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METACOGNITION-BASED LEARNING MODEL: IMPROVING AGILE INNOVATION AND CRITICAL THINKING SKILLS OF STUDENTS IN SCIENCE LEARNING IN ELEMENTARY SCHOOLS

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ABSTRACT

This research aims to analyze the influence of a metacognitive-based learning model on students' agile innovation and critical thinking skills in science learning at the elementary school level. The study population consisted of fourth-grade students in elementary schools. The sample was selected using cluster random sampling with an intact group type. Based on the sampling results, the experimental class comprised 32 students, who received pedagogical intervention in the form of metacognitive-based learning implementation, while the control class, with 31 students, was exposed to conventional learning models. A survey questionnaire was employed as a data collection instrument. Data analysis included descriptive and inferential analysis. Based on the analysis of agile innovation data, an F-value of 23.994 was obtained with a significance value of 0.000 (<0.05). From these results, it can be concluded that there is a significant difference in agile innovation between students who experienced metacognitive-based learning and those who did not. The group of students who received metacognitive-based learning showed a higher level of agile innovation than those who did not experience metacognitive-based learning. Additionally, data on critical thinking skills showed an F-value of 20.915 with a significance value of 0.000 (<0.05). In light of these findings, it can be concluded that there is a significant difference in critical thinking skills between students who experienced metacognitive-based learning and those who did not.

Keywords: agile innovation; critical thinking; elementary school; metacognitive-based learning; science learning

INTRODUCTION

The elementary school represents the initial stage of primary education in the formal education system. This makes elementary school a crucial foundation in education (Kemal & Setyanto, 2017; Lin et al., 2019; Nurlaily et al., 2019; Febriani et al., 2020; Widiana et al., 2023). As far as learning is concerned, students are taught foundational knowledge such as numeracy and literacy. The elementary school also helps develop social skills (Uge et al., 2019; Muhtar & Dallyono, 2020; Johnson et al., 2021; Kristiantari et al., 2023). Students can interact with peers to develop empathy and collaboration and understand the social norms that apply in the environment (Nugraha et al., 2018; Wati & Suarni, 2020). Therefore, elementary schools have an essential role in maintaining equality in education. In learning activities, children are taught ethical values and social behaviour to function in society. Students are taught to understand good and bad (Alabaş,

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2018; Pujawan et al., 2020; Aristiani & Agung, 2022). Another aim of elementary school education is to prepare students to continue their education to a higher level. The knowledge gained during elementary school is essential for continuing further education (Nugraha et al., 2018; Kanji et al., 2020; Wati & Suarni, 2020). Primary education empowers students with the knowledge and skills to make the right decisions. This can help students become educated citizens. This is why elementary schools play a crucial role in helping the younger generation (Frahasini et al., 2018; Mubarok & Anggraini, 2020). Therefore, elementary schools provide an understanding of various subjects, including science learning.

Science learning is a content area through which students learn and inquire about the physical world (Jampel et al., 2018; Riastini et al., 2020). Science learning can help students understand the world and develop critical thinking (Syawaludin et al., 2019; Wati & Sari, 2019). This makes science learning meaningful for students because it concerns natural phenomena. In science learning, students are taught to apply the scientific method. This activity involves learning activities that include observation, hypothesis testing, data collection, and results analysis to understand scientific concepts (Sumirat & Alamsyah, 2017; Jampel et al., 2018; Subali et al., 2019). This empowers students to develop critical thinking, creative thinking, and problem-solving skills. Students are too instructed to assess data and make choices based on proof (Sumirat & Alamsyah, 2017 ; Jampel et al., 2018; Subali et al., 2019; Kusumayuni & Agung, 2021). On the other hand, science learning also includes collaboration with students and instructors. Students can collaborate on tests, ventures, or examinations, creating social and collaboration skills. Science learning, moreover, includes the capacity to seek data, investigate abilities, get logical sources, and communicate their discoveries successfully. Previous findings also reveal that science learning can stimulate interest and prepare students to have critical and creative thinking skills (Demirtas & Cayir, 2021; Lo et al., 2021; Bachri et al., 2023). Other findings also state that science learning includes an understanding of ethics in scientific research and human activities towards the environment so that it can help students understand their responsibility towards the earth (Andriana et al., 2017; Jampel et al., 2018; Freddy et al., 2019; Riastini et al., 2020). Science learning is vital in shaping students' understanding of the world and preparing students to face challenges. However, the current problem most school systems face is that students either do not exhibit motivation in science classes or underperform. Previous research findings also confirm that students' science learning outcomes are low (Permana & Nourmavita, 2017; Sasono et al., 2017; Lukman et al., 2019; Rati et al., 2023). Other research studies have also found that many students still feel bored and grapple with scientific concepts (Sumirat & Alamsyah, 2017; Jampel et al., 2018; Subali et al., 2019; Fitria, 2019; Kusumayuni & Agung, 2021). Several factors that cause low science learning outcomes for students are as follows. First, the curriculum and teaching methods are ineffective. This is reinforced by previous findings, which state that many teachers still use inappropriate learning methods or models to improve the learning outcomes of students who underperform in science learning (Fransiska et al., 2018; Jampel et al., 2018). An inappropriate learning model will certainly make students lose interest in learning science, so the learning model must be considered carefully. Second, limited pedagogical resources also contribute to this unfortunate reality. Previous research findings also confirm that a lack of learning facilities or learning media impacts science learning outcomes (Azimi et al., 2017; Uno et al., 2021; Hafni et al., 2022). Elementary schools in various places may have limited resources, such as minimal laboratory equipment or insufficient textbooks. This certainly hampers teachers' ability to provide quality science learning activities. Third, another factor that influences students' poor learning outcomes in science content areas is lack of interest. Previous research findings have confirmed that some students have no interest in learning science because students do not see the relevance of science in their daily lives (Andriana et al., 2017; Hasanah et al., 2018; Jampel et al., 2018; Freddy et al., 2019; Riastini et al., 2020).

Less interest can undermine their inspiration to think about science. Fourth, high anxiety toward learning science is also a cause of poor implementation. A few students feel anxious about learning science, feeling its complexity, or have had negative experiences in the past. This discomfort can impair the ability to learn science well. Fifth, the choice of learning sources is limited. Previous studies also affirm that the need for learning resources such as books, recordings, or learning media will influence students' learning outcomes (Panjaitan et al., 2020; Zulherman et al., 2021). Other discoveries also state that improper science learning exercises will influence students' critical thinking skills (Prasetyono & Trisnawati, 2018).

In overcoming the problem of low learning outcomes and critical thinking skills in elementary school students, teachers need to plan appropriate learning. One of them is implementing creative learning that encourages students to help improve students' critical thinking skills (Jampel et al., 2018; Baumfalk et al., 2019; Lestari et al., 2021). One of the learning models that can be used in science learning is the metacognitive-based. The metacognitive-based learning model can be a learning approach emphasizing the advancement of metacognition (Mohiddin, 2018; Suprianta & Alawiyah, 2019). The improvement of metacognition includes students' capacity to realize, control, and direct their claims in thinking. Metacognition involves students' self-awareness of their thinking processes (Van Der Horst & Albertyn, 2018; Kavousi et al., 2019). In metacognition, students are allowed to learn how they learn, recognize successful learning procedures, and evaluate their understanding of a concept. Furthermore, students are allowed to arrange their claim learning methodologies. This incorporates deciding the steps necessary to attain learning objectives, selecting appropriate equipment, and controlling time successfully (Tsai et al., 2018; Sukarno & Widdah, 2020). Students are included in observing their understanding. When learning, students are enabled to screen their learning progress, recognize barriers, and alter learning procedures if needed. This certainly incorporates the ability to recognize mistakes and resolve incorrect assumptions. In addition, students are encouraged to reflect on their learning experiences (Mohiddin, 2018; Van Der Horst & Albertyn, 2018; Suprianta & Alawiyah, 2019). This includes assessing the learning procedures used, understanding what has been accomplished, and reflecting on themselves as a learner. These learning activities certainly expand students' knowledge.

A few studies state that the proper learning model can cultivate a high level of excitement for learning (Wulandari et al., 2018; Yunita & Tristiantari, 2019). Other research also states that choosing an appropriate learning model can increase understanding and improve student learning outcomes (Dewi et al., 2017; Suharti et al., 2019; Lestari et al., 2020). Metacognition-based learning involves students' self-understanding of their thinking processes so it can enhance students' thinking skills (Mohiddin, 2018; Suprianta & Alawiyah, 2019). It is concluded that the metacognitive-based learning model can be a solution to improve students' agile innovation and critical thinking skills. The advantage of the metacognitive learning model is that it supports collaboration between students. Students can discuss their learning processes, exchange effective strategies, and provide constructive feedback to each other. This will undoubtedly have a positive impact on students' thinking skills. There are no studies regarding metacognitive-based learning models to increase students' agile innovation and critical thinking skills. Based on this, this research aims to analyze the influence of metacognitive-based learning models in improving agile innovation and critical thinking skills in science learning in elementary schools.

METHODS

This research was underpinned by the principles of quasi-experimental research. The research design was a nonequivalent post-test-only control group design. Participants in this research study were Grade 5 students in elementary schools in Bali Province, Indonesia. Samples were taken using a cluster random sampling technique with intact group type. Based on the sampling results, it was found that the experimental class with a total of 32 students underwent pedagogical intervention in the form of metacognitive-based learning, while the control class with a total of 31 students received a conventional learning model.

The method used in the data collection process was a questionnaire. The data collected in this research included agile innovation and critical thinking skill scores. This information was obtained through instruments such as a questionnaire for agile innovation, consisting of 20 statements, and a questionnaire for critical thinking skills, containing 20 statements. Respondents gave a score of 4 for the option "Always" (SL), a score of 3 for "Often" (OF), a score of 2 for "Rarely" (RR), and a score of 1 for "Never" (NV). Each instrument was equipped with a grid containing the dimensions and indicators being evaluated. The dimensions for agile innovation and critical thinking skills measured in this research are listed in Table 1. Both instruments had been tested for validity and reliability. The instrument's validity was tested using the CVR/CVI formula, and the reliability was tested using Cronbach's Alpha formula. The analysis results show that all instrument items are considered valid, with an average coefficient of 1.00 for the agile innovation questionnaire and 1.00 for the critical thinking skill questionnaire. In addition, reliability calculations produced a coefficient of 0.894 for the agile innovation questionnaire and 0.943 for the critical thinking skill questionnaire.

Table 1. Dimensions and Indicators of Agile Innovation and Critical Thinking Skills

Variable	Dimensions	Indicator
Agile Innovation	Creativity	Generate new ideas in solving science problems
		Try innovative approaches to experimentation
	Flexibility	Adapt to various changes in science learning
	Collaboration	Work together in groups to complete science assignments or projects
		Contribute to group discussions to increase shared understanding
	Responsive to Feedback	Be willing to receive feedback and improve work or ideas based on the feedback
	Initiative	Have the motivation to start and explore science concepts independently
Critical Thinking Skills	Analysis	Analyze scientific information and conclude results from experiments or observations
		Identify factors that influence experimental results
	Critical Questions	Able to ask critical questions related to science material
		Think critically about the answers and solutions produced
	Solution to problem	Identify problems in a scientific context and seek creative solutions
		Use scientific knowledge to solve everyday problems
	Evaluation	Evaluate scientific information from various sources
		Understand the difference between fact and opinion in scientific context
	Argumentation	Able to compose arguments supported by scientific evidence
		Able to convey opinions clearly and convincingly

The analytical methods applied in this research included descriptive and inferential analysis. Descriptive analysis was intended to provide an overview of the data collected, such as average values and standard deviations. Meanwhile, inferential analysis concerned hypothesis testing and used the Multivariate Analysis of Variance (MANOVA) test. Before the test, an assumption test was carried out involving a data distribution normality test, variance homogeneity test, multivariate homogeneity test, and multicollinearity test. All stages of data analysis were carried out using IBM SPSS Statistics version 25.00 software.

RESULTS AND DISCUSSION

The results of the descriptive analysis show that the application of metacognitive-based learning has a positive effect on science learning in elementary schools. This is manifested through differences in the average scores of agile innovation and critical thinking skills. Details of the descriptive analysis results can be found in Table 2.

Table 2. The Descriptive Analysis Results

Variables	Group	Mean	Std. Deviation	N
Agile Innovation	Experimental Group	75.90	9.01	32
	Control Group	65.03	8.59	31
Critical Thinking Skills	Experimental Group	73.03	8.83	32

Before testing the hypothesis using the MANOVA analysis, a classical assumption test was carried out. The first stage was the normality test of data distribution using Kolmogorov-Smirnov. The analysis results show that all data follows a normal distribution, indicated by a Sig value> 0.05. After ensuring the normality requirements were met, the homogeneity test was conducted. The homogeneity test was carried out with two analyses: the homogeneity of variance test using Levene's test of equality and the multivariate homogeneity test using Box's test of equality of covariance matrices. Both analyses provided similar conclusions, namely that the data is homogeneous, as evidenced by the Sig value >0.05. The next step in the assumption test was the multicollinearity test, which aims to evaluate the possibility of multicollinearity symptoms in each dependent variable analyzed. The results of the analysis show that there are no symptoms of multicollinearity between agile innovation and critical thinking skills. Next, hypothesis testing can be carried out by fulfilling all the conditions for carrying out the MANOVA analysis. The results of the MANOVA analysis can be found in Table 3.

Table 3. The MANOVA Test Results

	Effect	Value	F	Hypothesis df	df error	Sig.
Intercept	Pillai's Trace	0.991	3141.546	2,000	60,000	0,000
	Wilks' Lambda	0.009	3141.546	2,000	60,000	0,000
	Hotelling's Trace	104718	3141.546	2,000	60,000	0,000
	Roy's Largest Root	104718	3141.546	2,000	60,000	0,000
Group	Pillai's Trace	0.345	15,797	2,000	60,000	0,000
	Wilks' Lambda	0.655	15,797	2,000	60,000	0,000
	Hotelling's Trace	0.527	15,797	2,000	60,000	0,000
	Roy's Largest Root	0.527	15,797	2,000	60,000	0,000

The results of the MANOVA analysis in Table 3 show that the F value for Pillai's Trace, Wilks' Lambda, Hotelling's Trace, and Roy's Largest Root is 3141.546, with a significance value of 0.000 (<0.05). These results indicate that there are significant differences simultaneously between students who experience metacognitive-based learning and students who do not experience metacognitive-based learning in terms of agile innovation and critical thinking skills. Furthermore, the partial influence on agile innovation and critical thinking skills is presented in Table 4.

Table 4. The Results of Testing Effects Between Variables

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	Agile Innovation	1861.179	1	1861.179	23,994	0,000
	Critical Thinking Skills	1266.872	1	1266.872	20,915	0,000
Intercept	Agile Innovation	312755.972	1	312755.972	4031,997	0,000
	Critical Thinking Skills	295946.237	1	295946.237	4885.924	0,000
Group	Agile Innovation	1861.179	1	1861.179	23,994	0,000
	Critical Thinking Skills	1266.872	1	1266.872	20,915	0,000
Error	Agile Innovation	4731.678	61	77,568		
	Critical Thinking Skills	3694.843	61	60,571		
Total	Agile Innovation	318662,000	63			
	Critical Thinking Skills	300368,000	63			
Corrected Total	Agile Innovation	6592.857	62			
	Critical Thinking Skills	4961.714	62			

Based on Table 4, the agile innovation data obtained an F-value of 23,994 with a significance value of 0.000 (<0.05). From these results, it can be concluded that there is a significant difference in agile innovation between students who experience metacognitive-based learning and students who do not experience metacognitive-based learning. The group of students who experience metacognitive-based learning have a level of agile innovation with the next average score compared to those who do not encounter metacognitive-based learning. Besides, critical thinking data in Table 4 also appears to have an F-value of 20.915 with a significance value of 0.000 (<0.05). By alluding to these discoveries, it can be concluded that there is a significant difference in critical thinking skills between students involved in metacognitive-based learning and students not involved in metacognitive-based learning. The students who experience metacognitive-based learning have critical thinking skills with a better average score than those who do not experience metacognitive-based learning.

The research results show critical contrasts in students' agile innovation and critical thinking skills between students who experience metacognitive-based learning and those who do not experience metacognitive learning. It appears that the metacognitive-based learning model can offer assistance to students. This can be caused by a few factors. First, the metacognitive-based learning model can increment agile innovation in elementary school students. Metacognition could be a project-based learning movement. Metacognitive learning includes observing and controlling one's understanding of an issue (Palennari, 2016; Schoenfeld, 2016; Akbari et al., 2021). In learning activities, students are allowed to arrange problem-solving methodologies, recognize barriers, and adjust to changes. This underpins the advancement of problem-solving skills, which are imperative viewpoints of learning activities (Hamid et al., 2017; Indraswati et al., 2020; Silwana et al., 2020). Previous research results also state that students' problem-solving skills will be well created if learning activities require students to think critically (Palennari, 2016; Naufal et al., 2017; Maynastiti et al., 2020; Wulandari et al., 2020). Metacognitive-based learning models advance collaboration and thought exchange among students. Group discussion exercises in learning activities can open up metacognition and enhance students' thinking (Rahayu et al., 2020; Kim & Kim, 2021). Learning exercises can assist students with issues of different focuses (Athanases et al., 2020; Dahlstrom-Hakki et al., 2020).

Second, metacognitive-based learning models can improve critical thinking skills in elementary school students. The metacognitive-based learning model makes a difference to students in building critical thinking skills through reflection on their learning preparation (Mohiddin, 2018; Suprianta & Alawiyah, 2019). Students who know how to memorize themselves cause them to be able to recognize imaginative arrangements to unravel issues, develop critical thinking, and create metacognition skills (Kavousi et al., 2019; Suprianta & Alawiyah, 2019). Metacognitive-based learning models encourage students to plan and evaluate their learning strategies. Learning activities like this involve flexibility of thinking so that students can change their approach if the initial strategy is ineffective. Other research also reveals that flexibility of thinking is the key to facing change and adapting to new challenges (Mutakinati et al., 2018; Rahmati et al., 2018; Kavousi et al., 2019; Suprianta & Alawiyah, 2019; Silberman et al., 2021). Metacognitive-based learning models can also help develop positive attitudes toward learning and challenges. Students will learn to see mistakes as learning opportunities and respond proactively to challenges. This positive attitude supports innovation by creating a comfortable environment so students can try new ideas without fear of making mistakes (Mohiddin, 2018; Suprianta & Alawiyah, 2019). Metacognition involves the use of in-depth strategic questions. Students are invited to ask questions about what they know and need to know and how to achieve a more profound understanding. Previous findings also state that questioning activities will trigger critical thinking processes and help students develop evaluation skills (Mutakinati et al., 2018; Suprianta & Alawiyah, 2019; Silberman et al., 2021).

Third, metacognitive-based learning models can increase elementary school students' motivation and enthusiasm for learning. Metacognitive learning gives students challenging assignments (Van Der Horst & Albertyn, 2018; Kavousi et al., 2019). The assignments encourage students to think critically, plan, and reflect. In addition, the metacognitive-based learning model pays attention to the social and emotional aspects of learning. Students are allowed to develop self-confidence, manage stress, and understand the role of emotions in the learning process (Mohiddin, 2018; Van Der Horst & Albertyn, 2018; Suprianta & Alawiyah, 2019) Implementing the metacognitive learning model in the classroom helps students become more independent, responsive learners, and effectively overcome learning challenges. This learning activity creates a learning environment that encourages students to think reflectively about how they learn, understand the material, and develop metacognitive abilities (Khoiriah, 2015; Widyantari et al., 2019; Wardana et al., 2021). Through metacognitive learning, students are invited to discuss their learning process. Metacognition helps students become more independent learners. They learn to overcome obstacles, find creative solutions, and plan steps to achieve innovative goals (Sihaloho et al., 2018; Van Der Horst & Albertyn, 2018; Febrina & Mukhidin, 2019).

Previous research findings also reveal that the development of metacognition can regulate students' thinking processes because it involves students' self-understanding of their thinking processes (Van Der Horst & Albertyn, 2018; Kavousi et al., 2019). Other research also reveals that appropriate learning activities can encourage students to improve their learning experience. It has an impact on students' knowledge (Mohiddin, 2018; Van Der Horst & Albertyn, 2018; Suprianta & Alawiyah, 2019). In this regard, it can be concluded that a metacognitive-based learning model is one of the models that can improve students' thinking skills. This investigation suggests that metacognition-based learning models can promote agile innovation and critical thinking skills in students. Using metacognitive-based learning models empowers students to think imaginatively, adaptably, and inventively. This solidifies the establishment for creating metacognitive abilities at the elementary school level. Such learning exercises, without a doubt, affect the expanded knowledge of students.

Despite the promising suggestions of this investigation, there are a few restrictions that ought to be addressed. One major impediment is the test estimate and statistic scope. The investigation was conducted on a small group of students from a specific geographic region, which may not be representative of the wider student population. This limits the generalizability of the discoveries. In addition, the length of thinking time is quite short, which may not be enough to capture the long-term impact of the metacognitive-based learning model on agile innovation and critical thinking skills. Another limitation is the potential inconsistency in the use of the learning model by different teachers, which may affect the consistency and quality of results.

Future research should address this limitation by conducting investigations with larger and more diverse tests to improve the generalizability of the results of this research. Longitudinal studies are too prescribed to examine the supported effects of the metacognitive-based learning model over time. In addition, standardizing tests for different teachers and settings can help ensure consistency and unwavering quality of the findings. It would be helpful to investigate the integration of computerized innovations and tools in metacognitive-based learning to promote improved metacognition and critical thinking. In addition, future research is expected to explore the components of the metacognitive-based learning model that are most interesting in improving these skills to provide more experience for teachers to optimize their teaching techniques.

CONCLUSION

The analysis of agile innovation data uncovers a factually critical difference in results between students who experience metacognitive-based learning and those who do not, as proven by an F-value of 23.994 and a p-value of 0.000 (<0.05). This suggests that metacognitive-based learning essentially improves critical thinking skills among students. Notably, students who experience metacognitive-based learning show better average scores in agile innovation than their peers. The data on critical thinking also shows a significant difference, with an F-value of 20.915 and a p-value of 0.000 (<0.05). The results confirm that metacognitive-based learning significantly improves critical thinking skills. The students who experience this learning model demonstrate predominantly critical thinking skills, as reflected in higher mean scores compared to those who do not experience metacognitive-based learning. This emphasizes the significant effects of metacognitive-based learning on key cognitive competencies. The improvement in agile innovation and critical thinking skills observed in the experimental group recommends that incorporating metacognitive methodology into instructional preparation can foster critical thinking skills and agile innovation. It has noteworthy suggestions for honing instructional and educational program plans, encouraging to consider metacognitive components to better plan students for complex problem-solving and highly motivated decision-making situations.

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