

The Effect of Inquiry Learning Strategies and Self Regulated Learning on Critical Thinking Skills

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Abstract

This study aims to identify students' critical thinking skills between guided inquiry and conventional learning, to determine the effect of Self Regulated Learning (SRL) on critical thinking skills, as well as to determine the effect of the interaction between guided inquiry and SRL on critical thinking skills. This study was a quasi-experimental study with a 2x2 anaphatic experimental design, which involved 128 students. The study's findings indicate that guided inquiry learning differs from conventional learning in terms of students' critical thinking skills, that SRL has an effect on critical thinking skills, and there is also an interaction effect between inquiry learning strategies and SRL on critical thinking skills.

Keywords

inquiry; SRL; critical thinking



I. Introduction

One of the competencies needed to compete in facing global challenges in the 21st century is the ability to think critically (Mutohhari et al., 2021; Kusumoto, 2018; Scott, 2015; Kuhlthau, 2010; Boyatzis, 2008). Critical thinking skills are part of higher order thinking skills (Samsudin & Hardini, 2019; Ghanizadeh & Heydarnejad, 2015); which are reflective and deep (Ennis, 1993). Critical thinking skills are an integral part of problem solving skills (Zubaidah et al., 2018; Mutohhari et al., 2021) and become an important feature for making decisions (Ennis, 1993), also plays an important role in achieving success at school or at work (Suarniati et al., 2018). Critical thinking skills are not genetic (Ghanizadeh & Heydarnejad, 2015), so it must be trained or taught. Therefore, until now critical thinking skills have become one of the focuses of educational goals because the core of education is thinking (Kusuma et al., 2017; Madhuri et al., 2012). Currently, studies on critical thinking skills continue to develop, for example: the relationship between learning strategies and critical thinking (Qing et al., 2010; Kitot et al., 2010; Kusumoto, 2018; Wale & Bishaw, 2020; Duran & Dökme, 2016)); the relationship between active learning and critical thinking (Nelson & Crow, 2014; Kim et al., 2013), metacognitive relationship with critical thinking (Papanastasiou et al., 2020; Magno, 2010) and the relationship between constructivism and critical thinking (Mashaza, 2017; Allen, 2008; Topolovčan & Matijević, 2017).

The fact shows that students' critical thinking skills are still relatively low (Suarniati et al., 2018). One of the causes of the low critical thinking skills of students is that the learning strategies used by teachers in schools are still not optimally activating students' cognitive, because teachers still use teacher-centered learning strategies (Wenning, 2005).

It is essential that an innovative learning strategy be devised in order to help pupils develop excellent critical thinking skills. One of the learning strategies that can activate students' physical and thinking skills is an inquiry learning strategy. Because the inquiry

class is a student-centered learning (Duran & Dökme, 2016) facilitate students to be active and collaborative (Kuhlthau et al., 2007) through observation, asking questions, predicting, analyzing, synthesizing, communicating and reflecting (Wale & Bishaw, 2020), constructivist (Topolovčan & Matijević, 2017; Muhammad, 2020) develop metacognition (Magno, 2010; Andriyanto et al., nd), form creative and independent students (Sadeh & Zion, 2009; Chili Trundle et al., 2010), which gives students the opportunity to improve critical thinking skills, and develop the various skills they needed (Duran & Dökme, 2016). Hence, Inquiry is recommended for teaching science (Alberta et al., 2004). There are several studies related to the influence of inquiry learning strategies with critical thinking skills (eg: Taiposri & Wannapiroon, 2015; Kitot et al., 2010; Qing et al., 2010).

There have been numerous research that have explored the association between inquiry learning strategies and critical thinking skills; however, there are still only a handful that have examined the relationship using self-regulated learning (SRL) as the moderating variable.

Inquiry classes can be carried out optimally if students involved in learning have SRL. SRL is the ability of students to plan, control, and reflect on themselves in learning to achieve goals (Pintrich, 2004). SRL also conditioning thoughts, feelings, and actions to achieve goals (Maksum et al., 2021). SRL is very important for students because it can encourage students to learn more deeply and meaningfully (Zimmerman, 2002; Zimmerman, 2002). SRL has a positive effect on one's understanding, and understanding has an effect on critical thinking skills. SRL has a positive effect on critical thinking skills (Winiari & Santyasa, 2019; Sukowati et al., 2020).

II. Research Methods

This research is a quasi-experimental research, involving 128 high school students which divided into four classes. Two classes were given guided inquiry learning, and two classes were given expository learning. This study employed a non-equivalent pretest post-test control group design to examine how the independent variable affected the dependent variable (Tuckman, 1999). The research design used in this study can be seen in Table 1.

Table 1. The 2 x 2 Factorial Design

Independent Variable		Learning Strategy (A)	
		Guided Inquiry (A1)	Conventional (A2)
Moderate Variable	High (B1)	Critical Thinking Skills	Critical Thinking Skills
	Low (B2)	Critical Thinking Skills	Critical Thinking Skills

Operationally, this experimental design model uses a 2x2 factorial experimental design. This design involves a group of research subjects who receive different treatment.

Research variables include independent variables, moderator variables, and dependent variables. As the independent variable is a guided inquiry learning strategy and as a control is a conventional learning strategy (expository). As the moderate variable is SRL, which is classified into 2 dimensions, namely high SRL and low SRL. Meanwhile, the dependent variable is critical thinking skills. The SRL instrument used consisted of three aspects, namely aspects of cognition, motivation and behavior, with a total of 20 items. Scoring uses a Likert scale of 1-5. All test items are valid because all r statistic $> r$ table (0,31) and Reliable ($r > 0,7$). Meanwhile, to measure critical thinking skills using a critical thinking test according to Ennis (1993) which consists of five indicators, namely:

provide simple explanations, creating basic skills, conclude, make advanced explanations and set strategies and tactics, in the physics subject matter of Straight Motion. There are 10 questions in the form of essays, and the score for each item is 10. All items are valid with a value of $r > r(0.31)$ and reliable ($r = 0,75$). The hypothesis test used is a two-way ANOVA with a 5% confidence level.

III. Results and Discussion

3.1 Results

The results of the description analysis of critical thinking skills in terms of learning strategies and SRL are presented in table 2.

Table 2. Description of critical thinking skills based on learning strategies and SRL

	Learning strategies		SRL	
N	Guided inquiry	Expository	High	Low
N	64	64	70	68
Average	79.40	70.01	78.23	60.09
Standard Deviation	7.51	7.23	7.11	7.05

From Table 2, it can be explained that the average score of students' critical thinking skills who learn to use guided inquiry strategies gets a score of 79,40, with $SD = 7,51$, while for conventional learning strategies a score of 70,01 was obtained with an SD of 7,23. These results indicate that the critical thinking skills of students who learn through guided inquiry strategies are higher than conventional learning strategies. These results indicate that descriptively the critical thinking skills of students who study with guided inquiry are relatively better than conventional ones. Furthermore, table 2 also show that the average score of critical thinking skills of students who have a high SLR is 78,23 with $SD = 7,11$ while the low SRL is 60,09 with $SD = 7,05$. This shows that descriptively students with high SRL have better critical thinking skills than those with low SRL. The results of the 2-way analysis of variance are presented in Table 3.

Table 3. 2-way ANOVA test results

Source	sig
SP	0.000
SRL	0.000
SP*SRL	0.034

The results of data analysis using 2-way ANOVA presented in Table 3 can be explained that: 1) on the SP source, the value of $\text{sig} = 0.000$ is obtained. Because $\text{sig} < 0,050$, then H_{01} is rejected, and H_{11} is accepted. This means that there are differences in critical thinking skills between students learning through guided and conventional inquiry learning strategies; 2) on the SRL source, the value of $\text{sig} = 0.000$ is obtained. Because $\text{sig} < 0.050$, then H_{02} is rejected. This means that there is a difference in critical thinking skills between students who have a high SRL and students who have a low SRL; 3) Meanwhile, for the SP*SRL source, the value of $\text{sig} = 0.034$ is obtained. Because $\text{sig} < 0.050$, then H_{03} is rejected. This means that there is an influence between the interaction of inquiry learning strategies with SRL on critical thinking skills.

3.2 Discussion

a. Difference students' critical thinking skills between the use of Guided Inquiry Learning Strategies and Conventional Learning

The results of hypothesis testing indicate that there is a difference critical thinking skills between groups of students who learn by using guided inquiry learning strategies with conventional learning. Meanwhile, when viewed from the average score of critical thinking skills, the average score of students' critical thinking skills who received learning through guided inquiry learning strategies was higher than the average score taught through conventional methods. This means that the critical thinking skills of students who learn using guided inquiry learning strategies are higher than students who learn to use conventional learning strategies.

The findings of this study are relevant to the results of previous studies, such as: students' critical thinking skills taught through inquiry-based learning are higher than traditional teaching methods (Wale & Bishaw, 2020); Inquiry learning strategies affect critical thinking skills (Duran & Dökme, 2016; Taiposri & Wannapiroon, 2015; Prayogi et al., 2018; Masitoh & Ariyanto, 2017; Qing et al., 2010; Kitot et al., 2010). The same thing was conveyed by Alberta (2004), that the inquiry learning strategy is the best learning practice compared to traditional learning to build quantitative skills. This finding also confirms previous research, including: Inquiry-based learning places students as active thinkers to seek relationships between individuals and their environment (Maison et al., 2021), build a dialogical environment (Palupi et al., 2020), broaden student thinking (Maison et al., 2021), create diversity of understanding, and make students more positive, creative and independent. Through inquiry, students can ask complex questions, expand thinking, create diversity and to gain a deeper understanding (Qing et al., 2010)

Compared to learning strategies conventional (expository), inquiry learning is student-centered learning (Randall et al., 2012), which is holistic, facilitating the quality of students' thinking through group discussions (Wenning, 2005), and promote critical thinking skills (Mashaza, 2017). Inquiry-based learning is able to promote students' critical thinking skills because the method is full of students' mental activities such as interpretation, analysis, evaluation, explanation, inference, and self-regulation (Wale & Bishaw, 2020). Further, according to Prince and Felder, inquiry learning is a broader learning than inductive learning, which changes memorization into applying, analyzing, and synthesizing (Randall et al., 2012). Inquiry is a learning strategy that is suitable for 21st century learning (Kuhlthau et al., 2007), which facilitates the diversity of students' backgrounds, intellectual abilities, and learning styles.

Whereas in conventional learning, student participation in learning is very low, because learning is teacher-centered. Students as learning participants are passive, because they only receive information and knowledge from the teacher. The impact is low critical thinking skills.

There are several arguments that can be used as the basis for justification that the critical thinking skills of students who receive inquiry learning are better than conventional learning.

First, The inquiry learning strategy applies the principles of constructivist learning (Allen, 2008), and constructivism learning is proven to promote critical thinking skills (Topolovčan & Matijević, 2017). The results of previous studies show that constructivist learning has an effect on critical thinking skills, for example (Mashaza, 2017; Muhammad, 2020; Allen, 2008; Kwan & Wong, 2015). Inquiry learning strategies are included in constructivist learning, because inquiry learning strategies provide opportunities for students to relate the knowledge they already have with new knowledge by comparing,

connecting, and synthesizing. So that students can compare, relate, analyze, synthesize old knowledge with new ones, higher order thinking activities are needed. The ability to think serves as the basis for constructing knowledge. The constructivist learning approach emphasizes the role of the learner as an active participant in learning (Hoy, 2008). Inquiry as constructivist learning does not only facilitate students to observe or actively participate in learning activities, but requires students to become independent learners (Snowman & Biehler, 2000) in discovering or constructing knowledge (Allen, 2008).

Second, Inquiry is an active learning application, cooperative learning and collaborative learning (Kuhlthau et al., 2007). Inquiry class includes active learning, because inquiry facilitates students to build and develop their own ideas about science, learning by doing, observing, analyzing, inferring and communicating.

A student-centered model of education is the best way to help pupils succeed (Kusumoto, 2018). An active learning environment allows students to achieve better critical thinking skills (Nelson & Crow, 2014; Kim et al., 2013; Kusumoto, 2018). Learners who learn in active learning are not afraid to face tough tasks and will enjoy challenging assignments, and can find deeper connections in various activities (Nelson & Crow, 2014). Inquiry classes facilitate students to develop critical thinking skills, through activities asking questions in an effort to find problems to be studied and making hypotheses as logical temporary conclusions (Epçaçan, 2019).

One of the main characteristics of the application of inquiry learning is the division of small groups, which serve to provide opportunities for students to work together and collaborate to develop students' potential, helping cognitive participation will improve critical thinking skills (Kim et al., 2013)

Inquiry classes also provide opportunities for students to work together and collaborate in a learning community (Kuhlthau et al., 2007; Maison et al., 2021) in each phase of the inquiry. Through collaboration, each student learns from other students in social interactions both within groups and between groups. Students will communicate with each other, exchange ideas and argue about concepts, ideas according to the perspectives of others, in an effort to solve problems (Mutohahari et al., 2021). The process of communicating and exchanging ideas is what will expand students' thinking and promote critical thinking skills, because communication is the main feature for developing critical thinking (Epçaçan, 2019).

Effective learning must occur collaborative learning, namely involving, building and maintaining student learning communities. Through the student community, encourage and provide opportunities for students to find the faults, get feedback, and revise their thinking while learning from others that involved in investigations and cooperative problem solving activities. Moreover, learners will collaborate to create new knowledge while learning as well as how to think critically and creatively through inquiry, reflection, exploration, experimentation, as well as trial and error (Alberta et al., 2004).

Third, Inquiry is learning oriented to the development of metacognition (Kitot et al., 2010). Inquiry is not just getting students to think, but teaching them to think about thinking, not what to think about (Randall et al., 2012), as well as learn how to learn (Kuhlthau, 2010) that is the essence of metacognition. Metacognition has been shown to improve the ability to think critically (Magno, 2010; Samsudin & Hardini, 2019; Moh. et al., 2020).

b. The Influence of SRL on Critical Thinking Skills

According to the findings of hypothesis testing, there are discrepancies in critical thinking skills between students who have high and low SRL levels. The average student has greater critical thinking skills than students with a low SRL, when considered from the perspective of the average student. This shows that the critical thinking skills of students who have a high SRL are better than those with a low SRL. This is in accordance with the results of previous studies that SRL has an effect on critical thinking skills (Raković et al., 2022; Heydarnejad et al., 2021). Critical thinking is a very important part of SRL (Baranovskaya et al., 2018). SRL has a reciprocal relationship with critical thinking skills.

Self-regulated learning is an ability of students to set their learning goals, and then monitor, regulate, and control their cognition, motivation, and behavior, which are guided by learning goals that have been set and contextualized to the environment actively and constructively (Pintrich, 2004).

SRL is one of the important concepts in social learning theory. According to Pintrich (2004) Self Regulated Learning is a way of active student learning individually to achieve academic goals by controlling behavior, motivating their self and using cognitive in learning. SRL focus on the importance of autonomy and responsibility for learning that lies in students (Süer & Altun, 2015)

Students who have a high SRL will be responsible for their learning activities, have autonomy in their learning, design learning goals, control all their learning activities, find solutions to problems that they may face, develop standards for the level of perfection in achieving goals, and evaluate the best way to achieve their goals. High SRL will have an effective and efficient strategy to achieve the goals and several strategies to correct the errors. High SRL also knows their strengths and weaknesses and knows how to use them productively and constructively to achieve goals.

When students set learning goals, monitor, regulate, and control learning activities that include cognition, motivation and behavior, it must be accompanied by logical considerations through self-potential analysis activities, both learning resources, learning environment, or strengths and weaknesses. Therefore, an evaluation is carried out and continued with constructing goals. If this activity is done repeatedly, it will affect critical thinking. Because analysis, evaluation and synthesis are the main features of critical thinking (Lelasari et al., 2021)

There are three elements that create SRL, namely metacognition, motivation and behavior (Panadero, 2017). In the aspect of metacognition, metacognition is knowledge about cognitive processes, as well as efforts to be involved in the process of behaving and thinking so as to improve the learning process. Using cognitive strategies in achieving these goals is a form of critical thinking application (Magno, 2010). Metacognition can be understood as thinking about the content and processes of one's thoughts (Scoot, 2015). Metacognition is a person's ability to regulate themselves, that is to regulate, organize and monitor their own thinking processes, and critical thinking is a product of metacognition (Magno, 2010). Learners who have better metacognition, when learning experiences obstacles, will try to find more productive ones to leave unproductive learning strategies, while students with less metacognitive skills will continue to use the same strategies, even though they ultimately fail (Haeruddin et al., 2020). Obstacles are a means to mature themselves, including adults in thinking. Because with the obstacles, students will do their best to find alternative solutions that requires the ability to think.

The results of several studies show that there is a metacognitive effect on critical thinking skills (Magno, 2010; Heydarnejad et al., 2021; Gaupp et al., 2018; Maksum et al., 2021)

In the aspect of motivation, that motivation plays a role in increasing cognition and learning success (Zimmerman, 2002). Motivation includes the perception of the task, self-efficacy and goal orientation. Self-regulated learners are oriented towards the success of achieving learning goals, therefore they always think positively about the tasks given. If someone experience obstacles in completing a task, with self-efficacy he will look for various alternative solutions, and that requires broad thinking, including critical thinking. When all tasks can be completed properly it will increase self efficacy

Meanwhile, in the behavioral aspect, self-regulated learners will plan, control and evaluate all their behavior, including: learning efforts, time, place, schedule and learning environment including getting help from peers, teachers and others. Self-regulated learners will use their study time as best they can to optimize all their potential to achieve learning goals. Choose a learning environment according to the character of the learning style he has, and also arrange a schedule that is adjusted to the time he has. Efforts to accept potential, choose the appropriate learning environment and match the schedule they have, which certainly require critical, analytical and logical thinking.

c. The Effect of Interaction between Inquiry Learning Strategies and SRL on Critical Thinking Skills

The results of the third hypothesis test, show that there is an interaction effect between inquiry learning strategies and SRL on critical thinking skills. The interactive influence between learning strategies and SRL indicates a synergy between learning strategies, especially inquiry learning and SRL in improving critical thinking skills.

Inquiry learning is an active learning process that requires active and collaborative student participation, both physically and mentally. Inquiry includes a series of activities to formulate questions as the core of the problem, conduct hypotheses, investigate extensively to find evidence, testing the evidence, drawing conclusions, discuss as an effort to communicate learning outcomes and reflect to improve conclusions, so that new meaningful knowledge is obtained. In order for this complex series of activities to be carried out properly, self-regulated learning is needed. Because the inquiry class requires students to be autonomously responsible for planning and evaluating learning to see learning progress, both individually and in the classroom to achieve learning goals (Psycharis et al., 2014). In an inquiry class, students who have a high SRL will think positively, be able to face various learning obstacles they experience, and will look for various alternative solutions, thus presenting deep thoughts.

In line with the SRL, that the application of Inquiry learning in the classroom can help students to be more critical, more creative and more independent (Kuhlthau et al., 2007; Alberta et al., 2004). Cultivating inquiry in classroom learning means cultivating SRL, so that students are able to face various problems in real life, because in Inquiry class requires students to solve problems through investigating activities that increase their skills and knowledge independently (Sukowati et al., 2020).

SRL indispensable in inquiry learning, which means that inquiry learning can run successfully to achieve learning objectives when students have a high SRL. Self-regulated learners can direct students to become independent learners, in an effort to achieve learning goals, namely critical thinking skills and hard work will provide academic success (Heydarnejad et al., 2021). Moreover, SRL emphasizes autonomy and control by the individual, who monitors, directs and regulates every action taken to achieve goals, acquisition of information, broadening of expertise, and self-improvement. (Paris & Paris, 2001).

Learners who have a high SRL will try hard to follow the inquiry procedure, because they have high motivation and willingness. The inquiry learning strategy in each phase requires independent skills, and this can be fulfilled by students who have a high SRL. This is in accordance with what was stated by Paris and Paris (2001) that SRL emphasizes autonomy and control by the individual in expanding skills and self-improvement.

SRL also plays a role in controlling the learning environment, namely optimizing self-control by directing and regulating students' efforts and behavior towards learning objectives. Self-control also plays a role in helping students learn according to what is planned, and stay on the planned path to achieve learning goals, and avoid or minimize obstacles that hinder learning goals (Sukowati et al., 2020). Self regulated learner is not easily discouraged, will endure difficult tasks, is not easily disturbed by an uncomfortable environment, maintains activeness in every phase of inquiry.

SRL also plays a role in activating cognition, behavior, and motivation that are systematically oriented towards achieving goals (Zimmerman, 2000). Learners who have a high SRL will be motivated to achieve learning goals, namely they are willing to repeat physics experiments until clear evidence is found, study the material repeatedly until they understand, clarify and seek answers to any problems that are not yet clear, both with friends in a group. or between groups. In turn, SRL promotes learning and the perception of greater self-competence in maintaining self-regulatory motivation to achieve goals (Pintrich, 2004).

Inquiry learning provides opportunities for students to undergo a proactive process as an important element in learning based on SRL. In addition, inquiry learning also encourages students to modify and construct the required learning process through a facilitator or the teacher. Students who have a high SRL will find it easier to modify and construct learning.

One of the advantages of inquiry learning is the use of heterogeneous groups, meaning that inquiry facilitates the diversity of learners. Inquiry is cooperative learning in which each student must cooperate with his peers to achieve his individual goals. The application of inquiry learning strategies in the classroom allows students to take part in each phase of the entire learning process, and each learner has full responsibility for mastering the material, and ultimately achieving the expected goals. Therefore, students who have a high SRL are better prepared to take part in learning using the inquiry model.

There is a strong synergy between the use of inquiry learning strategies and SRL (Sholikhan et al., 2020), because there are many similarities between the two that mutually reinforce each other in achieving learning objectives, namely critical thinking skills, including: 1) inquiry and SRL are both oriented towards constructivism learning; 2) both activate students' metacognition, which serves to increase students' thinking levels; 3) both are student center, active learning and collaborative learning; 4) both aim to create independent students.

IV. Conclusion

Based on the results of the analysis, it can be concluded: (1) There is a difference in critical thinking skills between the use of inquiry learning strategies and conventional; (2) There is a difference in critical thinking skills between students who have high and low SRL; and (3) There is an interaction between inquiry learning strategies and SRL on critical thinking skills

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