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## Analysis of Students' Learning Activities During Virtual Laboratory Based Learning on the Excretory System

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**Abstract:** Limited laboratory facilities and the lack of diverse instructional media may hinder students' engagement in biology practicum activities, resulting in suboptimal learning activities. This study aimed to describe students' learning activities during the implementation of a Virtual Laboratory in a urine content testing practicum on the excretory system topic at MAN 4 Aceh Besar. The study employed a pre-experimental method involving a single experimental class consisting of 35 students from class XI-2, selected through purposive sampling. Data were collected through observations of students' learning activities using an observation sheet comprising seven indicators: visual activities, oral activities, listening activities, writing activities, mental activities, emotional activities, and drawing activities. The data were analyzed descriptively using percentage analysis. The findings revealed that the implementation of the Virtual Laboratory enhanced students' learning activities across all observed indicators. The average percentage of students' learning activities increased from 81% in the first meeting to 95% in the second meeting, both of which were categorized as highly active. The highest percentage in the second meeting was observed in the emotional activities indicator, reaching 100%, while all other indicators were also classified as highly active. These findings indicate that the Virtual Laboratory was effective in creating a more interactive, engaging, and student-centered learning environment, thereby increasing students' participation throughout the learning process. Therefore, the Virtual Laboratory can serve as an effective alternative instructional medium to support biology practicum activities, particularly in teaching the excretory system.

**Keywords:** Learning activities, excretory system, urine content testing, virtual laboratory, biology practicum.

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### INTRODUCTION

Biology learning is not only focused on the mastery of concepts and facts but also emphasizes learning processes that encourage students to discover and construct knowledge independently. Through this approach, students are expected to develop scientific process skills, critical thinking abilities, and a deeper understanding of biological

phenomena (Dwi, 2022). Therefore, biology education requires students not only to memorize concepts but also to actively engage in various learning activities that support scientific inquiry. The success of biology learning is highly influenced by students' learning activities during the instructional process (Ningrum, Sumarno, & Sulistyowati, 2023).

Learning activities encompass all forms of student engagement during the learning process, including both physical and mental activities. According to Suryani (2023), learning activities include various actions such as reading, observing, listening, asking questions, discussing, writing, conducting experiments, analyzing information, and drawing conclusions (Suryani & Rini, 2023). Learning activities serve as important indicators of students' involvement in the learning process. The higher the level of student engagement, the greater the likelihood of achieving learning objectives effectively. Conversely, low levels of learning activity may result in passive participation, making the learning process less meaningful (Anggara & Rakimahwati, 2021).

According to Diedrich, as cited by Sardiman (2014), learning activities can be classified into several categories, namely visual activities, oral activities, listening activities, writing activities, drawing activities, motor activities, mental activities, and emotional activities. These various forms of activity should be facilitated in the learning process to provide students with comprehensive learning experiences. In biology education, such activities can be developed through laboratory practices that allow students to observe, investigate, verify, and communicate findings directly. Consequently, laboratory activities represent one of the most effective strategies for enhancing student engagement in biology learning. Furthermore, practical activities stimulate intellectual skills, including formulating hypotheses, designing experiments, and analyzing data to solve contextual problems.

Laboratory work constitutes an essential component of biology education because it enables students to connect theoretical concepts with directly observable phenomena. Prior to the COVID-19 pandemic, biology practical activities were commonly conducted in laboratories as a primary means of supporting experiment-based learning. Through laboratory experiences, students can develop scientific process skills, gain deeper conceptual understanding, and increase their active participation in learning. Therefore, the implementation of laboratory activities requires adequate facilities, particularly laboratory infrastructure (Silviana, Ayub, & Wahyudi, 2023).

Laboratories and the equipment available within them are important educational facilities that support the teaching and learning process in schools. The significance of laboratories has been emphasized in Government Regulation Number 19 of 2005 concerning National Education Standards, Article 42 paragraph (2), and Article 43 paragraphs (1) and (2). According to Wirjosoemarto et al. (2002), a laboratory is a supporting facility for teaching and learning activities used for experimentation, research, and the verification of theories acquired from various learning resources. Moreover, laboratories serve as places where scientific theories are applied, tested, and investigated through scientific activities supported by adequate facilities in terms of both quality and quantity (Ministry of National Education, 2007). Thus, laboratories play a strategic role in helping students understand learning materials through direct experiences. However, this function can only be optimized when laboratories are well managed and supported by adequate facilities.

One of the essential requirements for science learning, particularly biology, is the effective utilization of laboratories supported by proper management systems. Laboratory management plays a crucial role in ensuring effective learning because laboratories must be maintained in a ready-to-use condition, equipped with sufficient facilities, and supported by efficient administration. In reality, however, many schools continue to face challenges in laboratory utilization. Limited laboratory facilities, insufficient equipment and materials, large class sizes, and curriculum demands often prevent practical activities from being conducted optimally. These conditions restrict students' opportunities to actively participate in experimental activities. Therefore, alternative learning approaches are

needed to support practical activities despite laboratory limitations (Nurlia Zahara & Elita Agustina, 2018).

To address these limitations, learning media capable of providing meaningful learning experiences are required. Learning media refer to any tools, materials, or facilities used as intermediaries in the communication process between teachers and students to enhance instructional effectiveness. Such media may include objects that can be seen, heard, read, or manipulated, thereby assisting students in understanding learning materials. However, instructional practices in schools are still largely dominated by conventional media that are less capable of accommodating the demands of twenty-first-century learning (Ramli, 2014). Therefore, innovative learning media that align with students' characteristics and instructional needs are necessary to enhance student engagement and participation in the learning process (Eriawati et al., 2025).

Advances in science and technology have encouraged the development of various digital learning media. One instructional medium that can be utilized in biology education is the Virtual Laboratory. A Virtual Laboratory is a computer-based learning medium designed to simulate laboratory activities through virtual experimentation. This medium provides features that closely resemble real laboratory conditions, including the use of laboratory equipment and materials in digital simulation form. Through such simulations, students can engage in experimental activities even when laboratory facilities are limited (Emda, Setiawan, & Darwani, 2025).

According to Rajaram (2001), a Virtual Laboratory is a computer-based laboratory environment that enables students to connect theoretical concepts with practical applications through simulated experiments. This medium integrates various multimedia components, including text, images, animations, videos, audio, and interactive simulations, to achieve learning objectives effectively. The use of Virtual Laboratories allows students to perform various learning activities, such as observing objects, conducting experimental procedures, collecting data, analyzing experimental results, discussing findings, and drawing conclusions. Therefore, Virtual Laboratories not only function as alternatives to conventional laboratory activities but also have the potential to enhance students' learning activities throughout the instructional process (Meilina, Rohmah, A., & Farikha, 2023).

One biology topic that requires visualization and practical activities to support student understanding is the excretory system. This topic covers the structure, function, and mechanisms of human excretory organs, many of which occur internally and cannot be directly observed. The abstract nature of these concepts often causes students to experience difficulties when instruction relies solely on lecture-based methods. Therefore, learning media capable of visualizing the processes involved in the excretory system are needed to help students understand concepts more concretely while actively engaging in the learning process (Wulandari, Sukamto, & Putri, 2025).

Based on preliminary observations conducted at MAN 4 Aceh Besar, it was found that the school has implemented the Merdeka Curriculum in Grade XI Biology classes. However, several challenges remain that hinder optimal student engagement. The school laboratory lacks sufficient equipment and materials to support experimental activities effectively. In addition, the limited variety of instructional media causes some students to become less active and easily lose interest during lessons. These conditions indicate the need for innovative learning media that can support practical activities while simultaneously enhancing student engagement in biology learning.

Previous studies have demonstrated that the use of Virtual Laboratories can improve conceptual understanding, scientific process skills, and student engagement in biology learning. However, studies specifically examining students' learning activities during Virtual Laboratory-based instruction on the excretory system remain limited, particularly among senior high school students in Aceh. Furthermore, few studies have described student learning activities based on various activity indicators, including visual activities, oral activities, listening activities, writing activities, mental activities, emotional activities, and drawing activities during virtual laboratory implementation. Therefore, this study was

conducted to describe students' learning activities during the implementation of a Virtual Laboratory in learning the excretory system among Grade XI students at MAN 4 Aceh Besar..

## METHODS

This study employed a pre-experimental research method, which is a research design that does not fully meet all the requirements of a true experimental design. The selection of this method was based on the objective of the study, which involved only one experimental class to observe students' learning activities following the implementation of a Virtual Laboratory on the excretory system topic. The research was conducted at MAN 4 Aceh Besar, located on Teuku Nyak Arief Street, Tungkob, Darussalam, Aceh Besar Regency, Indonesia. The study population consisted of all Grade XI students at MAN 4 Aceh Besar, comprising five classes, each with 35 students. The research sample consisted of 35 students from Class XI-2. The sample was selected using a purposive sampling technique, which refers to the selection of participants based on specific criteria determined by the researcher (Zainal, 2012). Class XI-2 was chosen based on the recommendation of the Biology teacher at MAN 4 Aceh Besar. This class was selected because it represented a regular science-track class. In contrast, Class XI-1 was an advanced class whose students had generally achieved scores above the Minimum Mastery Criterion (MMC), while Classes XI-3, XI-4, and XI-5 were regular classes with a social science background.

Data were collected through observation to obtain information regarding students' learning activities during the learning process. Observations were conducted by the Biology teacher and five observers, each responsible for monitoring one student group. The observers used observation sheets prepared by the researcher to record students' learning activities during the implementation of the Virtual Laboratory on the excretory system topic in Class XI-2 at MAN 4 Aceh Besar.

The research instrument consisted of a student learning activity observation sheet. This instrument was designed to collect data regarding students' learning activities during the instructional process. The observation sheet included several indicators of learning activities, namely visual activities, oral activities, listening activities, writing activities, mental activities, emotional activities, and drawing activities.

The data on students' learning activities obtained through the observation sheets were analyzed using descriptive quantitative analysis with percentage techniques. This analysis was conducted to determine the level of students' learning activities during learning sessions utilizing the Virtual Laboratory on the excretory system topic (Anas, 2011). The activity scores obtained from the observations were calculated using the following percentage formula:

$$NP = \frac{R}{SM} \times 100\%$$

Description:

- NP = Percentage value
- R = Score obtained by students
- SM = Maximum score obtained
- 100 = Constant Number (fixed).

Next, the results of the percentage formula are obtained, then the criteria are determined based on *the likert scale*, namely as in table 1.

**Table 1.** Likert Scale Interval Table

No.	Interval	Shoes	Category
1	76% - 100%	4	Highly Active
2	56% - 75%	3	Active
3	26% - 55%	2	Quite Active

Furthermore, the percentage of learning activities is calculated on each indicator activity which includes *visual activities*, *oral activities*, *listening activities*, *writing activities*, *mental activities*, *emotional activities*, and *drawing activities*. The percentages obtained are used to describe the level of student involvement during the learning process.

Learning using virtual laboratories is considered effective in increasing student learning activities if the percentage of activities obtained is in the active or very active category. Thus, students are declared to have achieved the expected learning activity criteria if they obtain a percentage score of more than >55%, which is included in the active category.

## RESULTS

This research was carried out at MAN 4 Aceh Besar for the 2024/2025 school year. This research was conducted to see student activities by applying *Virtual Laboratory* in the urine content test practicum on the excretory system material of class XI MAN 4 Aceh Besar. During the learning process, student learning activities were observed using student learning activity observation sheets.

The results of the observation of student learning activities were obtained during the learning activities, by giving scores in the assessment sheet according to the criteria that had been set, and observed using the observation sheet of student learning activities by the observer during the learning at MAN 4 Aceh Besar in table 2.

**Table 2.** Results of Percentage of Student Learning Activities at the First Meeting in Class XI MAN 4 Aceh Besar

No	Indicator	First Meeting					Average Percentage	ket
		01	02	03	04	05		
1	<i>Visual Activities</i>	83%	75%	67%	75%	83%	77%	Highly Active
2	<i>Oral Activities</i>	75%	69%	63%	69%	81%	71%	Active
3	<i>Listening Activities</i>	100%	88%	75%	75%	100%	88%	Highly Active
4	<i>Writing Activities</i>	75%	83%	83%	92%	92%	85%	Highly Active
5	<i>Mental Activities</i>	75%	88%	88%	75%	75%	80%	Highly Active
6	<i>Emotional Activities</i>	88%	88%	88%	75%	88%	85%	Highly Active
7	<i>Drawing Activities</i>	75%	75%	100%	100%	75%	85%	Highly Active

Based on table 2, it can be seen that the percentage of student learning activities using *virtual laboratory* on the excretory system material for the first meeting consists of 7 indicators, including the percentage of *Visual Activities* activities which is 77% with the Very Active category. The percentage of activity in the *Oral Activities* indicator is 71% with the Active category. The percentage of activity on the *Listening Activities* indicator is 88% with the Very Active category. The percentage of activity in the *Writing Activities* indicator is 85% with the Very Active category. The percentage of activity in the *Mental Activities* indicator is 80% with the Very Active category. The percentage of activity in the *Emotional Activities* indicator is 85% with the Very Active category. The percentage of activity in the *Drawing Activities* indicator is 85% in the Very Active category.

**Table 3.** Results of Percentage of Student Learning Activities at the Second Meeting in Class XI MAN 4 Aceh Besar

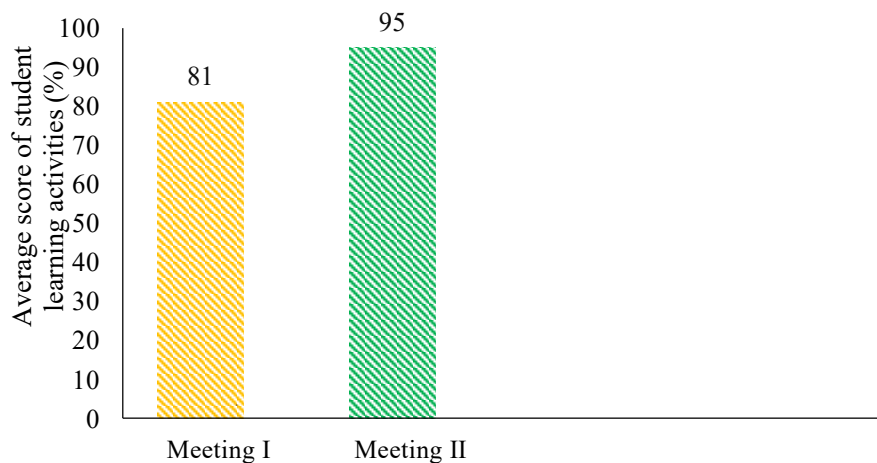
No	Indicator	Second meeting					Average Percentage	ket
		O1	O2	O3	O4	O5		
1	<i>Visual Activities</i>	100%	92%	92%	100%	92%	95%	Highly Active
2	<i>Oral Activities</i>	88%	88%	94%	88%	94%	90%	Highly Active
3	<i>Listening Activities</i>	100%	100%	100%	88%	100%	98%	Highly Active
4	<i>Writing Activities</i>	92%	100%	100%	100%	100%	98%	Highly Active
5	<i>Mental Activities</i>	88%	100%	100%	88%	88%	93%	Highly Active
6	<i>Emotional Activities</i>	100%	100%	100%	100%	100%	100%	Highly Active
7	<i>Drawing Activities</i>	75%	100%	100%	100%	100%	95%	Highly Active

Based on table 3, it can be seen that the percentage of student learning activities using *virtual laboratories* on excretory system materials for the second meeting consists of 7 indicators, including the percentage of *Visual Activities* activities which is 95% with the Very Active category. The percentage of activity in the *Oral Activities* indicator is 90% with the Very Active category. The percentage of activity in the *Listening Activities* indicator is 98% with the Very Active category. The percentage of activity in the *Writing Activities* indicator is 98% with the Very Active category. The percentage of activity in the *Mental Activities* indicator is 93% with the Very Active category. The percentage of activity in the *Emotional Activities* indicator is 100% in the Very Active category. The percentage of activity in the *Drawing Activities* indicator is 95% in the Very Active category.

**Table 4.** Results of Percentage of Student Learning Activities in the First and Second Meetings in Class XI MAN 4 Aceh Besar

No	Student Activity Indicators	Activities Meetings	Criteria	Meeting Activities	Criteria
		1		2	
1	<i>Visual Activities</i>	77%	Highly Active	95%	Highly Active
2	<i>Oral Activities</i>	71%	Active	90%	Highly Active
3	<i>Listening Activities</i>	88%	Highly Active	98%	Highly Active
4	<i>Writing Activities</i>	85%	Highly Active	98%	Highly Active
5	<i>Mental Activities</i>	80%	Highly Active	93%	Highly Active
6	<i>Emotional Activities</i>	85%	Highly Active	100%	Highly Active
7	<i>Drawing Activities</i>	85%	Highly Active	95%	Highly Active
<b>Average</b>		<b>81%</b>	<b>Highly Active</b>	<b>95%</b>	<b>Highly Active</b>

Based on table 4, on the difference in the percentage of student learning activities at the first and second meetings. The percentage of student learning activities was very active at the first meeting on the *Listening Activities* indicator, which was 88%. The *Oral activities* indicator at the first meeting obtained an active percentage of 71%. The percentage of Very Active student learning activities at the second meeting was obtained in the *Emotional activities* indicator, which was 100%, while the percentage of Activity was found in the *Oral activities* indicator, which was 90%. The average student learning activity can be seen in figure 1.



**Figure 1.** Overall Average Percentage Chart of Student Activity

Based on Figure 1, it can be seen that there is a difference in the percentage of student learning activities at the first and second meetings. The average percentage of students' learning activities at the first meeting was 81%, including the Very Active category. The second meeting saw an increase, namely the average percentage of student learning activities was 95% in the Very Active category.

## **DISCUSSION**

This study uses a pre-experimental method by involving one class as an experimental class, namely class XI-2 MAN 4 Aceh Besar. The research aims to describe student learning activities during the learning of excretory system materials using *virtual laboratory media*.

Learning activities are all forms of student involvement, both physically and mentally, during the learning process. Physical activity is reflected through various actions that students take, such as observing, discussing, writing, and carrying out learning tasks. Meanwhile, mental activity is related to the process of thinking, understanding, analyzing, and connecting information obtained during learning activities (Sudjana, 2011). Based on the results of observations, student learning activities in learning using virtual laboratory media in urine content test practicum showed a very active category. The assessment of activities was carried out on 35 students by referring to seven indicators, namely *visual activities*, *drawing activities*, *oral activities*, *listening activities*, *writing activities*, *mental activities*, and *emotional activities*.

In the aspect of *visual activities*, the activities observed include students' attention to the teacher's explanation and the display of learning media used during the learning process. The results of observation showed that this aspect was in the very active category with an average percentage of 77% at the first meeting and increased to 95% at the second meeting. This increase indicates that the use of virtual laboratories is able to attract students' attention and help them understand concepts that were previously difficult to learn through conventional learning. This media also provides a more concrete learning experience so that it can encourage the development of students' analytical and critical thinking skills (Sarwono, Primadiyono, & Suryanto, 2025). In addition, the increase in students' involvement in *oral activities* can be seen from their courage in asking questions related to practicum procedures and the mechanism of the excretory system that are not yet understood (Aini, Megawati, & Rojayanti, 2021).

The *drawing activities* aspect includes students' ability to make drawings or schemes related to excretory system materials, such as the structure of excretory organs, the process of urine formation, and observation results obtained through virtual practicums. The percentage of activity in this aspect reached 85% in the first meeting and increased to 95%

in the second meeting, both of which were included in the very active category. These findings show that visualization of concepts through images is able to help students understand the relationships between concepts in a clearer, more structured, and systematic manner (Yuliana, 2023).

In the aspect of *oral activities*, the activities observed included students' ability to ask questions, answer questions, express opinions, and conclude learning materials. The percentage of activity at the first meeting reached 71% with the active category, then increased to 90% at the second meeting and included the very active category. This increase shows that students are more confident and dare to participate in discussion and question and answer activities. Low verbal activity in the early stages of learning can be influenced by psychological factors, such as fear of making mistakes or concerns about peer responses (Waddu, Liling, & Tandiera, 2025). However, teacher assistance in facilitating discussions and guiding students in formulating questions has been proven to be effective in fostering curiosity and increasing students' communicative participation during learning (Eli & Widiyanti, 2020).

In the aspect of *listening activities*, the activities observed include students' ability to listen to group presentations, teacher explanations, and audiovisual impressions used during learning. The observation results showed a percentage of 88% in the first meeting and increased to 98% in the second meeting, both of which were in the very active category. These results show that the use of learning videos and simulations available in virtual laboratories is able to increase students' focus and attention to the material presented (Fauza, Yennita, Rahmad, Syaflita, & Nor, 2025).

In the aspect of *writing activities*, the activities observed included recording materials, working on student worksheets (LKPD), and answering evaluation questions. The percentage of activity obtained was 85% at the first meeting and increased to 98% at the second meeting. The high level of writing activity shows that students are actively involved in the learning process and have high motivation to complete the assigned tasks. Good learning motivation plays an important role in encouraging students to participate optimally in every learning activity (Farhani, Rusmawan, & Suyatini, 2022).

The aspect of *mental activities* is related to the ability of students to recall the material that has been learned, analyze information, answer questions, and draw conclusions based on learning results. The percentage of activity in this aspect reached 80% at the first meeting and increased to 93% at the second meeting with the very active category. These results show that the use of virtual laboratories is able to help students understand concepts more deeply. In addition, the level of motivation to learn and confidence that students have also affect their ability to express opinions and draw conclusions. According to Elya Shofa and Wirawan Fadly, internal factors in the form of motivation and confidence have a significant influence on students' ability to make conclusions. Students who have a high level of confidence tend to have an easier time presenting arguments and pouring them into good conclusions. On the other hand, students with low confidence levels tend to have difficulty expressing ideas or ideas they have. Therefore, confidence is one of the important factors that can increase students' motivation in drawing conclusions (Elya & Wirawan, 2022).

In the aspect of *emotional activities*, the activities observed included students' enthusiasm in participating in learning, involvement during the activity, and perseverance in following the learning until completion. The percentage of activity obtained was 85% at the first meeting and increased to 100% at the second meeting, which falls into the very active category. High emotional activity indicates that students have a high interest and curiosity towards the material being studied. Interactive simulations presented through virtual laboratories provide an engaging learning experience that can increase students' emotional involvement during the learning process (Irsan, Meidji, & Jayadi, 2025).

The results of the observation showed that students' learning activities during learning using virtual laboratory in the urine content test practicum of excretory system material increased from 81% in the first meeting to 95% in the second meeting. Both values

fall into the category of being very active. These findings indicate that the use of virtual laboratories is able to create a more interactive and student-centered learning process. The high level of learning activities provides opportunities for students to be directly involved in the learning process so that they can support the development of thinking skills, creativity, independence, and confidence which ultimately contribute to improving student learning outcomes.

## CONCLUSION

Based on the results of research that has been conducted in class XI MAN 4 Aceh Besar, it can be concluded that the use of *virtual laboratory media* in the urine content test practicum of excretory system material is able to increase student learning activities. This is shown by the increase in the average percentage of learning activities of the first meeting from 81% to 95% at the second meeting, with the very active category. The increase occurred in all indicators of learning activities, namely *visual activities, oral activities, listening activities, writing activities, mental activities, emotional activities, and drawing activities*. The results of this study show that *virtual laboratories* are able to create more interactive, interesting, and student-centered learning so as to encourage active student involvement in the learning process and can be an effective alternative learning media to support the implementation of biology practicum, especially in excretory system materials

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