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The Effect of the Guided Inquiry Learning Model with a Scientific Approach to Green Chemistry and Global Warming Material on Students Critical Thinking Ability and Learning Motivation

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Abstract: This research aims to determine the effects of the guided inquiry learning model implemented with a scientific approach simultaneously on students critical thinking abilities and learning motivation. This research is a quasi-experiment with a pretest-posttest control group design. The research was conducted at SMAN 1, Semarang. The research sample consisted of class X students at SMAN 1, Semarang. The sample consisted of a total of 136 students from class X. The sampling technique used was cluster random sampling. The instruments used in this research consisted of a critical thinking ability test in the form of reasoned multiple-choice questions and a learning motivation questionnaire. The analysis technique used involves the use of multivariate statistics, specifically using the Manova test. The results of the research show that there are significant differences in student's critical thinking abilities and learning motivation when implementing the guided inquiry learning model with a scientific approach. In general, the combined effect of the guided inquiry learning model with a scientific approach provides an effective contribution of 30.9% of the variance in critical thinking abilities and learning motivation.

Keywords: Critical thinking; Guided inquiry; Learning motivation; Scientific approach

Introduction

Chemistry is a scientific discipline characterized by its abstract and complex nature, so it requires a comprehensive understanding (Damsi & Suyanto, 2023). Therefore, chemistry is a scientific discipline that requires a substantial capacity for reasoning and understanding, which is closely related to three different dimensions: macroscopic, microscopic, and symbolic. According to Wahyudiati (2022), combining these three elements is very important for understanding chemical ideas in the learning process. According to Salyani et al. (2020), the chemistry learning process follows a methodical organization where simpler ideas are introduced before progressing to more complex ideas.

Chemistry plays an important role in overcoming complex challenges in life. However, it is seen that many students learn chemistry without a genuine desire, which results in a lack of understanding after completing their assignments. According to Sutoyso et al. (2019), it is very important for students to be given active guidance to foster critical thinking during the learning process. This is especially important in the context of chemistry education because the concepts in this discipline are intricately interrelated, as highlighted by Salyani et al. (2020). The capacity for critical thinking requires the skill of evaluating phenomena and arguments thoroughly by utilizing scientific knowledge and factual evidence to ensure the most optimal answer Burhanuddin et al. (2019). The study conducted by Nur'Azizah et al. (2021) explored several dimensions of critical thinking skills, including their potential to facilitate the explanation process, increase basic knowledge, draw conclusions, offer more explanations, and propose methods and practices. Utilization of critical thinking skills has the potential to improve the

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academic performance of students who have problem-solving abilities (Anstine & Isayev, 2023).

The level of student involvement in academic activities appears to be limited due to a teaching approach that is primarily teacher-focused, with student involvement limited to completing assigned student worksheets (LKS). The extent to which learning is in-depth directly correlates with its significance, thereby facilitating students understanding of the subject matter. It is very beneficial for students to be actively involved in the learning process, because this will increase their understanding. However, in practice, teachers take a more prominent role in the learning process by providing knowledge without direct involvement from students. This causes a lack of active participation by students in the learning process, so that the results obtained are less than optimal. The educational curriculum in schools places more emphasis on the acquisition of knowledge and understanding, with limited attention to the development of skills related to application, analysis, synthesis, and evaluation. As a result, this imbalance in educational priorities leads to a lack of motivation among students and a lack of opportunities to engage in critical thinking exercises.

Achieving learning goals can be achieved through developing critical thinking skills, which include certain cognitive abilities demonstrated by students in their critical thinking behavior. According to Sarwinda et al. (2020), The skills in question require students to have better abilities in evaluating and synthesizing, not just being able to apply or analyze. There are several aspects that influence critical thinking abilities, including physical condition, anxiety level, intellectual growth, habits, and motivation (Benyamin et al., 2021).

Motivation is one of the main factors determining the success of students learning processes (Attika Robbi et al., 2020). Motivated students will be involved in the learning process and can maintain engagement without continuous encouragement or direction. Motivation can make students interested in learning and directly participate in internal processes aimed at achieving the desired goals. Motivation for students to pay attention to lessons and study topics to gain a better understanding (Nur'Azizah et al., 2021).

The use of teacher-centered learning approaches has the potential to hinder student engagement and contribute to the development of misunderstandings. Misconceptions refer to wrong understandings that deviate from existing theoretical frameworks (Salyani et al., 2020). This phenomenon occurs because students have an understanding of the information they have obtained, but the conception they hold is not in line with the standards set by scientific research. One aspect that contributes to students limited understanding of chemistry topics is the prevalence of misunderstandings among students. Many students have a mistaken understanding of an accurate understanding of scientific principles.

According to Rokhim et al. (2023), misconceptions have the potential to hinder students progress in classroom learning. Identification of misconceptions in the field of chemistry can be concluded from the less than optimal academic performance shown by students (Hadisaputra et al., 2019) the use of different strategies, such as the implementation of student worksheets, media, or learning models, has been suggested as a way to identify and overcome misconceptions in educational environments (Rokhim et al., 2023; Salyani et al., 2020).

The learning model functions as a conceptual framework that assists educators in the development and implementation of learning strategies aimed at facilitating the acquisition of knowledge, concepts, competencies, and cognitive processes among students (Rusmansyah et al., 2019). This learning approach is designed to increase student engagement, foster an intrinsic desire to learn, foster critical thinking skills, deepen levels of understanding, and stimulate creativity among students. The guided inquiry learning model is a scientifically based strategy that has the potential to improve critical thinking skills and learning motivation in the context of green chemistry and global warming.

The guided inquiry learning model includes many steps, including problem identification, problem formulation, hypothesis formulation, conducting experiments, data processing and analysis, hypothesis testing, and drawing conclusions. According to Mulyana et al. (2018), this particular strategy promotes the engagement of learners and encourages the development and utilization of their talents and competencies. According to research conducted by implementing an inquiry-based learning approach has been proven to improve students critical thinking abilities, resulting in high levels of achievement ranging from 72% to 97%. According to research conducted by Juniar et al. (2022), the use of the guided inquiry learning model has been proven to result in increased learning outcomes and science process abilities among students compared to the use of traditional learning models.

Several research findings indicate deficiencies in understanding and awareness of the application of learning models, critical thinking skills, and learning motivation. This research aims to investigate the impact of the guided inquiry learning model with a scientific approach on students critical thinking abilities and learning motivation.

Method

This research is a quasi-experiment with a non-equivalent pretest-posttest control group research

design. Details regarding this research can be found in Table 1. This research was conducted at SMAN 1, Semarang. Sampling was carried out using the cluster random sampling method from 6 classes, consisting of classes X-8, X-9, X-11, and X-12, with a total of 136 students. This research consisted of two experimental classes and two control classes. The experimental class applies a guided inquiry learning model with a scientific approach, while the control class uses a discovery learning model. The instruments used in this research include multiple choice-based test questions for certain reasons to measure students critical thinking abilities, as well as a questionnaire to assess students learning motivation. This research data analysis uses multivariate statistical analysis techniques with the Manova test.

Table 1. Research Design: Non-Equivalent Group Pretest-Posttest Control Group Design

O_1	X	O_4
O_3		O_5

Information:
O_1 : experimental group before treatment
O_2 : experimental group after treatment
O_3 : control group before treatment
O_4 : control group after treatment
X : treatment (guided inquiry model with a scientific approach)

Result and Discussion

The results of the linearity test can be seen from the Sig value. The deviation from linearity obtained is greater than 0.05, meaning that there is a linear relationship between the variables critical thinking ability and learning motivation in each dependent variable and the independent variable (see Table 2).

Table 2. Linearity Test Results

			Sig.
Groups eks KBK* Groups eks MB	Between Groups	(Combined)	0.405
		Linearity	0.434
		Deviation from linearity	0.388
Groups kontrol KBK* Groups kontrol MB	Between Groups	(Combined)	0.446
		Linearity	0.998
		Deviation from linearity	0.398
Groups kontrol KBK* Groups eks MB	Between Groups	(Combined)	0.502
		Linearity	0.590
		Deviation from linearity	0.469
Groups eks KBK* Groups kontrol MB	Between Groups	(Combined)	0.420
		Linearity	0.020
		Deviation from linearity	0.666

The multicollinearity test results obtained from critical thinking skills and learning motivation obtained a tolerance value of 0.983 (see Table 3), indicating that there is no multicollinearity, because the tolerance value is > 0.01. The VIF value of critical thinking skills and learning motivation is 1.017, indicating that there is no multicollinearity, because the VIF value is <10 (Olejnik & Hubertus, 2006).

Table 3. Multicollinearity Test Results

	Collonieearity Statistic	
	Tolerance	VIF
Critical thinking ability	0.983	1.017
Learning motivation	0.983	1.017

The results of the multivariate analysis indicated that there were significant differences in students critical thinking abilities and learning motivation simultaneously between the experimental class (using a guided inquiry learning model with a scientific approach) and the control class (using a discovery learning model). The significance value is 0.000 < 0.05, and the value of Hotelling's trace and Roy's largest root is 0.448, which results in rejection of H_O, as seen in Table 4.

Table 4. Manova Test Results

	Effect	Value	Partial Eta Square	Sig.	Information
Model	Hotelling's Trace	0.448	0.309	0.000	There are differences and there are effect
	Roy's Largest Root	0.448	0.309	0.000	

The results of the partial eta square test show that the guided inquiry learning model with a scientific approach has an influence of 30.9% on students critical thinking skills and learning motivation on green chemistry and global warming, with a significant value of 0.000 < 0.05. The remaining 69.1% is influenced by other unknown factors. The results of the n-gain analysis of student's critical thinking abilities and learning motivation in the experimental group and control group can be found in Figure 1.

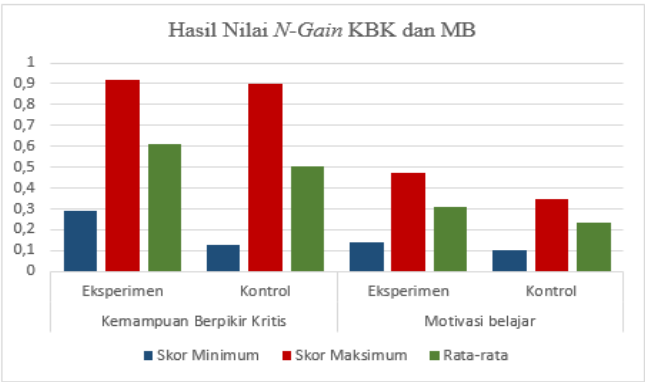

Figure 1. Average n-gain of critical thinking ability and learning motivation

Based on the average n-gain value obtained, it can be seen that the students thinking abilities and learning motivation look different (the experimental class is better than the control class) because the learning model treatment given is different.

Analysis of Differences in Critical Thinking Abilities and Learning Motivation of Students Who Follow the Guided Inquiry Learning Model with a Scientific Approach and the Discovery Learning Model

Assessment of student's critical thinking abilities is carried out by administering a multiple-choice exam consisting of 22 questions. Meanwhile, assessing students learning motivation was carried out using a questionnaire consisting of 24 statement items. The experimental class showed a moderate n-gain value, namely 0.6118 for critical thinking skills and 0.3088 for learning motivation. In contrast, the control class showed a moderate n-gain value of 0.5066 for critical thinking skills and 0.2316 for learning motivation. These findings show that there is a real difference in the pretest and posttest scores related to student's critical thinking abilities and enthusiasm for learning when comparing the application of learning models in the experimental class and the control class.

Markers of critical thinking abilities used include providing brief explanations, developing basic skills, interpreting actions, analyzing processes, assessing practices, and formulating conclusions. The indicators presented in this research come from the works of other experts, including Changwong et al. (2018), Ennis (2011), Facione (2015), and Gupta et al. (2015). The synthesis of these indicators of thinking ability produces several results, including appreciation in the learning process, interesting activities during learning, the ability to persevere in facing tasks, the ability to remain steadfast in the face of difficulties, great interest and attention in learning, the tendency not to get bored easily with routine things, enthusiasm for learning, and a sense of self-confidence (Hamzah, 2011; Sardiman, 2011; Uno, 2015). The learning motivation questionnaire consists of two categories of items: positive statements and negative statements. There are 18 positive statements, while there are 12 negative statements.

The guided inquiry learning model with a scientific approach is thought to be a factor causing differences in students critical thinking abilities and learning motivation. This is due to this model's emphasis on encouraging active student involvement during the learning process, thereby increasing the meaningfulness of the learning experience. The experimental class group of students showed higher average scores in terms of critical thinking abilities and willingness to learn when compared to the control group. These findings indicate that experimental class students have better critical thinking skills and learning motivation compared to the control class.

The guided inquiry learning methodology, which combines a scientific approach, aims to improve students critical thinking skills and learning motivation. Learning activities in the guided inquiry learning approach are designed to place students at the center of learning, thus requiring their active participation. Research findings conducted by Mawardi et al. (2020), show that there are striking differences between students who use the experimental class and the control class. In particular, students in the experimental class, using Learning Tools (LKS), demonstrated the ability to find, analyze and assess information. In the 21st century, students are seen to experience important improvements in their critical thinking abilities, which then contribute to increasing their enthusiasm for learning.

The average pretest score for critical thinking skills among students in the experimental and control groups was 53 and 44 respectively. Likewise, the average post-test score for students in the experimental class and control class was 82 respectively. and 74. These findings indicate that, overall, students in the experimental class demonstrated a higher level of understanding about green chemistry and global warming compared to their peers in the control class. The control class showed difficulty in carrying out certain indicators of critical thinking abilities, including indicators 2 (providing simple explanations), 3 (interpretation), and 4 (analysis). These indicators are proven to have the lowest value compared to other indicators, as can be seen from the results of the posttest assessment. This phenomenon can be attributed to the fact that students tend to only focus on the delivery of lesson material by the teacher, thus seeing the teacher as the only provider of knowledge in the classroom. On average, students who are involved in developing critical thinking skills tend to experience misunderstandings. This error occurs when students choose the correct option but give the wrong reason, or vice versa, when students choose the wrong option but give a valid reason. As a result, the value obtained is not optimal. This phenomenon occurs because there is a mismatch between students understanding of the knowledge they have acquired and the alignment of their conceptual understanding with scientific evaluation. One element that contributes to students limited understanding of chemical ideas, resulting in the formation of misunderstandings among students (Salyani et al., 2020).

This research is in line with the findings of Seranica et al. (2018), which stated that the guided inquiry learning approach had an impact on students critical thinking abilities. This is because the guided inquiry learning model encourages students to be actively

involved in the process of identifying concepts related to environmental phenomena under the guidance of the teacher. The average pretest score of students learning motivation for the experimental class and control class was 65, but the average post-test score for the experimental class and control class was 77 and 75 respectively. The experimental class showed a striking difference in participants' learning motivation. students compared to the control class, it can be seen from the students greater learning motivation values. According to research conducted by Nurlaila et al. (2021), the use of the guided inquiry approach has been proven to increase students learning motivation. This is due to the fact that students can discover and understand their own learning ideas through direct experience.

Analysis of the Effective Contribution of the Guided Inquiry Learning Model with a Scientific Approach and the Discovery Learning Model on Students Critical Thinking Ability and Learning Motivation

This research examines the impact of the guided inquiry learning model with a scientific approach on the development of student's critical thinking skills and learning motivation. The research results show that the application of the guided inquiry learning model with a scientific approach produces a significant influence of 30.9% on critical thinking skills and learning motivation. This phenomenon occurs because of the differences in treatment given to the experimental group and the control group. According to Chusni et al. (2022), the use of the guided inquiry learning model produces a learning process that is inherently interconnected from a scientific point of view. The reason for this phenomenon can be attributed to the increased engagement shown by students when using the guided inquiry learning paradigm in conjunction with a scientific framework. The application of the guided inquiry learning model in experimental classes with a scientific approach includes a series of different stages. These stages include problem formulation through observation, hypothesis formulation through questions, experimental design through questions, carrying out experiments or tasks and collecting data, analyzing and interpreting data, and finally, drawing conclusions and communicating the results. Learning Tools and Program Design (LKPD) for the experimental and control groups were developed for a series of four sessions, each using a different model.

According to research conducted by Ibnusaputra et al. (2023), the application of the guided inquiry learning model with a scientific approach has proven to be very effective in improving students understanding of concepts and critical thinking abilities. The application of the guided inquiry model in education can be improved by incorporating contextual learning, because it functions as a basic framework for fostering scientific thinking and improving students cognitive abilities at a higher level (Wardani & Anggraeni, 2020). According to the findings of Ramandha et al. (2018), the application of the guided inquiry learning approach has shown its efficacy in facilitating students understanding of real ideas and encouraging the development of advanced cognitive processes.

Using a scientific approach in learning involves considering several factors such as students actions, settings, success, and their motivation to learn (Sudria et al., 2018). A study conducted by Dani et al. (2021), provides empirical evidence that supports the efficacy of the guided inquiry learning approach in increasing students willingness to learn and fostering their creativity in the context of the concept of heat and temperature. Therefore, the presence of learning motivation serves as a catalyst to increase student engagement, as it has been established that a strong inclination towards learning results in several benefits for students.

Conclusion

Based on the research results, it can be stated that there are differences in student's critical thinking abilities and learning motivation between the experimental and control classes on green chemistry and global warming. Overall, the guided inquiry learning model with a scientific approach has an influence of 30.9% on student's critical thinking abilities and learning motivation simultaneously.

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Author Contributions
Nur Elisa Hawa T: Conceptualization, validation, writing draft preparation, methodology, data curation, formal analysis, review and editing.

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Conflicts of Interest
The authors declare no conflict of interest.

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