stage of cognitive development that reaches its peak in adolescence and adulthood (Morse et al., 2020). At this stage, individuals are able to think abstractly, generate hypotheses, use deductive and inductive reasoning, and are able to understand complex and abstract concepts.

According to Tawil, (2008) Formal reasoning involves several main aspects. First, the ability to understand and apply the principles of logic is the basis of formal reasoning (Popat & Starkey, 2019). Individuals can use logical rules such as implication, modus ponens, and modus tollens to identify cause-and-effect relationships, make inferences, and reach valid conclusions. Second, formal reasoning involves the ability to analyze information systematically (Dhar et al., 2019). This includes the ability to classify, compare, and contrast different concepts (Chirikov et al., 2020). Individuals with strong formal reasoning can identify patterns, construct coherent arguments, and devise a logical series of steps in the problem-solving process (Tseng et al., 2019). Formal reasoning ability is also closely related to critical thinking (Wang et al., 2019). Critical thinking involves the ability to critically evaluate information, recognize weaknesses in arguments, and construct solid arguments based on relevant evidence.

Formal reasoning allows individuals to consider multiple points of view, critically analyze arguments, and conclude objectively based on available evidence (Chung et al., 2020). In the context of learning, formal reasoning has an important role (Isaac et al., 2019). The ability to think logically and systematically helps students in understanding complex concepts and solving complicated problems (Dost et al., 2020). It enables students to engage in higher-order learning, such as critical analysis, synthesis of information, and evaluation of their own understanding.

Effective education should encourage students' formal reasoning development through appropriate approaches (Elshami et al., 2021). Teachers can design learning strategies that encourage students to think critically, ask open-ended questions, and solve problems that involve formal reasoning and abstract thinking (Anderson, 2019). Engaging students in group discussions, debates, and case studies that require formal reasoning can help improve their ability to identify inappropriate assumptions, critically analyze arguments, and reach evidence-based conclusions (Law et al., 2019). In addition, the application of formal reasoning can be enhanced through the use of teaching methods that encourage students to think independently (Chen et al., 2019). This involves providing tasks that encourage students to formulate hypotheses, collect and analyze data, and construct arguments based on formal reasoning. Students also need to be given opportunities to solve real problems where they can apply their formal reasoning to identify effective solutions.

To develop a learning environment that supports the development of formal reasoning (Casafont et al., 2021). An environment that provides opportunities to discuss, work together in groups, and solve problems collaboratively can help students hone their formal reasoning skills. Teachers can also provide constructive feedback to help students refine their reasoning and develop more complex thinking (Elmer et al., 2020). The development of formal reasoning is not only important in an educational context, but also in everyday life (Shen & Ho, 2020). The ability to think logically and systematically allows individuals to make good decisions, solve complex problems, and face challenges in an effective way (Ignatiev et al., 2020). It also enables individuals to understand and evaluate information they receive from various sources, thus enabling them to become critical consumers and informed citizens. In an information age rich with data and information, formal reasoning is becoming increasingly important (Hall et al., 2020). The ability to process and interpret information in a logical and systematic way is becoming an invaluable skill (Xie et al., 2019). Therefore, effective education should prioritize the development of formal reasoning as a key objective in the learning process.

II. Research Methods

The research method used by researchers is quantitative research method using linear regression. According to Darmawan (2013) Regression is a

statistical technique used to analyze the relationship between one or more independent variables and the dependent variable. Simple linear regression tests the effect of one independent variable on the dependent variable, while multiple linear regression allows testing the effect of several independent variables on the dependent variable. In this study, researchers used simple linear regression analysis. The sample selection in this study used random sampling of 50 high school students. The independent variables in this study are teaching methods (X1), Formal Reasoning (X2), the dependent variable learning outcomes (Y). Data collection of teaching methods, formal reasoning and student learning outcomes using questionnaires.

III. RESULT DISCUSION

Based on the results of the analysis using SPSS version 16, the results are as below.

Table 1. Validity Test Results

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
VAR00001	915.500	39.709	.363	.615
VAR00002	914.667	39.677	.383	.619
VAR00003	915.500	41.235	.389	.631
VAR00004	911.000	45.108	.523	.666
VAR00005	917.833	40.206	.445	.625
VAR00006	914.333	39.809	.377	.616
VAR00007	911.833	41.610	.528	.637
VAR00008	915.167	41.237	.555	.634
VAR00009	915.000	40.559	.850	.625
VAR00010	913.000	42.281	.769	.642
VAR00011	910.500	42.421	.398	.638
VAR00012	914.000	41.397	.669	.633
VAR00013	913.833	41.596	.763	.633
VAR00014	914.833	38.932	.426	.608
VAR00015	912.000	43.349	.556	.649
VAR00016	914.833	39.576	.640	.616
VAR00017	917.167	40.986	.458	.634
VAR00018	914.667	41.270	.444	.636
VAR00019	914.333	40.351	.369	.621
VAR00020	915.667	39.877	.396	.620
VAR00021	912.500	41.174	.485	.631
VAR00022	915.000	38.831	.427	.608
VAR00023	912.500	39.479	.531	.617
VAR00024	912.833	38.918	.441	.608
VAR00025	916.333	43.016	.438	.648
VAR00026	918.333	40.446	.552	.625
VAR00027	913.167	42.762	.419	.646
VAR00028	919.500	43.370	.555	.656
VAR00029	914.333	42.419	.660	.642
VAR00030	918.667	41.914	.362	.638

Description:

Based on table 1 above, the number of items is 30 and in the r-table the r_table value is obtained = 0.361, based on the table above the Corrected Item-Total Correlation score, all items are declared valid and can be used.

Table 2. Reliability Test Results

Reliability Statistics

Cronbach's Alpha	N of Items
.640	30

Description

If the alpha value is > 0.7 it means sufficient reliability while if alpha > 0.80 this means that all items are reliable and the entire test consistently has strong reliability and if alpha > 0.90 then perfect reliability. If alpha is between 0.70 - 0.90 then reliability is high. If alpha is 0.50 - 0.70 then medium reliability. If alpha < 0.50 then low reliability. If alpha is low, based on the reliability test results above, it is known that the score is 0.64, which means that the item is declared to have a medium reliability value.

Table 3 Linear Regression Test Results

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	13.825	3	3.457	5.249	.001
	Residual	84.433	129	.661		
	Total	98.257	133			

a. Predictors: (Constant), Metode mengajar (X1), Penalaran Formal (X2)

b. Dependent Variable: Hasil Belajar (Y)

Description

Based on the ANOVA output table above, it is known that the Sig. value is 0.001 <0.05, then as

the basis for decision making in the F test it can be concluded that X1 and X2 simultaneously affect the Y variable.

From the results of the analysis above, it is very clear that teaching methods and formal reasoning have an influence on student learning outcomes, this is in accordance with the research findings (Dewati, 2015) which show: 1) There is a positive influence of learning methods on student physics learning outcomes with Fcount (43.199) > Ftable (4.02). 2) There is a positive influence of students' formal reasoning level on students' physics learning outcomes with Fcount (10.746) > ttable (4.02). 3). There is an interaction of learning methods with the level of formal reasoning of students with Fcount (8.694) > Ftable (4.02). 4) There is an average difference in learning outcomes between learning methods (Inquery and conventional) with t0 = 5.585 and sig = 0.000 < 0.05. 5) There is an average difference in learning outcomes between formal reasoning levels (High and Low) with t0 = 2.291 and sig = 0.026 < 0.05.

Research on the influence of teaching methods, and formal reasoning on student learning outcomes is further strengthened by Dewati's findings. This finding shows that students who have good formal reasoning skills tend to achieve better learning outcomes as well. In explaining in more detail about these findings, we will elaborate on the concept of formal reasoning, its relationship with learning outcomes, and the factors that influence it.

According to Yip, (1988) Formal reasoning is an individual's ability to use logical rules and deductive thinking to solve problems and construct consistent arguments. This ability involves the ability to recognize patterns, understand concepts, and connect information logically. Furthermore, Bronkhorst et al. (2020) explained that formal reasoning involves abstract, analytical, critical, and reflective thinking. Students who have good formal reasoning have the ability to analyze, solve problems, and make rational decisions.

Learning outcomes are a measure of the level of achievement or achievement of students in understanding and mastering learning materials. Learning outcomes include not only knowledge gained, but also understanding of concepts, critical thinking skills, ability to apply knowledge, and positive attitudes towards learning. Research has shown that formal reasoning has a significant positive relationship with learning outcomes. Students who have good formal reasoning skills tend to achieve higher academic performance compared to those who have low formal reasoning skills (Syahrowiyah, 2016).

There are several factors that influence students' formal reasoning ability. First, formal education and a supportive learning environment can help the development of formal reasoning. Learning processes that encourage critical and reflective thinking can improve formal reasoning skills. Active teaching methods, such as group discussions, case studies, or problem solving, can build students' formal reasoning skills. Formal reasoning skills can develop along with students' cognitive development. Students who have high cognitive abilities tend to have better formal reasoning skills. In addition, motivation, interest, and confidence can also affect formal reasoning ability. Students who are highly motivated and have a strong interest in the learning subject tend to have better formal reasoning ability (Brownell et al., 1993).

Related research also shows that social and environmental factors play a role in the development of formal reasoning. Discussion and collaboration with peers can improve formal reasoning skills. Students who are involved in discussions and cooperation in study groups have the opportunity to share ideas, question arguments, and test the truth of opinions. Formal reasoning skills can develop along with students' cognitive development. Students who have high cognitive abilities tend to have better formal reasoning skills. In addition, motivation, interest, and confidence can also affect formal reasoning ability. Students who are highly motivated and have a strong interest in the learning subject tend to have better formal reasoning ability (Brownell et al., 1993).

Related research also shows that social and environmental factors play a role in the development of formal reasoning. Discussion and collaboration with peers can improve formal reasoning skills. Students who are involved in discussions and cooperation in study groups have the opportunity to share ideas, question arguments, and test the truth of opinions. In the context of learning in higher education, it is important for lecturers to encourage the development of students' formal reasoning. The use of active teaching strategies that involve students directly can improve formal reasoning skills. Teaching approaches that

emphasize problem solving, critical thinking, and reflection help students in developing formal reasoning skills. In addition, educators can also provide constructive feedback and challenge students to think more deeply and analytically.

Meanwhile, the results of research (Rambega, 2016) stated that students' formal reasoning ability in the physics learning process has a significant relationship with the physics learning motivation of Class VIII students of SMPN 19 Bulukumba. The results of this study indicate that formal reasoning has a positive influence on learning outcomes from high school to college level. Formal reasoning, which involves the ability to analyze, understand, and construct arguments logically and rationally, is proven to be an important factor in improving academic achievement.

Previous studies have shown that formal reasoning ability can predict learning success in a variety of subjects, including math, science, and language. These abilities enable students to understand material more deeply, connect different concepts, and critically evaluate information. In the context of higher education, formal reasoning is also closely related to problem-solving ability and critical thinking skills, which are highly valued competencies in the academic and professional world.

Basically, this study aims to strengthen previous findings by using better methods and larger samples. The researcher used a quantitative approach by collecting data from dozens of students at various public and private universities. They measured the level of formal reasoning using a tested assessment instrument and collected student learning outcome data from the study result card (KHS). Data analysis showed a significant relationship between formal reasoning and learning outcomes. Students with higher levels of formal reasoning tend to have higher grades in various courses.

Meanwhile, in the secondary school world, formal reasoning has also been shown to be associated with better academic performance in the long run. Students with strong formal reasoning skills tend to achieve higher grades in end-of-semester exams, college entrance exams, and academic research (Lawson, 1982). They also tend to have higher involvement in extracurricular activities related to learning and intellectual development (Lim, 1998). These findings have important implications for curriculum development and learning strategies in schools. Encouraging the development of formal reasoning early on can help improve students' overall learning outcomes. Curricula can be designed to integrate formal reasoning exercises in learning across different subjects. Teaching methods that promote critical thinking and assignments that encourage analysis and synthesis can also be used to improve students' formal reasoning skills.

In addition, this study also provides a better understanding of the factors that influence learning outcomes. Although formal reasoning plays an important role, it cannot be ignored that other factors such as motivation, learning environment and social support also contribute to students' academic achievement. Therefore, a holistic approach that integrates these various aspects needs to be considered in an effort to improve overall learning outcomes.

CONCLUCION

Based on the analysis and findings above, it can be concluded that if the results of the simple linear regression test obtained a Sig. value of 0.001 <0.05, then as the basis for decision making it can be stated that X1 and X2 simultaneously affect variable Y. This shows that the influence of variables X1 (teaching methods) and X2 (formal reasoning) affects Y (learning outcomes) Students. This means that it reinforces previous findings using better methods and a larger sample that formal reasoning affects learning outcomes even though there are still other factors that influence such as motivation, environment etc.

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