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Prediction of Meta-Skills Based on Metcognition

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Abstract: Meta-skills and metacognition are 21st century skills. The correlation between metacognition and meta-skills has never been studied before. Even though both have a relationship based on concept studies. Therefore, this study aims to predict the extent to which metacognition can influence meta-skills. This quantitative research is correlational research conducted on 30 undergraduate students of Biology Education, Universitas Jambi. Students' metacognition was measured using a test. Students' meta-skills were measured using a questionnaire whose scores were transformed into interval data. The results were analyzed using simple linear regression. The results of data analysis showed there is a correlation between students' metacognition and meta-skills ($p = < 0.01$). There is a significant regression equation [$F (1. 58) = 14.28$, $p < 0.01$] with an R^2 of 0.20. Students' meta-skills can be predicted using the regression equation $y = 33.63 + 0.46x$. The regression coefficient ($B = 0.46$) indicates that an increase in metacognition score by 1 number will increase students' meta-skills score by 0.46.

Keywords: Correlational research; Metacognition; Meta-skills; Simple linear regression

Introduction

One of the common goals of the education system is to achieve students' meta-skills. Meta-skills are innate, timeless, higher-order skills that create adaptive learners and promote success in whatever context the future brings. From birth, children use their meta-skills as they test and explore the world around them, and it is these meta-skills that act as a key to unlock the development of other transferable and technical skills. Therefore, it is important that as children and young people progress through their education, practitioners make meta-skills explicitly visible and create opportunities for learners to recognise, understand and explore their metaskills development (The Scottish Funding Council, 2019). The development of students' meta-skills can be influenced by various factors, both external and internal (Spencer & Lucas, 2021). Students' meta-skills can also be predicted through the observation of several learning predictors.

One of the learning predictors that can be used to measure the extent of students' meta-skills is metacognition. Metacognition is the second most powerful predictor of learning after classroom management (Langdon et al., 2019; Walberg, 1988). Many previous studies have examined the effect of metacognition on student learning outcomes and performance (Binali et al., 2021; Langdon et al., 2019; Ohtani & Hisasaka, 2018).

In science learning, metacognition can help students to achieve conceptual understanding and good learning strategies (Dori et al., 2018), facilitate students to apply science concepts in real contexts (Fleur et al., 2021), improve students' conceptual mastery (Muhali et al., 2019), and sort out the information needed according to the context being studied (Beaufort, 2012). Moreover, metacognition is key to understanding the ideas of science concepts (Vrieling et al., 2018), helping students independently organize their knowledge to make or evaluate decisions accurately (Boud & Soler, 2016; Tai et al., 2018).

Previous research conducted by Yadollahi & Yazdani informed that there is a conceptual relationship between metacognition and meta-skills (Yadollahi & Yazdani, 2020). The correlation between metacognition and meta-skills has never been studied before. Therefore, the extent to which metacognition can influence meta-skills has not been explained. Based on

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these things, correlational research is needed to find out the extent to which metacognition can affect meta-skills.

Method

This quantitative research is a correlational research. This study was conducted on 30 undergraduate students of Biology Education, Universitas Jambi. Metacognition measured in this study includes 2 aspects, namely cognitive knowledge and cognitive regulation. The meta-skills measured in this study include self-management (focusing, adapting, integrity, initiative), social intelligence (communicating, collaborating, feeling, leading), and innovation (curiosity, creativity, sense-making, critical thinking). Students' metacognition was measured using tests (10 items). Students' meta-skills was measured using questionnaires with 79 items (Mardiyanti & Siburian, 2023). Indicators and tests of metacognition refer to Kusumawati et al. (2021), while indicators and questionnaires of meta-skills refer to The Scottish Funding Council (2019) and Mardiyanti et al. (2023). The metacognitive test grids can be seen in Table 1 and Table 2 for the meta-skills test grids.

Meta-skills scores were transformed into interval data. Meta-skills and metacognitive test results were analyzed using simple linear regression. Simple linear regression was conducted to predict the meta-skills of biology education students based on their metacognition scores. There is an influence of metacognition on students' meta-skills if the p value < 0.05. Students' meta-skills can be predicted through the regression equation y = constant + coefficient of regression x.

Table 1. Metacognitive Test Grid

Components	Indicators	Question number
Awareness	Understand the problem	1. 2. 3. and 4
	Knowing the initial knowledge that can be used to solve problems	
	Determine the method that will be used to solve the problem	
Regulation	Knowing whether the steps taken to solve the problem are suitable with the plan	5. 6. and 7
	Identify new problems that arise so that they can be resolved immediately	
	Assess the method used whether it is appropriate to solve the problem	
	Knowing that the answers that are done are suitable with the problems given	
Evaluation	Knowing that he is proficient or not in solving problems	8. 9. and 10
	Determine the actions that must be taken to master the initial knowledge and be proficient in solving problems	
	Find out if there are other ways to solve the problem	

Table 2. Meta-Skills Questionnaires Grid

Domain	Sub-domain	Question number
Self-management	Focusing	1. 4. 5. 72. 75. and 77
	Integrity	6. 7. 9. and 66
	Adapting	11. 12. 14. 15. 17. 18. 61. and 62
	Initiative	19. 21. 23. 24. 25. 56. and 57
Social intelligence	Communicating	26. 28. 29. 31. and 50
	Feeling	34. 35. 37. 38. 39. 44. and 45
	Collaborating	33. 36. 40. 41. 42. 43. and 46
	Leading	27. 30. 32. 47. 28. 49. and 51
Innovation	Curiosity	20. 22. 53. 54. 55. and 58
	Creativity	13. 16. 59. 60. and 63
	Sense-making	8. 10. 64. 65. 67. 68. and 69
	Critical thinking	2. 3. 70. 71. 73. 74. 76. 78. and 79

Result and Discussion

Students' Metacognition

When students perform metacognition, there are three important components that they do, namely awareness, regulation, and evaluation (Magiera & Zawojewski, 2011; Wilson & Clarke, 2002, 2004). The results of the metacognitive test show in Figure 1.

To improve metacognition skills, the first step is the awareness that students must have in every step of their thinking. Awareness is a state where they realize what they think or what others think. This state shows that they think what is known (task, specific knowledge, relevant knowledge, or problem solving strategies), think about where they are in the problem solving process, think about what still needs to be done or what can be done. Metacognitive awareness can then stimulate a process of regulation. Regulation is a state in which students think about their strategic planning, goal setting, and choice of problem solving strategies. After

students do regulation in thinking, then they can continue to the evaluation process. Evaluation is a situation where students review the decision-making process which indicates that the students think about the effectiveness and limitations of their mind, the effectiveness of the strategy they chose, the assessment of the results obtained, the assessment of their progress, ability, or understanding (Purnomo & Bekti, 2021).

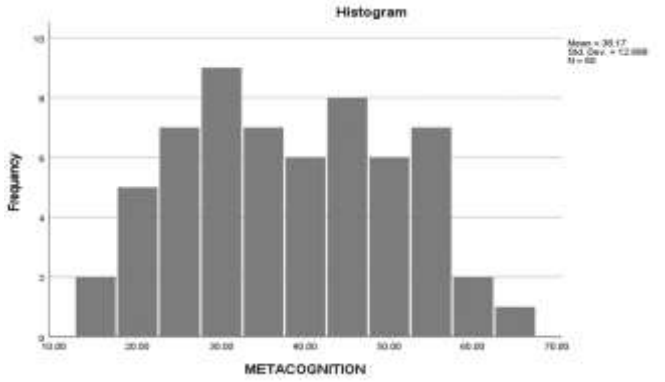

Figure 1. Graph of students' metacognition scores

Students' Meta-Skills

Students' meta-skills is assessed from the aspects of self-management (focusing, adapting, integrity, initiative), social intelligence (communicating, collaborating, feeling, leading), and innovation (curiosity, creativity, sense-making, critical thinking) (Mardiyanti & Siburian, 2023; The Scottish Funding Council, 2019). The results of students' meta-skills test show in Figure 2.

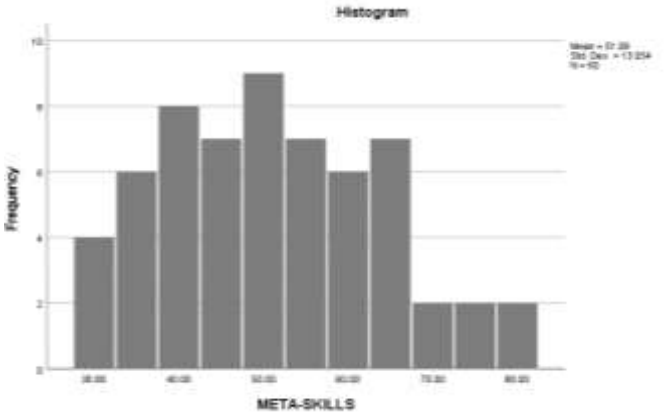

Figure 2. Graph of students' meta-skills scores

Assumptions of Simple Linear Regression

Before conducting a simple linear regression test, there are several assumptions that need to be fulfilled, namely linearity, homoscedasticity, and normality of residual data distribution. The assumptions of linearity and and homoscedasticity are tested using a scatter plot. Scatter plot of linearity can be seen in Figure 3. Based on the resulting scatter plot, metacognition has a linear relationship with students' meta-skills. Scatter plot of homoscedasticity can be seen in Figure 4. Based on the resulting scatter plot, assumption of homoscedasticity fulfilled.

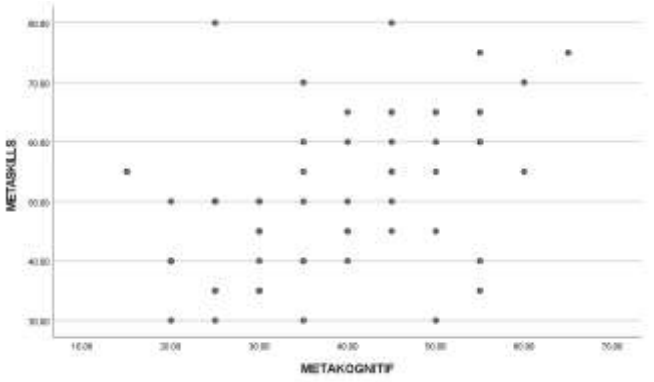

Figure 3. Scatter plot of linearity

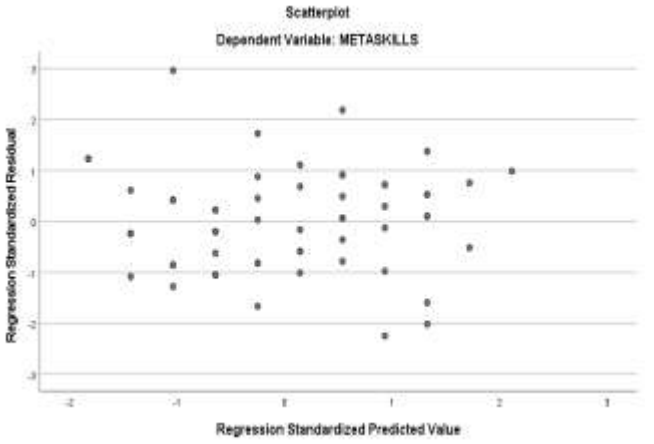

Figure 4. Scatter plot of homoscedasticity

The results of the normality test on the residual data distribution can be seen in Table 4. The Kolmogorov-Smirnov test [D (30) = 0.06, p = 0.20] or the Shapiro-Wilk test [W (30) = 0.99, p = 0.80] inform that the residual data are normally distributed.

Table 3. Test of Normality on the Residual Data Distribution

	Kolmogorov-Smirnova			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Unstandardized Residual	0.06	60	0.20*	0.99	60	0.80

*. This is a lower bound of the true significance.

a. Lilliefors significance correction

Results of Simple Linear Regression: The Extent to which Metacognition can Influence Meta-Skills

The correlation test results in Table 4 show that there is a correlation between students' metacognition and meta-skills (p = < 0.01). Simple linear regression was conducted to predict the meta-skills of Biology Education students based on their metacognition scores. The simple linear regression test results can be seen in Table 5, Table 6, and Table 7.

Table 4. Correlations

		Meta-skills	Metacognition
Pearson Correlation	Meta-skills	1.00	.44
	Metacognition	0.44	1.00
Sig. (1-tailed)	Meta-skills	.	< 0.01
	Metacognition	< 0.01	.
N	Meta-skills	60	60
	Metacognition	60	60

Table 5. ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1986.85	1	1986.85	14.28	< 0.01[b]
	Residual	8067.73	58	139.10		
	Total	10054.58	59			

a. Dependent variable: meta-skills
b. Predictors: (constant), metacognition

Table 6. Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	*Durbin-Watson*
1	0.44[a]	0.20	0.18	11.79	2.11

a. Predictors: (constant), metacognition
b. Dependent variable: meta-skills

A significant regression equation was obtained [F (1. 58) = 14.28, p < 0.01] with an R^2 of 0.20. The effect of metacognition as a predictor for meta-skills is very large with an R^2 = 0.20. This is very reasonable because metacognition has been shown in many studies to be the most powerful predictor of learning (no. 2) after classroom management (no. 1). Metacognition as a predictor of learning was found to be stronger than cognitive processes (no. 3), home environment/parental support (no. 4), and student and teacher social interactions (no. 5) (Langdon et al., 2019; Walberg, 1988).

Table 7. Coefficients

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	33.63	4.87		6.91	< 0.01
	Metacognition	0.46	0.12	0.44	3.78	< 0.01

a. Dependent variable: meta-skills

Metacognition can be used as a predictor for students' meta-skills. Students' meta-skills score can be predicted using the regression equation y = 33.63 + 0.46x. The regression coefficient (B = 0.46) indicates that increasing the metacognition score by 1 number will increase the students' meta-skils score by 0.46. This means that the greater the student's metacognition, the greater the student's meta-skills. This is related to the metacognitive components, such as cognitive knowledge (including declarative knowledge, procedural knowledge, conditional knowledge) and cognitive regulation (including planning, information management strategies, monitoring understanding, debugging strategies, evaluation) (Rhodes, 2019).

Metacognition is characterized by a collection of deliberate meta-abilities and meta-skills used with the purpose of ensuring the effective functioning of the cognitive and psychophysiological system. This is done to enhance functional capability, self-efficacy, independent living, and overall life satisfaction. The practice of metacognition involves the utilization of skills and strategies aimed at raising consciousness. These include an individual's capacity to observe, control, and adjust their internal mental processes. Furthermore, it involves recognizing the distinction between functional and dysfunctional states of mind and consciously opting for states that activate their full range of abilities and identity (Drigas et al., 2022; Drigas & Mitsea, 2020, 2021; Jankowski & Holas, 2014). This is related to previous research conducted by Yadollahi informed that there is a conceptual relationship between metacognition and meta-skills (Yadollahi & Yazdani, 2020).

Learning through metacognition can be viewed as a paradigm of self-guided and lifelong education, encompassing an extensive array of meta-skills essential for individuals from their education years through advanced ages. This approach acknowledges various factors influencing the development of meta-skills across diverse domains, including the physical, intellectual, socio-emotional, and even spiritual aspects (Drigas et al., 2023). Meta-skills serve as foundational pillars for academic success in both learning and executing professional tasks with efficiency and effectiveness in the workplace. Identifying these essential skills is critical in structuring curricula and refining teaching and learning methods, consequently influencing approaches to assessment and evaluation. Furthermore, meta-skills play a pivotal role in nurturing college students to evolve into lifelong learners, fostering adaptability to workplace changes, and enhancing their capabilities (Yadollahi & Yazdani, 2020). These meta-skills are indispensable for cultivating individuals as critical thinkers, innovators, responsible

citizens, and mindful, future-ready minds (Drigas et al., 2023).

The holistic curriculum approach to meta-skills categorizes them into three types: cognitive meta-skills, HOTS (Higher Order Thinking Skills), and psychomotor meta-skills. Cognitive meta-skills yield outcomes such as decision-making, problem-solving, judgment, and learning. HOTS, on the other hand, culminate in complex decision-making, complex problem-solving, complex judgment, and deep understanding. Finally, the attainment of psychomotor meta-skills is reflected in the realization of professional decisions (Yadollahi & Yazdani, 2020). So it can be concluded that decision-making is strongly related to meta-skills. This is in accordance with the results of research conducted by Spencer & Lucas which informs that decision making is one of the processes in meta-skills (Spencer & Lucas, 2021).

In other studies, metacognition can influence the decision-making process (Qiu et al., 2018; Rhodes, 2019). Furthermore, Qiu et al. in their research explained that the human brain can evaluate decision uncertainty using internal signals and then make appropriate adjustments to make initial decisions. The process of considering the outcome of a decision and whether a decision should be adjusted is called metacognition, and tends to occur automatically (Qiu et al., 2018). This is because metacognition affects a students' learning process (Fleming et al., 2012; Qiu et al., 2018). Metacognition plays an important role in organizing and controlling one's cognitive processes in learning and thinking more effectively and efficiently (Lau & Passingham, 2006; Qiu et al., 2018). Metacognition ability is able to regulate students' cognition in learning activities (Del Cul et al., 2009; Shimamura, 2008; Song et al., 2011).

Conclusion

Meta-skills can be predicted from students' metacognition where an increase in metacognitive score by 1 number will increase students' meta-skills score by 0.46. This is because metacognition as the second strongest predictor in learning can affect many aspects of the student learning process. So, it is recommended to train, develop, and improve metacognition so that students' meta-skills can also increase.

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Author Contributions
Conceptualization, L. M; methodology, J. S. and L. M.; validation, J. S. and L. M.; formal analysis, L. M.; investigation, J. S. and L. M.; resources, J. S.; data curation, J. S. and L. M.: writing—original draft preparation, J. S. and L. M.; writing—review and editing, L. M.; visualization, L. M. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest
The author declares no conflict of interest.

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