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The effect of using a virtual anatomy system of student misconceptions on reproductive system

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ABSTRACT
This study aimed to determine the effect of using a virtual anatomy system (VAS) on student learning with regard to reproductive system with respect to the acquisition of misconceptions. This study used an experimental method by comparing the results of the class learning using virtual laboratory media with a control class. The result showed that a significant increase in learning outcomes in the experimental class 77.73 mean compared to the control class mean of 69.5. The magnitude of the increase in learning outcomes (N-gain) of the experimental class was 0.67 within the medium category beside control class. It can be seen that the level of misconceptions in the experimental class was 11.6% smaller than the control class at 37.6%.

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Introduction

Learning science will be more meaningful if it is accompanied by laboratory activities (Ping & Osman, 2019; Wiyanto et al., 2014). With laboratory activities, students' abilities in evaluating, designing, and processing problems increase (Bretz et al., 2013; Gutierez, 2015; Zeidler et al., 2019). Practical activities in the laboratory can train students' skills in scientific work (Wiyanto et al., 2014) and improve them mastery of concepts (Achuthan et al., 2020). The basic problem in schools is related to the use of laboratories in addition to limited facilities and infrastructure as well as limited human resources. Teachers as instructors need to understand and master laboratory equipment

well. To overcome the lack knowledge science in higher education, it needs to be reorganized. Learning science in higher education requires the maturation of basic concepts as a basis for developing more complex concept. It needs to be supported by complete facilities and infrastructure such as a laboratory. The completeness of laboratory facilities and infrastructure affects students' skills.

One of the skills that a prospective science teacher must have is the ability to use laboratory equipment and materials effectively. Skills in laboratory utilisation and management support the science learning endeavour under Permendiknas 26 of 2008 regarding laboratory management in schools with certain qualifications for both laboratory heads and laboratory technicians (Manlea, 2017). Laboratory activities support the improvement of psychomotor competence and scientific attitudes as well as solve the problem (Talens, 2016). With laboratory activities, student activities increase up to 80% in the learning process (Yusuf & Subaer, 2013). laboratory activities increase students' understanding of the material that is being studied (Ratamun & Osman, 2018) not only theoretical and abstract. A virtual laboratory is an interactive environment for creating and conducting experiments that is adapted to simulate processes and actions as in a physical laboratory. Or in other words, virtual laboratories are an affordable way for schools or universities to get laboratories for all kinds of subjects. Teachers use sophisticated technology to present a series of experimental processes that will produce authentic results. Virtual laboratories use the computer to simulate complicated things, expensive experiment devices, or replace the experiments located in hazardous environments (Mahanta & Kumar Sarma, 2012) Virtual laboratories become an option considering that currently there has been such rapid progress in information and technology (Zaturrahmi et al., 2020).

Compared to physical laboratories which obviously have limited space, virtual laboratories can be used to demonstrate the latest technologies in all classes. Virtual laboratories as complementary or independent facilities. Virtual laboratories can be a standalone activity when physical laboratories are unable to facilitate experiments due to limited resources. Virtual laboratories are even more efficient, significant and affordable for educational institutions in developing countries (Widiyatmoko et al., 2022), because the facilities available in physical laboratories are sometimes still scarce. Even though many have physical laboratories, the existing facilities are not yet complete so the learning potential is less than optimal. Learning using virtual media has the potential to make students active in learning because there are activities that may not be able to be fulfilled in a physical laboratory (Tuysuz, 2010).

Understanding science concepts is an important indicator for achieving success in science learning. Understanding concepts in science learning takes the form of mastering concepts that are in accordance with the agreement of scientists, do not deviate and do not give rise to other hypotheses that can cause cognitive conflict. Meanwhile, misconceptions are errors or discrepancies between concepts and scientific understanding accepted by experts. Misconceptions can also occur in students from students themselves, teachers, textbooks, and also from the learning methods carried out by student. Misconceptions can take the form of errors in understanding the initial concept, errors in connecting various concepts, and errors in ideas. Misconceptions can easily occur to students when students are trying to form knowledge based on new experiences (Hakim et al., 2012; Mufit et al., 2023).

Learning using virtual laboratory can support teachers in providing understanding to students (Resbiantoro et al., 2022; Rowe et al., 2018; Winarni, 2020). However, the limitations in the availability of facilities, and infrastructure (Alneyadi, 2019; Faour et al., 2018; Ratamun & Osman, 2018) as well as limited human resources make teaching science based on laboratory activities a challenge in itself. The development of learning using virtual laboratories has been widely developed, especially in higher education environments, to accommodate the limitations of physical laboratories.

This limited infrastructure problem can be overcome by using virtual technology that is designed according to the user's needs (Faour et al., 2018). The use of computers in developing virtual media in education is growing rapidly (Gunes et al., 2015; Thohir et al., 2020; Widiyatmoko, 2018).

This developing technology can provide practical solutions for science teachers to improve student learning outcomes despite limited facilities and infrastructure. Virtual laboratories provide opportunities for students to learn through joint activities in processing information, changing variables (Faour et al., 2018; Rowe et al., 2018), and seeing the impacts of the activities' results (Pujiastuti & Haryadi, 2020; Yuniarti et al., 2012). Learning using virtual tools can make students more active in learning and processing information (Gunawan et al., 2017; Ratamun & Osman, 2018). A facility that combines technological advances with limited laboratory activities means such as the *virtual anatomy system (VAS)*.

Virtual laboratories are used as supporting tools to enrich real experiences and motivate (Achuthan et al., 2020) students to conduct experiments and develop experimental skills. Through the use of virtual laboratory media for students of prospective teachers, it is hoped that the learning activities will be more meaningful with students identifying and practicing virtually.

A virtual anatomy system (VAS), which required experimentation or practicum to help explain the concepts in anatomy material, could be used as an alternative learning activity. The research conducted has also been investigated by Jaya in vocational education for Vocational High School (SMK) students. He stated that the development of a virtual laboratory for practicum activities can increase motivation which has an impact on increasing their cognitive abilities as well as improvements that lead to the psychomotor aspects and character of vocational high school students (Jaya, 2012). Virtual laboratories have advantages in improving students' affective abilities that describe feelings, interests, and attitudes towards the teaching process (Achuthan et al., 2020; Purwati et al., 2019). Research conducted by Isdaryanti related to the teaching aspect, it was known that when the performance ability of science teachers in teaching increases, then it has an impact on improving the student's character education (Isdaryanti et al., 2018). Therefore, increasing the ability to teach concepts to students of prospective teachers must be implemented (Winarni, 2017) as much as possible.

Several advantages can be obtained by having a virtual laboratory, including (1) because it does not require tools and materials like conventional laboratories so it is more economical (Fonna et al., 2013; Winarni, 2020), (2) it increases student motivation and curiosity, (3) it increases the students' ability to solve problems in learning (Anisa et al., 2020; Jannati et al., 2019; Winarni, 2020). Students can also do experiments wherever and whenever they need it. In addition, students can also try to repeat the material and study materials related to experiments. Another advantage of virtual laboratories is that they can train students' accuracy in developing concepts found from the results of practicum activities even though in the conditions with limited facilities such as tools and practicum materials.

Many developments in virtual media have been carried out and show that the use of virtual media, apart from improving student learning outcomes, also has an impact on increasing student motivation (Said, 2014) and increasing students' analytical skills (Widiyatmoko & Shimizu, 2019; Winarni, 2020). This study aims to determine the effect of use of the virtual anatomy system (VAS) of students' misconceptions on reproductive system.

Methods

Design Development

This research used a quasi-experimental method (Hastjarjo, 2019) by comparing the control group and the experimental group. Learning that uses a problem-based approach, for example in the female reproductive system, is how the female sex cells look ready to be fertilized during the mating season. In the experimental group, learning was supplemented by using virtual practicum with VAS, while the control group was not provided with additional practicum using VAS.

The samples for this research were 11 students in the experimental class and 10 students in the control class. In the experimental activity class, students are given material at the first meeting. At the

second meeting, students were given an explanation of the phases of egg cell development and carried out practical activities using a VAS until the focus was found from the virtual observation. The results obtained are described and analyzed including the egg cell development phase. For the control class, at the first meeting, material was provided. At the second meeting on egg cell development, students were asked to look for references to strengthen the explanation of the phases of egg cell development. After the second meeting ended, reflection and testing was carried out to see the level of understanding and whether there were any misconceptions that occurred after the learning was carried out.

Data Collection

Research data is in the form of test results arising from multiple choice objective tests supplemented by the Certainty Response Index (CRI) method for students (Hasan et al., 1999; Mustaqim et al., 2014). Table 1 CRI categories and category explanations.

Table 1

Cri scale by Saleem Hasan

Scale	Category
0	(Totally guessed answer), if the answer to the question is 100% guessed
1	(Almost guess), if you answer the question, the percentage of guess elements is between 75% -99%
2	(Not sure), if you answer the question, the percentage of guess elements is between 50%-74%
3	(Sure), if you answer the question, the percentage of guess elements is between 25%-49%
4	(Almost certain) if you answer the question, the percentage of guess elements is between 1%-24%
5	(Certain,) if you answer the question, there is no element of guessing at all (0%)

Results and Discussion

Research was carried out to determine the effectiveness of learning using VAS to overcome misconceptions. The results acquired showed that there was a significant difference between the experimental learning method using VAS on the reproductive system compared to the control class. The results of this research are in line with research conducted by Gunawan regarding the use of virtual labs in learning which was able to improve problem solving abilities in the experimental group compared to the control group (Gunawan & Liliasari, 2012).

The data obtained from the results of the recapitulation of students' pretest and posttest can be seen in Table 2. The results of student scores analysis.

Table 2

Data on comparison of learning outcomes for experimental and control groups

	Experiment class			Control class		
	pretest	*Posttest*	*N-gain*	*Pretest*	*postest*	*N-gain*
N (Number of students)	11	11		10	10	
Average	31.82	77.73	0.67	32.5	69.5	0.55

Table 2 shows that the mean score of the experimental group pretest is 31.82 and posttest is 77.73 with an N-gain reaching 0.67 which is in the medium category, while in the control group, the pretest score is 32.5 and the post-test score is 72.5 with an N-gain of 0.59 which is included in the medium category.

Table 3

T-test to see the significance of student learning outcomes

	F	Sig.	t	Df	Sig. (2-tailed)	Mean difference	Std. error difference	95% Confidence Interval of the difference	
								Lower	Upper
Score equal variances assumed	3,79	.066	-3,91	19	.001	-8.22727	2.10426	-12.631	-3.823
Score equal variances not assumed			-3,98	17,35	.001	-8.22727	2.10426	-12.571	-3.882

The results of the calculation of the significant value of 0.001 <0.005, it can be concluded that there is a difference between the learning outcomes of the experimental group and the control group

From the calculation of the N-Gain data, it can be seen that there was an increase in understanding of the concept received by the experimental group compared to the control group. So learning using the virtual anatomy system (VAS) as a learning medium helped to clarify the concept of the reproductive system for prospective teachers. The use of virtual laboratories also resulted in higher N-Gain in the experimental group compared to the control group in other research with different concepts (Athaillah et al., 2017). The results of research on learning with virtual media are in line with research conducted by Swandi (Swandi et al., 2015) in adding virtual media to modern physics learning using virtual laboratories which can improve generic science skills. Based on increased thinking abilities or learning outcomes, it can be used as a basis for learning outcomes data that can also have an impact on the possibility of reducing misconceptions.

Research on virtual media in learning anatomical concepts was also carried out by Fonna (Fonna et al., 2013) on the respiratory system, the results showed that the critical thinking skills of the number of students in the experimental group who used the virtual laboratory were better than those in the control group who did not use the virtual laboratory. Research relating to virtual media has shown significant results. Therefore, in research using VAS in learning the reproductive system is effective in preventing misconceptions.

This virtual anatomy system (VAS) media is realistic because it is very complete and contains materials and tools to be used in laboratory activities. The use of a virtual laboratory on reproductive material could facilitate students to understand the processes that occur in the reproductive system, starting from the process of observing the morphology of sperm cells, counting the number of spermatozoa, and observing egg cells according to the stage.

Errors made in laboratory activities using a virtual anatomy system (VAS) will train students as practical activities in the laboratory directly. This means that when students are faced with real conditions in the laboratory, errors in practical activities can be overcome. The use of the virtual anatomy system (VAS) on the reproductive system has had a positive impact on students so it will be told for the umpteenth time. This is shown in the student response questionnaire, the results of which are shown in table 4 below.

Table 4

Description of student responses

No.	Indicator	Statement	Agree	Disagree
1	Laboratory virtual views	Display under actual laboratory conditions	81.8%	18.2%
		Virtual Laboratory Stages is easy to use	72.7%	27.3%
		The virtual lab is very interesting to use	81.8%	18.2%
2	Media conformity to the concept	Using virtual laboratory media makes it easier to understand the concept of learning	72.7%	27.3%
		Virtual laboratories are very useful in the learning process	72.7%	27.3%
		The virtual laboratory makes it easy for me to do practical activities virtually	72.7%	27.3%
3	Virtual lab performance	Easy to access virtual lab	81.8%	18.2%
		Virtual lab saves time and money	72.7%	27.3%
		The virtual laboratory can be relearned after learning activities	72.7%	27.3%
		I wish there was a virtual lab for other materials	81.8%	18.2%
Average			76.3%	23.7%

The results of student responses to the appearance, the suitability of the media with the concept, and the performance of the virtual laboratory showed that 76.3% of students agreed that the virtual laboratory that was made and used was attractive, appropriate, and increased the desire to learn and the desire for similar learning media. This interest makes students better understand the material presented by the lecturer as a form of increasing curiosity (Tuysuz, 2010). With the virtual anatomy system (VAS), students were able to re-access practicum activities carried out to solidify the concepts (Rohmawati et al., 2018) that were learned so that learning activities became more effective and efficient. This positive student response makes the virtual anatomy system (VAS) a medium that needs to be developed more to improve the quality of learning in the future.

Conclusion

The conclusion and implication of this research is that understanding concepts is helped by using virtual anatomy system (VAS) media on reproductive system material. The average value of learning outcomes and understanding of concepts for experimental group students was better in understanding concepts than those in the control class. This improvement in learning outcomes is supported by positive student responses that support the use and development of the virtual anatomy system (VAS) to the next stage.

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