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Analysis of Science Generic Skills in Animal Respiration Practicum: Is it Improved Through Guided Inquiry-based Learning?

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abstract

Practicum not only advanced skills to use the practicum tools, but also basic skills, known as science generic skills, which emphasize students' ability to understand, identify, and solve presented problems. This study aims to analyze students' activities in animal respiration practicum, investigate their generic science skills after conducting the animal respiration practicum, and describe their responses to guided inquiry-based animal respiration practicum. This study employed the pretest-posttest control group designs. The data were collected using tests, observations, and questionnaires. Afterward, the collected data were analyzed using descriptive qualitative analysis. The results showed that the students' generic skills in guided inquiry-based animal respiration practicum are categorized as high shown in their learning activities. The students who apply the inquiry model and students who apply the conventional model have significantly different improvements in generic science skills. Moreover, the students very positively respond to the guided inquiry-based animal respiration practicum. This study concludes that the practicum has allowed students to understand the actual learning process.

1. Introduction

A laboratory is pivotal for education because it can support the teaching and learning process. Practicum activities require advanced and basic skills in using practicum tools. The basic skills that should be developed are generic science skills (Muspiroh, 2012; Agustina et al., 2016), which comprise basic abilities that everyone should possess. In particular, learning biology requires strong reasoning and basic skills. However, several studies have revealed that students still have low reasoning abilities as shown by their answers to essay questions. Most of the students are less able to explain questions using pictures, cannot provide logical arguments to solve questions, insignificantly analyze and solve problems, and inaccurately draw conclusions, especially when proving a theorem (Apriani et al., 2020).

Generic science skills refer to skills applicable to learning various concepts and solving various scientific problems. Moreover, generic skills refer to basic skills, thinking skills, and acting skills. To understand general abstract concepts, high reasoning abilities are needed (Agustina et al.,

2016). Generic science skills are needed to train students, especially in biology subjects. The lack of conducting experiments or practicum on materials will less significantly optimize the students' mindset to act (Risna et al., 2017). Generic science skills are critical for students because these skills could help them develop their careers based on their respective fields. Generic science skills are not acquired suddenly but must be trained so that these skills will continuously improve. Moreover, generic science skills are generally used for various scientific works and can underlie the establishment of laboratory activities (Agustina et al., 2016).

Biology is frequently associated with a rote science. As a result, students are less motivated to learn this subject more deeply and less actively participate in each learning activity to understand the concepts of learning material. It is no wonder that the concepts of learning material are still non-optimally understood and students' learning outcomes are still low. To prevent these negative impacts, various efforts should be made; one of which is to determine a learning method that actively involves students in learning activities. In this case, this research employed the guided-inquiry method to improve students' material connection abilities. Marheni and Suardana (2014) argue that the guided-inquiry learning model can improve students' self-concepts, scientific attitudes, and learning outcomes as well as improve their ability to integrate knowledge with daily life.

The objectives of the animal respiration practicum require the availability of a laboratory and the ability of generic sciences because this ability is generally applied in various scientific works and underly the implementation of laboratory activities. Science learning, especially biology learning at schools, should not be theoretical but must involve practicum and correlate the learning with natural phenomena; as a result, the students can apply what they have learned (Kusuma et al., 2015). On the other hand, a teacher must always design activities that refer to finding concepts when teaching any material. Therefore, a learning model that can facilitate students to collect and analyze data and can motivate them to learn biology is highly necessary. Piaget-inquiry defines a guided inquiry-based approach in a learning process as a learning atmosphere that enables students to freely conduct their experiments (Saliman, 2009; Anam, 2017).

Guided inquiry learning is crucial because it can train students to learn independently so that they do not depend on the teacher as the only source of learning. Moreover, guided inquiry learning maximally involves students' overall abilities to search and investigate materials so that they can formulate their findings confidently. Students' involvement in the learning process is an important part of developing their abilities (Anam, 2017). As a result, they can design their observation and develop tools, materials, and procedures for inquiry learning (Sahrir, 2019). These activities could increase students' generic science skills.

The guided inquiry-based learning process primarily emphasizes students' ability to understand and identify a problem carefully and thoroughly and finally provide answers or solutions to the presented problems. Triani (2013) has discovered that the guided inquiry learning model significantly improves students' generic science skills. Herpi (2017) deploys that students' achievement of generic science skills is categorized as high. Agustina et al. (2016) assessed students' generic science skills of each component and revealed that the students' generic science skills are categorized as high. The most appropriate practicum method is used to realize guided inquiry-based learning. Practicum activities require various types of facilities and infrastructure as well as teachers' skills to apply theories taught to students.

The observations and interviews of this research have revealed that schools with laboratory facilities still non-optimally utilize these facilities, tests of generic science ability have never been

implemented at schools, and students have not been used to using laboratory equipment to solve problems. As a result, they frequently fail to formulate conclusions from the practicum results and cannot define the concepts, theories, principles, and rules that underlie the practicum at a laboratory. The results of the research show that generic science skills still need to be improved (Nastiti et al., 2018; Pujiani et al., 2022, Doyan et al., 2022). Generic science skills need to be trained in students in biology lessons (Haviz et al., 2018). This study aims to analyze the activities of class XI MIPA students when conducting a guided inquiry-based animal respiration practicum, investigate the students' generic science skills after conducting the guided inquiry-based animal respiration practicum, and describe the students' responses to guided inquiry-based animal respiration practicum.

2. Methods

The study employed a descriptive quantitative method. This method analyzes data by factually describing the collected data (Sugiyono, 2015). The population of this study was students of class XI MIPA (a science class) at SMAN 1 Sukahaji (a public senior high school) in the academic year 2021/2022. Meanwhile, the research samples were students of XI MIPA 1 and XI MIPA 2. The research designs of this study were the pretest-posttest control group designs. The data collection techniques were observation sheets, tests, and questionnaires. This study employed ten indicators of generic science skills (Sudarmin, 2012). The first was direct observation to observe objects directly using the five senses. The second was an indirect observation to utilize measuring instruments as sensory aids. The third was awareness of scale to understand the scale or size correctly. The fourth was a symbolic language to understand the meaning of symbols in science. The fifth was a logical frame to find regular patterns of a natural phenomenon/event. The sixth was logical consistency to discover the regularity of certain properties and state the truth of a theory. The seventh was causal laws to estimate the causes and effects of natural phenomena or events. The eighth was modeling to explain certain phenomena using pictures, graphics, and other models. The ninth was a logical inference to conclude a symptom or event by referring to previous rules or laws. The tenth was an abstraction to describe and analogize an abstract concept or event into a real form in daily life. The concept applied in the learning of this research was practicum on the respiration of class Insecta of grasshoppers and crickets.

The research was conducted at SMAN 1 Sukahaji, Majalengka Regency from February to March in the even semester of the academic year 2021/2022. The population of this study was students of class XI MIPA at SMAN 1 Sukahaji in the academic year 2021/2022. Meanwhile, the research samples were students of XI MIPA 1 and XI MIPA 2. These samples were selected using the purposive sampling technique. Moreover, this study employed the pretest-posttest control group designs. Data collection techniques were observation sheets, tests, and questionnaires. The instruments were validated using expert judgment. After the data had been collected, the students' generic science skills activities in guided inquiry-based animal respiration practicum were analyzed using descriptive qualitative analysis. The student's learning outcomes and increased understanding were interpreted using the normalized gain (Hake, 1999). The normalized gain categories; $0.00 < \text{N-Gain} < 0.30$ (Low), $0.30 \leq \text{N-Gain} \leq 0.70$ (Moderate), $\text{N-Gain} > 0.70$ (High).

3. Results and Discussion

Students' activities in guided inquiry-based animal respiration practicum

The students' generic scientific abilities are shown in their learning activities during the practicum. Suwarna (2018) explains that generic skills are the result of intellectual abilities combined with psychomotor skills to produce attitudes that will stick throughout life. Generic scientific abilities are developed from process skills by combining skills with natural phenomena learned in science. Therefore, a learning process is necessary to combine knowledge and the actual situation in the field when learning science, especially biology. Generic science skills in biology learning are shown in Table 1.

Table 1. Percentages of students' activities

No	Indicators of generic science skills of students	Percentages	Categories
1	Direct observations	100%	Very high
2	Indirect observations	100%	Very high
3	Awareness of scales	100%	Very high
4	Symbolic languages	100%	Very high
5	Logical frames	75%	High
6	Logical consistency	87.5%	High
7	Laws of causes and effects	70.3%	Moderate
8	Modeling	95.3%	Very high
9	Logical inference	92.2%	Very high
10	Abstraction	34.4%	Low
	Average	85.47%	High

The analysis of generic science skills of class XI MIPA students when conducting guided inquiry-based animal respiration practicum at SMAN 1 Sukahaji has revealed that the average percentage of students' generic science skills is 85.47% and is categorized as high. This study has revealed that the students' activities are categorized as good because they understand the learning activities when conducting a series of guided inquiry-based animal respiration practicum which are modified with indicators of generic scientific abilities. These learning activities give students the impression of a real experience because they can solve problems through an investigation that considers the students' abilities and efforts. Moreover, students' active and personal engagement in a learning process enables them to gain more experiences than material or concept learning (Siregar, 2017). Choiriyanti (2018) has revealed that the learning process must be able to provide a truly meaningful learning experience for students so that they master materials with good eternity, not temporary and quickly forgotten materials.

The researchers measured ten indicators of the students' generic science skills, namely direct observation, indirect observation, awareness of scales, symbolic languages, logical frames, logical consistency, laws of causes and effects, modeling, logical inferences, and abstraction. Direct observation provides knowledge about objects based on the objects' respective circumstances (Anggraini & Somawati, 2018). This study has revealed that the students' direct observation has a percentage of 100%. This score is categorized as very high because the learning process using guided inquiry has developed the students' direct observation skills, namely at the stage of data collection.

Direct and indirect observations constitute indicators of generic science skills that are easily memorized and developed by the students. This finding is supported by Herpi (2017) who has revealed that the students show the highest score of the indicator of direct observation among the indicators of generic science skills. In addition, Pilia (2020) states that the students have the

highest percentages of direct and indirect observations to master generic science skills. Similar to direct observations that are continuously developed for students, indirect observations should be developed due to limited human senses. Class learning should be conducted using a guided inquiry learning model, and the students should be trained to perform indirect observations through practicum activities. Meanwhile, the indirect observation indicator has obtained a percentage of 100%; this score is categorized as very high. This finding is supported by Darmawan (2013) who states that the use of sensory aids produces experimental data and facts in experimental activities of the guided inquiry learning model; as a result, these activities run well, the students can understand the concepts learned, and their indirect observation indicator improves.

The indicator of awareness of scale refers to a skill to master a high sensitivity to a numerical scale as the microscopic and macroscopic scales (Sudarmin, 2012). Wijaya and Darmayanti (2019) argue that teachers should build students' awareness of scales by assigning them to compare different aspects. Meanwhile, the indicator of the awareness of scale has obtained a percentage of 100%; this score is categorized as very high. The guided inquiry learning model facilitates the students to train their generic science skill of awareness of the scale because this learning model enables the students to design practicum as well as prepare tools and practicum materials. As a result, the students could increase their sensitivity to numerical scales as a respirometer scale measurement. This finding is supported by Sudarmin (2012) who postulates that scaling skills, such as measuring solvent volumes and weighing solutes using measuring instruments, can be developed during practicum through solution-making activities.

Meanwhile, the students' generic science skill of symbolic languages is supported through guided inquiry-based student worksheets. The generic skill of symbolic language science refers to the use of mathematical rules to solve chemical problems or natural phenomena (Sudarmin, 2012). Meanwhile, the indicator of the awareness of scale has obtained a percentage of 100%; this score is categorized as very high. This occurs because the guided inquiry learning model allows the students to formulate what problems they want to learn; as a result, the learning materials follow their curiosity. Afterward, this learning model let the students propose a hypothesis on the formulated problem. Knowledge is developed through a scientific research process and is acquired through individual experience (Mo'tasim, 2017), and students have good generic symbolic language skills (Yulianti, 2016).

The indicator of the logical frame is trained through the problem formulation activity, a stage of guided inquiry learning to develop generic science skills. Problem formulation activities are supported by guided inquiry-based student worksheets which are designed to guide students to formulate problems. Before conducting the practicum, the researchers showed a video compulsorily listened to by the students. The video is used to stimulate students to formulate problems; thus, the students can improve their logical frames of generic science skills. The indicator of the logical frame has obtained a percentage of 75%; this core is categorized as high. The logical frame skill refers to a generic skill for systematic thinking and is based on the regular phenomenon of natural symptoms (Sudarmin, 2012). This skill will help students think systematically to solve learning problems emerging during the classroom learning process and problems emerging in daily life. This condition agrees with guided inquiry learning which has several stages of formulating problems; thus, the students are trained to formulate problems in the form of questions (Nasir, 2016).

Logical consistency is developed through the process of testing hypotheses. Before testing the hypothesis, the students conducted a practicum in the laboratory to collect data. The indicator of

logical consistency has obtained a percentage of 87.5%; this score is categorized as high. Logical consistency skills can be developed in the guided inquiry learning model through the testing hypothesis stage because this stage can determine acceptable and right answers based on the collected data and develop rational thinking abilities (Nasir, 2016). This statement is supported by Yuniarita (2014), who explains that guided inquiry learning can improve students' generic science skills because it creates a cooperative and interactive classroom atmosphere and enables the students to combine ideas, share opinions, conduct discussions, and deliver arguments.

Meanwhile, the indicator of the law of causes and effects is done at the stage of proposing a hypothesis. This stage is contained in the guided inquiry learning model to develop generic science skills. The formulated hypotheses are designed to develop generic science skills of the law of causes and effects. The indicator of the law of causes and effects has obtained a percentage of 70.3%; this score is categorized as moderate and indicates that learning using guided inquiry learning models can train the indicator of the law of causes and effects; thus, the students' generic science skills could improve. Students' active involvement in the inquiry process stimulates their potential to understand themselves so that they can build self-concepts (Sadia, 2014). Every constructivism learning gives students the freedom to explore the meaning of what is learned. This activity constitutes a process of adapting a new concept using the existing understanding in the students' minds. Afterward, the students make reasoning on what is learned by looking for the meaning and comparing it with their knowledge and needs in new experiences (Cahyo, 2013).

Furthermore, this current research develops the students' generic science skills of indicator of modeling at the stage of testing hypotheses. The students collected data through the practicum. These data were then processed so that the students could conclude their practicum work. The indicator of modeling has obtained a percentage of 95.3%; this score is categorized as very high and shows that learning using guided inquiry learning models can improve the indicator of modeling. This finding is also supported by Ermawati et al. (2018) who discover the same finding.

Logical inferences refer to the generic skills to draw new conclusions as a logical result of previous laws without conducting a new experiment. The indicator of logical inferences enables the students to conclude the activities of animal respiration practicum based on theory. This indicator has obtained a percentage of 92.2% and is categorized as very high. Classes that apply guided inquiry learning models can train students to think analytically and systematically to draw a conclusion (logical inference) based on theories, principles, and laws that underlie the results of each practicum. Therefore, guided inquiry can train the students' logical inference skills with very high scores. The inquiry develops intellectual abilities and all existing potentials, including the emotional development of a process that starts from formulating problems, formulating hypotheses, collecting data, analyzing data, and drawing conclusions (Nasir, 2016).

The indicator of abstraction is trained through hypothesis testing activities; thus, the students' generic science skills are developed. The indicator of abstraction has obtained a percentage of 34.4%; this score is categorized as low. The guided inquiry learning model in animal respiration practicum is still necessarily implemented, and the students' abstraction of science generic skills is still necessarily improved. Samiana et al. (2012) have revealed that students get a better abstraction of generic science skills because, during the learning process, they are required to actively investigate the given problems and analyze these problems. These activities train their abstraction skills.

When conducting the guided inquiry-based animal respiration practicum, the students achieve high scores in the categories of direct observations, indirect observations, awareness of scales,

symbolic languages, modeling, and logical scale inferences. The students' generic science skill indicators that have high percentages are logical frame and logical consistency. Meanwhile, the students' generic science skills indicator that has a moderate percentage is the law of causes and effects. Finally, the students' generic science skills indicator that has a low percentage is an abstraction. The percentages of the students' generic science skills show that the guided inquiry-based learning model can train their inquiry-based animal respiration practicum because this model helps students associate concepts with real life and improve conceptual abilities during a discussion.

Guided inquiry-based worksheets serve as practicum instructions and guide the students to conduct hypothesis testing to discover concepts and improve generic science skills. The learning process using a guided inquiry learning model is assisted with a detailed student worksheet which has instructions or guidelines in the form of questions or steps in each stage; thus, students can find concepts to learn (Sadia, 2014). Nasir et al. (2014) have discovered that the use of student worksheets based on generic science skills significantly influences learning outcomes because they can build their concepts to learn.

Differences in the improvement of generic science skills between experimental and control classes

This research has discovered that the experimental class receiving the guided inquiry practicum model has a greater pre-test and post-test values than the control class does. Trianto (2009) states that correct learning should help students learn a concept not force them to obtain as much information as possible at the end of the learning period. Guided inquiry is a student-centered learning model. Teachers' roles in this learning model are different from theirs in a conventional learning model (Olibie & Ezeoba, 2014). The average pretest and posttest scores for the experimental and control classes are presented in Figure 1.

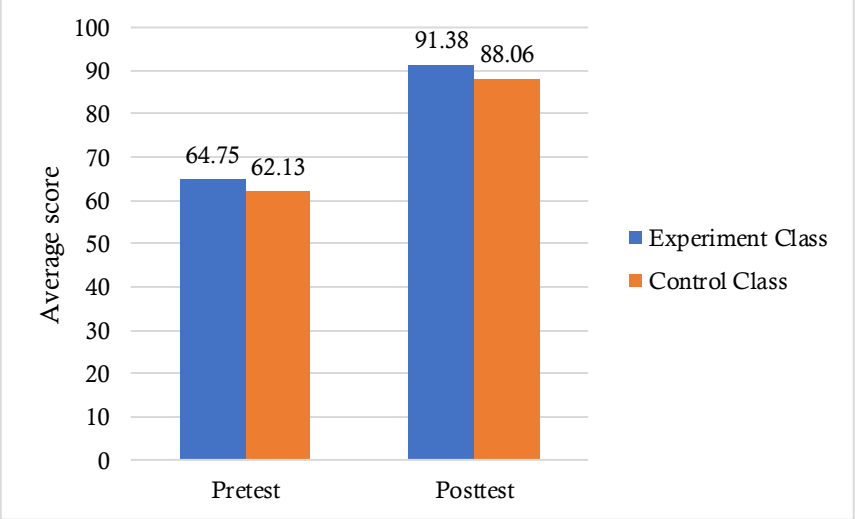

Figure 1. Average values of the pretest and posttest

In an ideal learning process, a teacher does not serve as a facilitator who provides information and data, but they have a role to design the learning. Meanwhile, students should not only receive information but should actively participate in developing learning (Zion & Mendelovici, 2012). Information and data construction can be developed through students' activities and thinking skills that allow them to construct information and add experience (Susilawati et al., 2015).

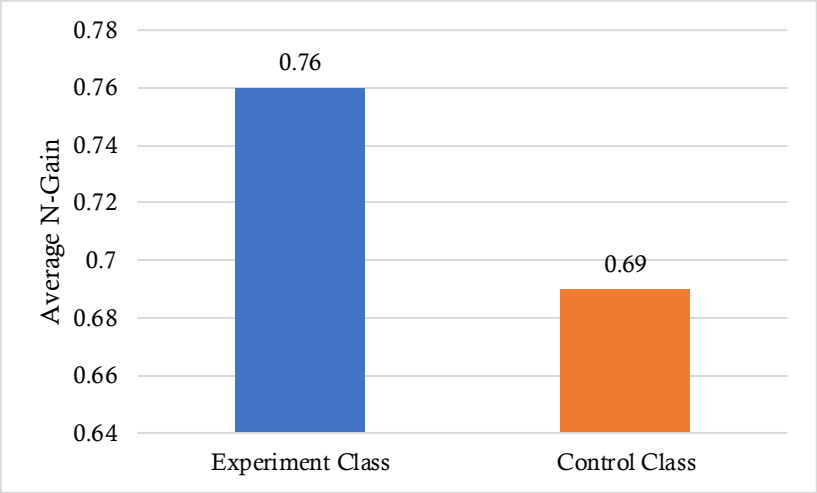

Figure 2. N-Gain average

Figure 2 shows that the experimental class has a higher average N-Gain than the control class does. The results of the different test using the Mann Whitney U emphasize different skill development with the significance value of 0.005 < 0.05. This score concludes that the students who apply for the guided inquiry model and the students who apply for the conventional model show significantly different improvements in generic science skills when conducting the animal respiration practicum at SMAN 1 Sukahaji. This result is supported by Ernawati et al. (2018) who have discovered that guided inquiry learning can significantly enhance students' generic science skills. The results of the generic science skills hypothesis test are presented in Table 2.

Table 2. Hypothesis test results

Data	Hypothesis Test	Significance Values	Description
Post-test	Mann Whitney U	0.005	H_0 is rejected.

Practicum activities strongly support the mastery and understanding of a theory. The implementation of practicum activities in inquiry learning leads to a maximum mastery and understanding of concepts and generic science skills. Students are not only trained to arrange, use, and manipulate tools but also develop basic skills, especially generic science skills. These skills will be useful for them to stock reinforcement material at a higher level when facing problems that need precise quick, and systematical solutions (Khoiri et al., 2020).

Practicum activities are very suitable to apply and improve the students' generic science skills because they can apply various generic science skills and develop scientific attitudes that support the process of acquiring knowledge (scientific products). Thus, it is clear that practicum has a key position in science learning because it enables students to develop and apply science process skills and scientific attitudes to obtain knowledge (Subiantoro, 2010). Guided inquiry learning encourages students to learn through active involvement and conduct an experiment to find a concept. Inquiry learning encourages students to solve problems independently and build generic science skills to analyze information (Khoiri et al., 2020). Learning to use inquiry can improve generic science skills (Halim et al., 2019; Faradila et al., 2019; Khoiri et al., 2020).

Students' responses to activities of guided inquiry-based animal respiration practicum

The questionnaire of the guided inquiry-based animal respiration practicum has revealed positive and negative statements based on four response indicators: interest, enthusiasm, opinions, and easiness of understanding. The statements are about the guided inquiry-based

animal respiration practicum. The importance of inquiry at schools has been emphasized in science, and the 2013 curriculum has introduced the inquiry process
through a scientific approach. Questions in textbooks or practicum guides show that learning processes of scientific concepts in inquiry-based animal respiration practicum are interrelated and consist of performance-based activities that enable the students to simply follow a given process (Sahrir, 2019). The percentages of students' response indicators to guided inquiry-based animal respiration practicum are presented in Figure 3.

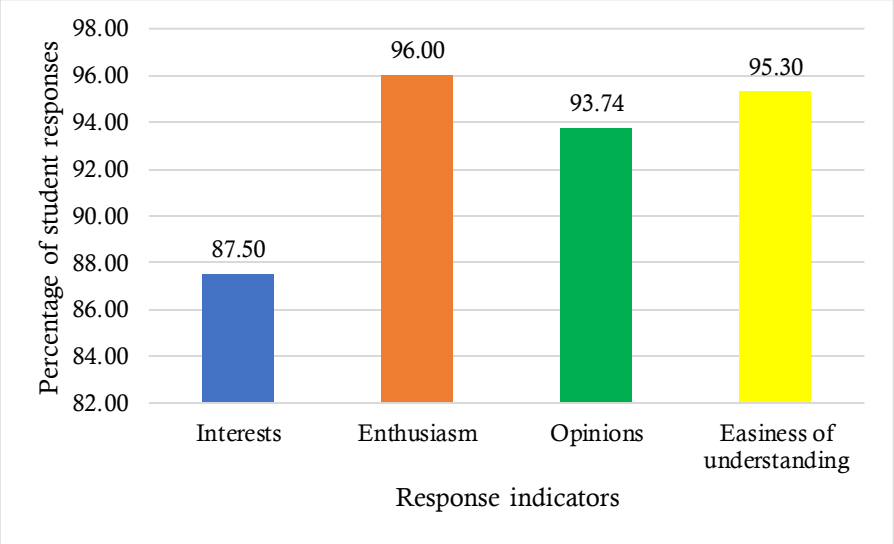

Figure 3. Percentages of students' responses

Figure 3 shows the percentage of students' response indicators of interests, enthusiasm, opinions, and easiness of understanding. The indicator of interest has a percentage of 87.5% and is categorized as very positive. The indicator of enthusiasm has a percentage of 96% and is categorized as very positive. The indicator of opinion has a percentage of 93.74% and is categorized as very positive. The indicator of easiness to understanding has a percentage of 95.3% and is categorized as very positive. Finally, the total percentage of each response indicator is 93.14%; this score shows that the students positively respond to the guided inquiry-based animal respiration practicum

The students positively respond to the guided inquiry-based animal respiration practicum because they conduct the learning based on the stages of the guided inquiry learning model. The questionnaire data analysis has found the students' positive responses to the guided inquiry-based animal respiration practicum. This finding is supported by Hasanah and Nurita (2021) who discover students' positive responses and deployed that guided inquiry learning is suitable for an IT practicum. The results showed that guided inquiry learning had a positive effect on students' generic science skills (Yohana et al., 2018). Students' curiosity influences generic science skills (Herianto & Wilujeng, 2020). The students' responses show that they could more easily understand science materials through practicum activities and feel more motivated when working in groups.

4. Conclusion

This study concludes that the students' activities in the guided inquiry-based animal respiration practicum are categorized as high with an average percentage of 85.47%. Moreover, the students who apply for the guided inquiry model have significantly different improvements in

generic science skills from those who apply for the conventional model. The Mann Whitney U test has revealed an Asymp Sig. (2-tailed) value of 0.005 < 0.05. The students also show a very positive response because the percentage of response indicators is 93.14%. Unfortunately, this study has not optimally implemented the guided inquiry-based animal respiration practicum to develop the students' generic science skills due to limited time in the learning process.

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