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Can the Inquiry Learning Model Improve Students' System Thinking Skills?

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ABSTRACT

This study aims to analyze the differences in improving students' systems thinking skills between guided inquiry and structured inquiry learning models. This research is a quasi-experimental research with Nonequivalent Control Group Design. The research subjects were 72 students from a high school in the city of Bandung. The research instrument used was a limited description test made based on indicators of system thinking skills that were measured including examining the components in the system; check the function of each component in the system; analyze the relationship of each component in the system; analyze the relationship between one system and another system; and analyze the balance in the system. The N-Gain test was used to analyze the increase in students' systems thinking skills in both inquiry classes and inferential statistical tests in the form of the Mann-Whitney nonparametric test to determine differences in students' systems thinking abilities in the two inquiry classes. Improving students' systems thinking abilities in the guided inquiry class obtained an N-Gain value of 0.73 with high criteria, while in the structured inquiry class an N-Gain value of 0.56 was obtained with medium criteria. The N Gain value is an indicator analyzing the relationship of each component in the system. Based on the results of inferential statistical analysis, it shows that there are significant differences in students' systems thinking abilities between guided inquiry classes and structured inquiry classes, in which students' systems thinking abilities in guided inquiry classes are better than structured inquiry classes.

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1. INTRODUCTION

So far in Biology learning, the majority of the material studied by students is often taught by teachers as separate topics, causing students to have an understanding of Biology material as topics that are not related to each other (Tripto *et al*., 2013). Indeed, this will be a problem when students only understand abstract and complex Biology material, as if it is separated from one topic to another because the way of thinking used has not maximized students' thinking skills. Thus, students need to have one of the thinking skills in order can think at a higher level to better understand abstract and complex Biology learning, such as systems thinking skills. This system thinking skill can be considered as a set of skills to analyze thoroughly so that it can increase the ability to identify and understand a system, predict system behavior, and design or modify systems to achieve the desired goals. Thinking systems can help students organize their thoughts in a meaningful way and make connections between problems that seem unconnected to be interconnected. This system thinking skill is needed by students because they remember that they need to be able to understand the various components and interactions between components that occur in a system so that students can think systematically about various things, especially the interaction relationships between various components (Nuraeni & Himatul, 2020; Setianingrum, 2022).

Based on the results of interviews conducted with Biology subject teachers and direct observation of Biology learning at one of the Bandung City Public High Schools, several problems were found with students during the learning process. One of the problems experienced by students, namely the lack of familiarity with understanding learning material with a system thinking approach, especially in Biology subjects. This causes students to be less able to fully understand Biology material as a whole so students experience difficulties in connecting between components in a system and knowing the causes and effects that occur in a system. One of the causes of students' lack of skills in systems thinking can be seen when students experience difficulties in working on descriptive questions that are analytical, correlation, and problem-solving after learning activities take place.

Learning will be more meaningful if students are given the freedom to be actively involved in seeking and discovering the concept of a problem that occurs around their environment. This is because, in the 2013 curriculum learning process, it is hoped that it can be held interactively, inspiring, challenging, and motivating students to be able to participate actively, providing sufficient space for students to be able to increase creativity, independence following students' interests, talents, physical and psychological development.

In addition to the problems experienced in learning Biology at one of the Bandung Public High Schools mentioned above, in the Biology learning process students are not given enough freedom to look for procedures and also learn concepts independently so that students are always given directions and instructions for carrying out learning. As a result, the material that students get only comes from educators, which means that students are not actively involved in the learning process that is being carried out.

Based on the problems above, a learning innovation is needed to train and even improve students' systems thinking skills through a learning model/approach that provides personal experience and student freedom through observation, association, asking questions, concluding, and communicating the learning that is being carried out. One learning model that supports students' freedom to be able to learn actively is the inquiry learning model. This is because this inquiry learning model can emphasize students be able to think analytically in finding and finding solutions to the problems faced so that students are expected to be actively involved in the learning process by carrying out scientifically oriented activities which

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will provide the impact on gaining knowledge from learning activities that are not just memorizing (Sulistiyono, 2020).

Inquiry learning models are categorized into three types, namely free inquiry, guided inquiry, and structured inquiry. These three types of inquiry learning models are distinguished by how big the teacher's role and students' freedom are in the process of learning activities (Pramudyawan *et al*., 2020). Each learning model certainly has its advantages and disadvantages, especially in the three types of inquiry learning models.

The structured inquiry learning model has drawbacks, such as the lack of student independence in the learning process. This is because, in the structured inquiry learning model, students are only given the freedom to seek results from the inquiry process, while it is the teacher's procedures and concepts in the inquiry process that provide them to students. The disadvantages of using a structured inquiry learning model can be overcome by using a guided inquiry learning model. This relates to the guided inquiry learning model which gives students the freedom and independence to seek their experimental procedures to obtain results in the inquiry process (Sari *et al*., 2020). Thus, in this study two different models of inquiry learning were used, namely guided inquiry and structured inquiry to find out the differences and also the effect of the two learning models on students' systems thinking skills.

The use of these two inquiry learning models will be carried out on excretory system material combined with indicators of systems thinking skills. This is because the excretory system is one of the Biology materials that is difficult for students to learn and understand. After all, it is very abstract and complex (Alberida, 2016). This excretory system discusses the process of removing metabolic waste substances that are no longer needed by the body, in the form of toxic compounds. So, if it is not removed from the body, it will disrupt the function of the organs in the body (Tresnawati *et al.*, 2019).

Based on the problems and solutions described above, this research has an update in measuring one of the higher-order thinking skills, namely systems thinking skills using the inquiry learning model. This is because until now the majority of research has focused on critical thinking skills using various learning models. The formulation of the problem in this study is whether there is a difference in improving students' systems thinking skills between classes using guided inquiry and structured inquiry learning models.

2. THEORETICAL FRAMEWORK

2.1. Inquiry learning model

The inquiry learning model is a series of learning activities that emphasize students in the learning process by thinking individually and using their knowledge to seek and find their answers to a problem. According to Alberta (2004), he explained that the inquiry model can make students the center of learning and the teacher acts as a facilitator and plays an important role in designing student learning experiences. Inquiry learning models are categorized into three types, namely free inquiry, guided inquiry, and structured inquiry. These three types of inquiry learning models are distinguished by how big the role of the teacher and the freedom of students is in the process of learning activities (Pramudyawan *et al*., 2020).

The explanation of the differences between the three types of inquiry learning models is as follows (1) free inquiry, in this inquiry students are actively involved in all stages of learning, including providing problems, determining tools and materials, designing procedures, communicating results independently and the role of the teacher only as a facilitator. This

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inquiry is similar to how researchers work, the learning cycle in this inquiry places more emphasis on students finding new concepts, then the teacher gives a formal answer to the name of the concept, and students apply the concept in a different context. (2) guided inquiry, in learning activities the teacher only provides problems to be investigated by students, while the formulation of the investigation problem, tools, and materials as well as the design of the student's own investigation procedures design and prepare it. The teacher's role in this inquiry is as a facilitator and guide to provide directions/instructions. (3) structured inquiry, in learning activities the teacher provides the formulation of investigation problems, materials, and procedures, while the results are sought by the students themselves so that the teacher's role in this inquiry is more in the learning process (Fuad, 2017; Handriani *et al*., 2015).

In this research, two different inquiry learning models were used, namely guided inquiry and structured inquiry to find out the differences and also the influence of the two learning models on student's KBS.

2.2. System thinking skills

This system thinking skill can be considered as a set of skills to analyze thoroughly so that it can increase the ability to identify and understand a system, predict system behavior, and design or modify systems to achieve the desired goals. Thinking systems can help students organize their thoughts in a meaningful way and make connections between problems that seem unconnected to be interconnected. In learning Biology, this system thinking skill is very much needed by students. This is because students are always emphasized to understand the concept of Biology learning material which is very complex and abstract. Of course, in studying Biology, many concepts in Biology material are related to one another and there are many causal concepts, especially in the material on cycles and organ systems (Nuraeni & Himatul, 2020).

These systems thinking skills can help develop students' understanding of highly volatile living systems. This thinking skill is needed in a lesson because remembering the provision of knowledge in schools still focuses on separate facts rather than concepts that are related to each other and process from time to time. System thinking skills will help students make decisions so they can reduce or even avoid mistakes because thinking in this system can help students make holistic decisions by looking at the impact of decisions or problems in other fields. This system thinking skill is needed by students because they remember that they need to be able to understand the various components and interactions between components that occur in a system so that students can think systematically about various things, especially the interaction relationships between various components (Nuraeni & Himatul, 2020; Setianingrum, 2022).

2.3. Excretory system material

This research will be carried out on excretory system material combined with system thinking skill indicators. This is because the excretory system is one of the Biology materials that is difficult for students to learn and understand. After all, it is very abstract and complex (Alberida, 2016). This excretory system discusses the process of removing metabolic waste substances that are no longer needed by the body, in the form of toxic compounds. So, if it is not removed from the body, it will disrupt the function of the organs in the body (Tresnawati *et al*., 2019). In line with the description above, this excretory system is felt to be very important to be studied by students, considering that the excretory system itself discusses the processes that occur in the human body, discusses interrelated components in the

DOI:
p- ISSN 2828-3287 e- ISSN 2828-3295

system, and discusses the causes and effects that occur in disorders/abnormalities that occur in the system in this material will be discussed concepts that are interconnected and closely related in everyday life. It is hoped that the use of this excretory system material can invite students to be able to train and even improve student's system thinking skills, especially in cycle material and organ systems.

The sub-materials that will be studied by students in this study include; (1) the organs and functions of the excretory system, including the kidneys which function in the process of forming and excreting urine, the liver which functions in the detoxification of poisons, and the remodeling of old/damaged red blood cells, the skin which functions in the process of forming and secreting sweat, and the lungs -lungs that function in the process of removing carbon dioxide and water vapor; (2) processes in the excretory system, including the process of forming and excreting urine, the process of overhauling old/damaged red blood cells, the process of forming and releasing sweat, and the process of removing carbon dioxide and water vapor; and (3) disorders/abnormalities in the excretory system; include: nephritis, kidney stones, albuminuria, acne, eczema, skin cancer, cirrhosis of the liver, hemochromatosis, bronchitis, pleuritis, tuberculosis, and other disorders of the excretory system.

3. RESEARCH METHODOLOGY

The type of research used in this study, namely quasi-experiments (like an experiment) with research design Nonequivalent Control Group Design, where the two experimental classes were not randomly selected when they were given treatment. In this study, no group acted as the control class, both groups acted as the experimental class which were given two different treatments. The variables in this study include independent variables, namely guided inquiry and structured inquiry learning models; and the dependent variable, namely students' systems thinking skills.

This research was conducted at one of the Bandung City State Senior High Schools for the 2022/2023 academic year. The population in this study, namely all class XI MIPA consists of seven classes of study groups with a total of 252 students. As for the sample in this study, namely class XI MIPA 2 and XI MIPA 3 as many as 72 students whose selection used the purposive sampling. In this case, the determination of the research sample to be used was chosen based on the student's abilities which were equivalent between the two experimental classes.

The data collection technique used in this study was a test technique in the form of a question instrument pre-test and post-test limited description of 15 questions based on indicators of system thinking skills, including (1) examining the components of the system; (2) examine the function of each component in the system; (3) analyze the relationship of each component in the system; (4) analyze the relationship between the system and other systems; and (5) analyze the balance in the system.

The data analysis technique in this study was the N-Gain test to find out the increase in students' systems thinking skills in both experimental classes and inferential analysis in the form of tests Mann-Whitney which is used to analyze the differences in system thinking skills in the two experimental classes, where before the inferential analysis is carried out other test stages, such as the normality test and homogeneity test as prerequisite tests for conducting inferential statistical tests in testing hypotheses.

DOI:
p- ISSN 2828-3287 e- ISSN 2828-3295

4. RESULTS AND DISCUSSION

4.1. Results of Improved Systems Thinking Skills (KBS)

The results of the descriptive value analysis of pre-test, post-test, and N-Gain in the two experimental classes, namely classes that use the guided inquiry learning model (experimental class 1) and structured inquiry (experimental class 2) in class XI MIPA 2 and XI MIPA 3 at one of the State Senior High Schools in Bandung City described in **Table 1**.

Based on the analysis of the data in **Table 1**, shows that initial knowledge and understanding obtained from values of pre-test in both experimental classes can be classified in the low category, where the average value in the experimental class I obtained was 22.172 while in the experimental class II was 17.422. Other different results can be seen in the value post-test between the two experimental classes, where the average value in the experimental class I was obtained at 79.267 while in the experimental class II was 63.286.

Table 1 also shows the results of the N-Gain test analysis to determine the magnitude of the increase in students' systems thinking skills in the two experimental classes. The N-Gain value in the experimental class I was 0.7399 with high criteria, while in the experimental class II, it was 0.5647 with moderate criteria. Thus, it can be said that the N-Gain value in experimental class I is higher than that in experimental class II, so it can be concluded that the guided inquiry learning model is better at improving students' systems thinking skills compared to structured inquiry learning models. Following Kuhlthau (2010) which states that guided inquiry can provide important treatment, there is a critical attitude of students in the investigation process. This can foster students' motivation in seeking answers to the questions they face, such as in the abstract and complex concept of Biology learning (Kuhlthau, 2010).

Table 1. Result description pre-test, post-test, and N-gain guided inquiry and structured inquiry classes.

Descriptive Statistics	Pre-test		Post-test		N-Gain	
	Experiment I – Guided Inquiry	Experiment II - Structured Inquiry	Experiment I – Guided Inquiry	Experiment II - Structured Inquiry	Experiment I – Guided Inquiry	Experiment II - Structured Inquiry
Minimum	6.60000	4.40000	53.30000	26.60000	0.40000	0.23000
Maximum	42.20000	42.20000	97.70000	86.60000	0.97000	0.82000
Mean	22.17200	17.42200	79.26700	63.28600	0.73990	0.56470
Standard Deviation	8.40290	10.11640	11.15340	17.55960	0.12799	0.17638

Based on **Table 2**, the results of improving students' systems thinking skills were obtained based on the N-Gain value per indicator of systems thinking skills in the two experimental classes. In the two experimental classes, the strongest indicator experienced an increase, which was found in the indicator analyzing the relationship of each component in the system. However, the two experimental classes had different criteria, the experimental class I had high criteria, while the experimental class II had medium criteria. In the experimental class I, three indicators were obtained that had high criteria and two indicators had moderate criteria in improving systems thinking skills (KBS). In experimental class II, all indicators have moderate criteria for improving systems thinking skills.

DOI:
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Table 2. Results of N-Gain scores per indicator of systems thinking skills in guided inquiry and structured inquiry classes.

Indicator of Systems Thinking Skills	Experiment I – Guided Inquiry		Experiment II - Structured Inquiry	
	N-Gain Score	Criteria	N-Gain Score	Criteria
Examine the components in the system	0.67	Moderate	0.51	Moderate
Examine the function of each component in the system	0.69	Moderate	0.59	Moderate
Analyze the relationship of each component in the system	0.78	High	0.58	Moderate
Analyze the relationship between the system and other systems	0.75	High	0.52	Moderate
Analyze the balance in the system	0.72	High	0.57	Moderate

Differences in improving students' systems thinking skills in the two experimental classes can be seen in the implementation of teacher and student activities during learning activities. The following describes the results of the observational analysis of the implementation of teacher and student activities in both classes of classical inquiry learning models in **Table 3**.

Based on **Table 3**, the implementation of teacher activities in both classes of the inquiry learning model obtained the same average score, which was 92.7% with very good criteria. However, the scores obtained at each meeting in the two classes of inquiry learning models obtained different scores. Based on the average score average on the implementation of student activities, the guided inquiry class has a higher score than the structured inquiry class. This is because in the guided inquiry class students act actively during learning activities, especially when designing and conducting experiments/investigations. They act actively because they feel they have the opportunity to pretend to be a scientist in solving problems through investigation. The implementation of student activities in the guided inquiry class obtained an average score of 87,3% with very good criteria and the structured inquiry class obtained an average score of 81,5% with very good criteria. Overall, the scores for the implementation of teacher and student activities at each meeting in both classes of the inquiry learning model had very good criteria.

Table 3. The achievement of the implementation of teacher and student activities in guided inquiry and structured inquiry classes.

Meeting	Achievement of Guided Inquiry Class (%)		Achievement of Structured Inquiry Class (%)	
	Teacher	Student	Teacher	Student
1	91.3 (Very good)	83.7 (Very good)	100 (Very good)	90.2 (Very good)
2	91.3 (Very good)	90.2 (Very good)	86.9 (Very good)	84.8 (Very good)
3	95.6 (Very good)	88.0 (Very good)	91.3 (Very good)	81.5 (Very Good)
Mean	**92.7 (Very good)**	**87.3 (Very good)**	**92.7 (Very good)**	**81.5 (Very good)**

This is following Erikko (2018) which states that the guided inquiry method can provide opportunities for students to solve problems given by the teacher. So that students can experience themselves participating in the learning process, even students are required to analyze, prove, and draw their conclusions regarding a concept of learning material that they

DOI:
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have obtained. Thus, students will be motivated to be more confident in the learning process and can improve student learning outcomes (Erikko *et al*., 2018).

4.2. Inferential analysis results

To analyze the comparisons/differences between guided inquiry and structured inquiry learning models on students' systems thinking skills, an inferential analysis test was used in the form of parametric or non-parametric statistical tests. Therefore, this inferential analysis can be said as a way to test the research hypothesis. In parametric or non-parametric statistical tests, prerequisite tests are first carried out in the form of normality and homogeneity tests. Furthermore, after the prerequisite test is carried out, a statistical test can be determined to test the hypothesis to be used.

This normality test was carried out to find out whether the data obtained came from a normally distributed population or not. The homogeneity test is used to find out which groups are being compared and which have a homogeneous variance. Parametric or non-parametric statistical tests were carried out to test the hypothesis used to test whether there were significant differences in the improvement of students' systems thinking skills between classes using the guided inquiry learning model and classes using the structured inquiry learning model.

In this study, normality tests, homogeneity tests, and parametric or non-parametric statistical tests were carried out using the SPSS version 26 program. The results of the inferential analysis of students' systems thinking skills in classes using guided inquiry and structured inquiry learning models can be seen in **Table 4**.

Based on Table 4, it was found that the Asymp.sig (2-tailed) normality test of students' systems thinking skills in each experimental class was different. In the guided inquiry class, a significance value was obtained that was greater than the significance level of 0.05 so that it could be concluded that the result data post-test tested normal distribution. In the structured inquiry class, a significance value was obtained that was smaller than the 0.05 significance level so that it could be concluded that the result data post-test tested is not normally distributed. The significance value of the homogeneity test of students' systems thinking skills in each experimental class obtained a significance value that was smaller than the significance level of 0.05. Thus, it can be concluded that the data results post-test in both experimental classes are not homogeneous.

Table 4. Results of Hypothesis Testing Analysis of Students' Systems Thinking Skills in the Two Experimental Classes.

Guided Inquiry Normality Test		**Structured Inquiry Normality Test**		**Homogeneity Test**		***Mann-Whitney* Test**	
Asymp.sig (2-tailed)	**Ket**	**Asymp.sig (2-tailed)**	**Ket**	**Sig**	**Ket**	**Sig**	**Ket**
0.145	Normal	0.005	No normal	0.003	No homogeneous	0.000	Reject H0

Based on the results of the analysis of normality and homogeneity tests, it was found that one of the data populations was not normally distributed. Therefore, a hypothesis test is used in the form of a non-parametric statistical test, namely a test Mann-Whitney. Test Mann-Whitney intended to determine the effect of a treatment given to the two different research classes. In **Table 4**, the significance value of the test is obtained from Mann-Whitney which is smaller than the significance level of 0.05. Thus, this shows that there are significant

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differences in students' systems thinking skills in classes that use guided inquiry learning models and structured inquiry on excretory system material.

Differences in systems thinking skills can also occur because, in structured inquiry classes, the process and learning materials have been provided by the teacher from the start so that students do not gain the ability to think broadly. This is because, in the structured inquiry learning model, students only follow all predetermined procedures and conclude only the results of their investigations, including a series of experimental/investigative activities. In structured inquiry students follow all the stages of a predetermined procedure, including in designing experiments/ investigations to investigate the problem at hand. In this case, students will not gain the ability to think independently because in structured inquiry the questions and the trial/investigation process are known beforehand.

In contrast, guided inquiry requires students to be more active in learning activities, such as designing their own experimental/investigation procedures to be carried out so that students are more required to think critically and think broadly. This is in line with Tewa's research (2018) which states that in the guided inquiry learning model, students are accustomed to working hard to gain knowledge. In learning activities, students use their reasoning abilities to think critically in understanding the directions given by the teacher so that students can understand the problems faced, collect as much information as possible, and in groups students discuss to analyze data and draw conclusions.

5. CONCLUSION

Based on the results of the research and discussion above, it can be concluded that there are significant differences in students' systems thinking skills in classes using guided inquiry and structured inquiry learning models on excretory system material. In addition, the results showed that the value of increasing system thinking skills (students in the guided inquiry class was higher than structured inquiry, so it can be said that the guided inquiry learning model is better at improving students' systems thinking skills than the structured inquiry learning model.

6. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. Authors confirmed that the paper was free of plagiarism.

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