RESEARCH ARTICLE

The inquiry investigation group learning model: Improving students' critical thinking skills, cognitive learning outcomes, and scientific attitudes

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Abstract: Innovative learning is carried out through a combination of the Investigation Group (IG) and Inquiry Strategy (IS) into a modified learning model namely IIG (Inquiry Investigation Group). This study analyzes the effect of the IIG model on critical thinking, cognitive learning outcomes, and scientific attitudes on Class XI High School students in West Seram Regency. The sample was 102 students, and the data was analyzed using inferential statistics namely covariance analysis (ANCOVA). The results show that the IIG model has an effect on critical thinking (0.000<p=0.05), cognitive learning outcomes (0.000<p=0.05), and students' scientific attitudes (0.000<p=0.05). This indicated that IIG consists of learning stages of orientation, conceptualization, investigation, report generation, and discussion-evaluation. The finding of the research recommends the application of the IIG model in learning other biology concepts in high school. In addition, this research can contribute to providing innovation in biology learning in the era of society 5.0.

Keywords: cognitive learning outcomes; critical thinking; inquiry investigation group; scientific attitude

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Introduction

The concept of education in Indonesia is currently undergoing development towards the era of society 5.0. This has an effect on various fields such as health, urban planning, transportation, agriculture, and education (Özdemir, 2018). Therefore, students need several skills namely leadership, digital literacy, communication, emotional intelligence, critical thinking, as well as constructive, innovative, social, and spiritual attitudes (Falaq, 2020; Sajidan et al., 2020; Potočan et al., 2021). Some of these abilities are classified as high-level. The higher order thinking skills (HOTS) use critical, analytical, and creative thinking. It is the ability to master a concept and explain it in different ways, as well as making decisions and solutions to problems (Dewi, 2021; Yonata & H Nasrudin, 2018). Several learning models are used to improve the abilities of students in this era of society 5.0. One of the innovations is collaborating learning models with appropriate strategies, such as the Investigation Group (IG) and the Inquiry strategy (IS) which is known as the Inquiry Investigation Group (IIG) learning model. According to Santyasa et al. (2019), the IG model is oriented to the results of an investigation, analysis, and information synthesis to solve a problem, hence, it is suitable to be used for science learning. Astiti (2018) reported that the use of the IG model combined with brainstorming techniques improved cognitive learning outcomes. According to Komala et al. (2020), the learning model empowers students to solve problems through HOTS. Meanwhile, inquiry learning has been widely used in biology education. The application of inquiry strategies in biology learning in High School can increase students' HOTS (Rahmat & Chanunan, 2018) and improve critical thinking in learning the concept of the plant world (Hasan et al., 2019). The strategies also improve students' achievement with a reflective cognitive learning style (Margunayasa et al., 2019). Presently, the IG model and inquiry strategy have been used in and collaborated with several studies.

Arinda et al. (2019) found that collaborating the IG model with Phet (Physics Education Technology) media could improve students' scientific attitudes. This shows that the IG learning model is suitable to be combined with an inquiry strategy. Listiana et al. (2016) and Listiana et al. (2020) reported that the combination of the GI model with Think Talk Write (GITTW) improved HOST and self-regulation in learning biology concepts. Listiana and Bahri (2019) also reported that the GITTW model increased high school students' thinking in studying biology compared to the TTW model. Ristanto et al., (2018) developed CIRC integrated learning and guided inquiry into a single unit called CIRGI for developing scientific literacy and mastery of biological concepts. Naimnule and Corebima (2018) reported that INREACT (a combination of inquiry and the REACT learning model) improved critical thinking. Ningsih et al. (2022) reported that the GIETAL learning model (the collaboration of Group Investigation with E-Task in Activities Learning) helped the students learn biology during the Covid-19 pandemic. Asyari et al. (2016) reported that PBL and GI collaboration was a learning collaboration that produced stages of planning, argumentation, formulation of questions and problems, as well as analyzing and providing solutions to environmental problems.

In addition, Gunawan et al. (2020) also explained that the inquiry strategy combined with the Advance Organizer could help empower students' higher-order thinking skills in studying biology so that they could find solutions for solving biology in everyday life. Brown (2010) reported that the POGIL (Process-oriented guided-inquiry learning) learning model was able to empower students' critical thinking in studying biology through a series of questions. Ravista et al. (2021) also reported that the use of an electronic module based on an inquiry strategy accompanied by a virtual laboratory could improve students' critical thinking in learning biology. Inquiry strategies could also improve biology learning outcomes through a series of combinations of techniques or methods and modifications. Akanbi and Kolawole (2014) reported that a combination of inquiry and discovery strategies and independent learning techniques could improve students' cognitive learning outcomes so that learning achievement in biology could be efficient. Kencanawati et al. (2021) modified inquiry learning in biology into 7 steps namely analyzing problem, formulating hypotheses, collecting data, comparing communication between groups, making conclusions, communicating results, and reviewing them through critical analysis.

Some studies show that the inquiry strategy is suitable to be used in studying biological concepts in schools to improve critical thinking skills, cognitive learning outcomes, and scientific attitudes. It emphasizes the discovery activities carried out by students, hence, it requires intense activity. According to Matson and Parsons (2006), the inquiry strategy requires the active participation of students in learning. Keys and Bryan (2001) stated that through inquiry activities with discoveries, they were able to develop scientific process skills and improve cognitive learning outcomes effectively. Scientific attitude is a way of behaving in the learning process through experiments that improve thinking skills. Therefore, it affects students' cognitive processes (Ozden & Yenice, 2014; Ilmi & Sunarno, 2020).

Based on previous studies and the explained theory, the IG model focuses on the process of inquiry and student collaboration, while the inquiry strategy focuses on the investigation and activity of students. Therefore, the two can be combined into a single unit called Group Investigation Inquiry Learning or abbreviated as the IIG model. The application of IIG is carried out on class XI students in studying the circulatory system. In this concept, students are invited to conduct constructivist-based investigations to understand the human circulatory system and develop critical thinking skills and scientific attitudes. In addition to having high-level thinking skills, students also need to be equipped with a scientific attitude, indicating the results of their investigations can be scientifically justified. Marlina (2013) found that using the environment as a laboratory shaped scientific attitudes in studying biology. Previous studies found that the environment can be used as an external laboratory to shape scientific attitudes. Students who study the concept of the circulatory system also form a scientific attitude through investigation and discovery. Therefore, this study analyzes the effect of applying the IIG model on the critical thinking, cognitive learning outcomes, and scientific attitudes on Class XI High School students, West Seram Regency.

Results and Discussion

This is a quasi-experimental study, and the independent variables are the IG and IIG learning models, while the dependent variables are critical abilities, cognitive learning outcomes, and scientific attitudes. Furthermore, the design of the study used pre-test and post-test control group design (Table 1). This was conducted in the odd semester of the 2021/2022 academic year.

Table 1. The study design for IIG and IG classes

Pre-test	Group	Post-test
O_1	X_1	O_2
O_1	X_2	O_2

Where: O1 (Pre-test in IIG and IG classes); O2 (Post-test in IIG and IG classes); X1 (Class using the IIG

learning model); X2 (Class using IG learning model).
The population was class X students of SMA Negeri 1 Kairatu, Madrasah Aliyah Al-Ikhlas Kairatu, and Madrasah Aliyah West Seram. The selection of schools uses the technique of drawing school names to get public high schools and private high schools. Furthermore, the sample was students from two classes of the schools. Each class had 17 students, hence, the total number of the sample was 102. Each class only had a small number of students to comply with the COVID-19 protocol. The school allowed face-to-face teaching and learning activities but the attendance of students was limited to a small number.
The study stage began with the following activities: (1) initial test (measuring critical thinking and cognitive learning outcomes), (2) application of the IIG model to class X1 and IG to class X2 (Table 2), and (3) final test (measuring critical thinking and cognitive learning outcomes). The learning material taught was the human circulatory system. Observation sheets were used to measure students' scientific attitudes at the beginning and end of learning.

Table 2. Stages of integration of the IIG learning model

Investigation Group (IG)	Inquiry Strategy (IS)	IIG Learning Model Integration Stages
1. Identifying the topic 2. Planning learning assignments 3. Carrying out investigations 4. Compiling reports 5. Presenting reports 6. Conducting evaluation	1. Orientation 2. Conceptualization 3. Investigation 4. Discussion 5. Conclusion	1. Orientation: organizing students into study groups, identifying topics, formulating titles 2. Conceptualization: formulating questions and hypotheses, seeking information, formulating stages of investigation 3. Investigations 4. The creation of final report 5. Discussion 6. Evaluation

The test instrument of the essay consists of 5 questions that have validity and reliability values as shown in Table 3.

Table 3. Specifications of essay questions equipped with validity and reliability scores

Question Number	Cognitive Level	HOTS/ LOTS	Validity		Reliability	
			Significant	Interpretation	Significant	Interpretation
1	C4	Meets HOTS Criteria	0.750 (*)	Valid	0.945 (*)	Excellent
2	C4		0.147 (*)			
3	C4		0.277(*)			
4a	C4		0.180 (*)			
4b	C4		0.400 (*)			
5a	C5		0.147 (*)			
5b	C5		0.466 (*)			
5c	C5		0.356 (*)			
5d	C5		0.393 (*)			

*) Significance at p ≥ 0.05

The significance value of each question shows p≥0.05, which means that each question has met the criteria of validity and reliability so that it can be used in the learning process.
An essay is used as the instrument to measure critical thinking and cognitive learning outcomes. The two types of instruments have different ratings as seen in Table 4 and Table 5.

Table 4. Description of the assessment of cognitive learning outcomes

Question Number	Score	Description of the assessment of cognitive learning outcomes
1	5	The answer can link the questions of blood group, antigen, and blood cells into a true narrative
2	10	The answer can solve cases about differences in blood groups of pregnant women and fetuses that connect the concept of the circulatory system
3	10	The answer can relate the concept of the circulatory system to hypertensive disorders in patients
4a	10	The answer contains the concept of cause and effect when there is a blood transfusion between different groups
4b	10	The answer contains reasons that are connected with the concept of the

Question Number	Score	Description of the assessment of cognitive learning outcomes
		circulatory system
5a	5	The answer contains an assessment of the case
5b	10	The answer contains an assessment of the case accompanied by the concept of a supportive circulatory system
5c	15	The answer contains suitable criteria to prove the title of the investigation activity
5d	15	The answer contains criteria that are suitable for the process of investigating the circulatory system

Table 5. Description of critical thinking skills

Score	Critical thinking description
5	The answers contain all correct, clear, and specific concepts; the description of the answers is supported by strong and clear arguments; the answers have good and interrelated flow of thinking; the answers are presented with good and correct grammar
4	The answer contains some correct, clear, and less specific concepts; the description of the answers is supported by clear but less specific arguments; the answers have good lines of thinking and some interrelated concepts; the grammar of the answers is good and correct
3	The answers contain a small number of correct and clear concepts; the description of the answers is supported by unclear arguments; the flow of thinking is quite good, with only a small number of related concepts; the answers are delivered with quite good and correct grammar but with some spelling errors
2	The answers contain unclear and dubious concepts; the description of the answers is supported by arguments; the flow of thinking is not good and the concepts are not related to each other; the answers are presented with quite good and correct grammar but with incomplete sentences
1	All answers contain incorrect concepts; the description of the answer does not contain arguments; the flow of thinking is not good; the grammar of the answers is not good
0	No answer or wrong answer

Adapted from the instrument of Zubaidah et al. (2015)

Furthermore, the essay test was developed to measure critical thinking skills and cognitive learning outcomes on the human circulatory system material. Meanwhile, the scientific attitude was developed using indicators to measure students' scientific ability in learning biology as seen in Table 6.

Table 6. Description of students' scientific attitude

Scientific attitude indicator		Rating indicator	Rubric		
			3	2	1
1	Curiosity	1. Students ask the teacher about the topic of identification and the selection of the investigation title 2. Students formulate questions and hypotheses, seek information, and formulate stages of investigation	Students are very enthusiastic	Students are less enthusiastic	Students are not enthusiastic
2	Critical	1. Students critically respond to the findings/investigations of other groups 2. Critical students answer questions from other groups	Students are very critical	Students are less critical	Students are not critical
3	Perseverance	3. Students are diligent in carrying out investigations 4. Students are diligent in presenting the results of the investigation	Students are very diligent	Students are less diligent	Students are not diligent
4	Honest	5. Students report investigative data as is	Students are very honest	Students are less honest	Students are not honest

Scientific attitude indicator		Rating indicator	Rubric		
			3	2	1
5	Open minded	6. Students appreciate a friend's answer	Students really appreciate	Students less appreciate	Students do not appreciate
6	Cooperation	7. Students actively cooperate with other group members in conducting investigations	Students are very active	Students are less active	Students are not active

Adapted from Rumahlatu et al. (2019)

The data analysis was carried out using inferential statistics (ANCOVA) to determine the effect of applying the learning model on critical thinking, cognitive learning outcomes, and students' scientific attitudes. The results of the initial tests of critical thinking and cognitive learning outcomes, as well as the initial observations of scientific attitudes were used as covariates. Before carrying out the inferential analysis, the data were first tested for homogeneity and normality. The homogeneity test used Levene, while the normality used the Kolmogorov-Smirnov test (Table 7). This data analysis technique used an excel application and SPSS for Windows version 18.0.

Table 7. Analysis of normality and homogeneity of the dependent variable

Variable	Significant	Desc.	Significant	Desc.
Cognitive learning outcomes	.756	Homogeneous	.270	Normal
Critical thinking	. 121	Homogeneous	.615	Normal
Scientific Attitude	.479	Homogeneous	.300	Normal

*) Significance at p ≥ 0.05

Each variable has a significance value of p≥0.05, which means that each variable has met the homogeneity and normality criteria so that it can be analyzed using ANCOVA statistics.

Results and Discussion

The influence of the learning model on students' critical thinking

The ANCOVA test showed that the independent variable of the learning model had a significant value of 0.000 <p = 0.05. This means that the learning model has an influence on students' critical thinking in studying the circulatory system as presented in Table 8. To know the differences between the IIG and IG models, a further LSD test was carried out as shown in Table 9.

Table 8. ANCOVA on students' critical thinking skills

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2459.601[a]	2	1229.801	28.945	.000
Intercept	10031.722	1	10031.722	236.111	.000
Critical_thinking_initial	1668.856	1	1668.856	39.279	.000
Learning_model	868.215	1	868.215	20.435	.000*
Error	4206.242	99	42.487		
Total	88776.000	102			
Corrected Total	6665.843	101			

*) Significance at p ≤0.05

Table 9. Further LSD test on students critical thinking skills

Learning model	Mean	LSD Notation
IIG	31.1569	a
IG	25.5882	b

According to Table 9, further test of LSD showed notational differences between grades IIG and IG. This indicates that students who are taught using the IIG model have a higher average value of critical thinking than those taught with IG. Critical thinking is the ability to solve problems using a different way than usual. Persky et al. (2019) explained that the factors influencing these abilities were students' perceptions, metacognitive skills, ways of thinking, automatic thinking skills, and the effort of each

student.

Bezanilla et al. (2019) reported that there was a close relationship between the learning methods used by teachers and students' critical thinking skills. IIG learning is the development of an inquiry-based and constructivist approach which is done by empowering students to investigate problems related to the human circulatory system. This study and discovery activity take place on the topics of the observation of human circulatory system using the torso, blood group analysis in pregnant women, the creation of artificial circulatory system, and the observation of Dengue Hemorrhagic Fever (DHF) patients and those with low and high blood pressure at PUSKESDES. Meanwhile, GI learning is only investigation-based which is oriented to observation topics in IIG class. There are differences between the two classes, in which the IG class does not go through the orientation and conceptualization stages such as the IIG. Research using IG and IIG learning provides opportunities to train and familiarize students with investigation activities directly related to the concept of the circulatory system. However, there is an additional stage in class IIG, a combination of stages of inquiry strategies such as orientation and conceptualization. According to Pedaste et al. (2012), the stages of the inquiry strategy are Orientation and Conceptualization (formulation of the questions and hypotheses), Investigation, Discussion (communication and reflection), and Conclusions. The orientation and conceptualization are part of the constructivist stage. Constructivist learning is the condition of empowering students to develop with teams to find solutions to questions that have been formulated (Khalaf & Zin, 2018). The constructivist basis consists of formulating questions and hypotheses, testing the hypotheses, as well as making and analyzing observations (Pedaste et al., 2012). Therefore, it can be concluded that inquiry and constructivist activities can empower students' critical thinking skills. This is based on the opinion that constructivism enhances the ability to develop ideas and thinking by asking various questions (Topolovčan & Matijević, 2017; Kwan & Wong, 2015; Tunca, 2015; Lunenburg, 2011).

The effect of learning models on cognitive learning outcomes

The ANCOVA test showed that the independent variable of the learning model was significantly 0.000<α=0.05 (Table 10). This means that the learning model influences students' cognitive learning outcomes in studying the circulatory system. The next stage was conducting a further LSD test to determine the differences in the learning model used (Table 11).

Table 10. ANCOVA on cognitive learning outcomes

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	3125.940[a]	2	1562.970	16.813	.000
Intercept	14617.706	1	14617.706	157.244	.000
Cognitive_initial	149.459	1	149.459	1.608	.208
Learning_model	3075.101	1	3075.101	33.079	.000
Error	9203.207	99	92.962		
Total	639937.000	102			
Corrected Total	12329.147	101			

Table 11. Further LSD test on students' cognitive learning outcomes

Learning model	Mean	LSD Notation
IIG	83.8431	a
IG	73.0392	b

The further LSD test in Table 11 showed that there was a notational difference between the IIG and the IG. The classes taught using the IIG learning model have a higher average score than those in the IG. This proves that students who are taught using the IIG have better cognitive learning outcomes. Yulianawati et al. (2021) and Indrawati et al. (2021) also reported the same result that implementing the GI-GI model (Group Investigation Inquiry) would effect cognitive outcomes in learning science concepts. This shows that the combination of both models and strategies can improve students' cognitive outcomes.

The outcomes increase with the application of the IIG model formed through a cognitive way of thinking. According to Redifer et al. (2019), cognitive thinking is referred to as a load that is formed through working memory. Therefore, the combined stages of IIG provide opportunities for students to have time to form cognition. This is carried out through Orientation (organizing students into study groups, identifying topics, and formulating titles) and Conceptualization (formulating questions and hypotheses, seeking information, and formulating investigation stages). Rahayu et al. (2018) developed inquiry learning which showed that each stage could improve cognitive learning outcomes on all biology concepts for junior high school students. Interesting and varied experiences when applying inquiry are

also a factor in improving cognitive learning outcomes (Kwon et al., 2017; Glackin & Harrison, 2017). This was also described by Lachowsky and Murray (2021) and Vlasenko et al. (2020) that inquiry-based learning and discovery based on transformative pedagogy built students' understanding through the way of scientists during the learning process. Through the investigation, they will transform the results into what was learned at the orientation and conceptualization stages.

Af'idayani et al. (2018) explained that discovery-based inquiry learning is based on constructivism theory, hence, students can construct their understanding of the material being studied. Meanwhile, Sudria et al. (2018) clarified that conceptual understanding was formed through a combination of inductive reasoning namely abstract conceptualization, observation, and concrete experience. This is strengthened by deductive reasoning namely verifying and generalizing concepts that have been experienced in the previous stages. This implies that the cognitive outcomes of those who are taught using the IG and IIG models are formed through inductive (investigation and discovery) and deductive reasoning (generalization of the investigation result). However, there are differences between the two learning models. The IIG model has the stages of inquiry learning for conceptualizing concepts through formulation of problem, hypotheses and data collection, and the formulation of the stages of investigation in a sequential step. Meanwhile, in IG, the students directly conduct investigations without undergoing the stages of conceptualizing their way of thinking. According to Alshehri (2016), cognitive thinking is formed through learning models that help improve the way of thinking. Stender et al. (2018) added that the various skills acquired during inquiry learning helped students construct their knowledge.

The influence of the learning model on students' scientific attitudes

The ANCOVA test showed that the independent variable of the learning model had a significance of 0.000 <p=0.05. This means that the learning model has an influence on the scientific attitude of students in studying the circulatory system as shown in Table 12. To know the differences between the two models, the LSD further test was carried out as presented in Table 13.

Table 12. ANCOVA on students' scientific attitude

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	145.957[a]	2	72.979	25.199	.000
Intercept	181.332	1	181.332	62.613	.000
Scientific_attitude_initial	.036	1	.036	.012	.912
Learning_model	144.503	1	144.503	49.896	.000
Error	286.710	99	2.896		
Total	96358.000	102			
Corrected Total	432.667	101			

Table 13. Further LSD test on students' scientific attitude

Learning Model	Mean	LSD Notation
IIG	31.861	a
IG	29.472	b

The LSD test analysis in Table 13 shows that the difference in notation between IIG and IG classes. This indicates that students who are taught using the IIG model have a higher average scientific attitude than those taught using the IG. Astuti et al. (2020) explained that the attitude was an activity to train scientific skills through study activities. This shows that the IIG model empowers scientific attitudes more than the IG for SBB District High School students in studying the circulatory system. Hadiati et al. (2019) also revealed that different learning models affected the attitudes differently because various methods would bring up ways of thinking which affect their attitudes. Alam (2017) described that the attitude of scientific students also had an effect on their success in learning science. Learning with the IIG and IG models can empower students to conduct investigations according to the theme of each group. However, in IIG learning, students are first taught to identify investigative ideas, as well as formulating titles, questions and hypotheses, and stages. The stages in the IIG class are different from the IG which directly conducts investigations. The stages in the IIG can empower students' scientific attitudes better, hence, they can identify investigative ideas, as well as developing curiosity and critical thinking. Nugraha et al. (2020) reported that students' interest in formulating new ideas could improve their attitudes.

To carry out investigative activities, students will develop an attitude of perseverance. To work together in groups, they need to be open-minded and work cooperatively. According to Lacap (2015), those with high scores in openness tend to behave, respect, and listen to other people's ideas well. Also, they accept criticism and are willing to learn and admit new information, while honesty is built during data

reporting on the results of investigations and findings. An attitude of openness is one of the characteristics of a researcher (Mulhall et al., 2017; Salman & Al-Hamidawi, 2022). Honesty is very important for students in learning because it plays a role in their ability to explain concepts using knowledge they have earned through direct observation or theories (Jancirani et al., 2012). The attitude of openness and honesty is interconnected and must be owned by students in empowering their scientific attitude as researchers. Hanifah et al. (2016) stated that scientific attitude referred to activities carried out by students such as scientists. According to Saklressy et al. (2021), the better the learning process and positive responses from students are, the better their scientific attitude is. Furthermore, Sari et al. (2018) showed that scientific attitudes were the basis for students to determine their reactions to environmental conditions. This attitude is one of the factors to manage the way of thinking and behave, hence, it affects cognitive learning outcomes and critical thinking when studying the concept of the human circulatory system.

Conclusion

The results showed that integration of the IIG learning model has an effect on students' critical thinking, cognitive learning outcomes, and scientific attitudes in studying the human circulatory system. The stages in the model can empower critical thinking skills, cognitive learning outcomes, and scientific attitudes. This finding recommends the application of the IIG model in learning other biology concepts in high school. In addition, this research can contribute to teachers in designing innovative biology learning in the era of society 5.0.

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Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

Author Contributions

M. P. and D. R: methodology and analysis; S. I. A. S: review and editing; and K. S: all sections.

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