

Thoughts of Biology Virtual Lab: A Meta-analysis study of Urogenital System Practicum in Universitas Terbuka

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Abstract

Practicum is an essential part of the student learning process. It promotes strengthening scientific process skills in students. On the other hand, limited access to experiencing hands-on activities requires serious attention due to the characteristics of a distance education system that restrains face-to-face activities in student learning. For this reason, a virtual lab is necessary to meet the needs of students to comprehend the functions of scientific actions while their learning. The paper will discuss the role of a virtual lab in the Biology practicum at Universitas Terbuka (UT) and the suitable type of virtual lab in biology practicum for Universitas Terbuka students. This paper is a meta-analysis study of the journals and articles about virtual laboratories. There are about 17 journals and articles used, starting from 2001 to 2021, except that this study involves preliminary data from UT students who attended biology practicum courses during the Covid-19 pandemic. The sample of the students is 33, and it used purposive sampling. The data analysis is descriptive. The research recommends using the virtual laboratory to advance biological knowledge in biology practicum and Virtual Reality as suitable for urogenital system material because virtual lab provides many benefits as a medium of learning in biological practicum because it can represent the dissection of animal urogenital organs so that students will more easily understand the material. 3D simulation in Virtual Reality should provide an exciting and meaningful learning experience for students.

Keywords: Virtual lab, Virtual Reality, Urogenital System, Biology Practicum, Universitas Terbuka



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INTRODUCTION

Biology practicum in higher education is a critical activity that supports the Biology learning in the course. Practicum drives student learning through observation, experiment, or testing of a concept. Its principles relate to strengthening students' understanding of scientific knowledge and actions inside and/or outside a laboratory. Additionally, practicum strongly promotes scientific skills improvement of students (Kusmawan, 1998) through activities of fostering or increasing students' observation skills, stimulating their curiosity, and improving students' accuracy, objectivity, and honesty (Budiastra, 2020). Hofstein & Lunetta (1982) said that laboratory courses foster more robust potential advantages than a classroom activity. Assessed students' abilities to ask questions in inquiry-based laboratory activities are better than students in conventional courses (Hofstein et al., 2005).

Moreover, with the Pandemic Covid-19, students' access to the Biology practicum has more limitations. UNESCO recognized that the coronavirus pandemic has a very bad impact on the education system around the world (UNESCO, 2020). The coronavirus (Covid-19) affect income level of the state (Wajdi et al., 2020). As Pujari (2020), coronavirus affects all areas of the education system, examination, and evaluation; it starts from a new semester (term) and extends the school year.

UNESCO began to implement the practice of distance education to address some of the risks of this pandemic.

Distance learning is the education system provided by an online learning environment and on which research has been undertaken (Akimov & Malin, 2020; Bose, 2013; Lee, 2017; Dean Nielsen, 1997;

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Ramos et al., 2011; Raygan & Moradkhani, 2020). Distance learning is different from face-to-face education, shown in the learning set by the physical attendance of the teacher and students. The delivery modes change from face-to-face education to distance learning, and so do the learning outcomes (Košar, 2021).

Distance education provides solutions in the form of educational applications, platforms, and resources to help teachers, students, also parents. A digital learning management system, a massive open online course platform, and self-learning content (UNESCO, 2020) constitute a solution to cover this problem with the adaptation of Virtual Laboratory.

A virtual laboratory is proven to be an important educational medium to overcome the problem of lack of practical experience in education (Kfir, 2005). The virtual laboratory provides a simulated version of a conventional laboratory with a student-centered approach. Students are fully equipped with virtual representations of natural objects used in the conventional laboratory (Faour & Ayoubi, 2018). The use of a virtual laboratory offers student's opportunity to investigate situations that cannot be tested in areal-time without speeding up or slowing down (Becker, 2005).

Related to this, Universitas Terbuka (UT) has been applying a distance learning system since 1994. Universitas Terbuka has the vision to become a qualified world open and distance higher education institution in generating academic programs, as well as in implementing, developing, and disseminating information on open and distance higher education. It is one of the missions of Universitas Terbuka to conduct research and develop an open distance-education system (Belawati et al., 2012)

As in Ratnaningsih (2013), Universitas Terbuka (UT) provides a very wide range of learning opportunities and assistance services for everyone without time barriers. The open and distance education system has enabled UT to attract all communities in the most remote areas categorized as the least privileged.

In facilitating the biological practicum constrained by coronavirus disease, UT seeks to make breakthroughs to support creating facilities used in distance learning. One of them is by holding a webinar tutorial (Tuweb). The Tuweb is an online tutorial mode that is *synchronous* (at the same time) and non-contiguous (not side by side), where interactions between tutors-students, and students are conducted in the same time (real-time) but in different spaces/places (Universitas Terbuka, 2020). Unfortunately, the practice of Biology courses implemented by Tuweb still contains some constraints. Students are still practicing a total face-to-face and a blended system practicum in some areas, even though some somewhat dangerous risks, considering the pandemic has not entirely disappeared.

Biology practicum held Tuweb also causes polemics where students lack knowledge and skills in real. Sometimes, students do not perform the procedure of practicum independently as they should, even though there have been guidelines for the implementation of practicum. Some practicum topics can only be done by a few students, namely those related to the body's metabolic system: blood flow, muscle system, respiratory system, urogenital system, and respiration system.

With these concerns in mind, we convened a working group of researchers and educators to address two questions concerning the future of virtual Lab in biology: (1) Why are virtual Lab essential to advancing biological knowledge in biology practicum? Moreover, (2) Which ones of the Virtual Laboratory design are better for biology practice in higher education, especially in Universitas Terbuka? Here, we explore each of these questions from the study literature.

THEORETICAL PERSPECTIVES

Literature Review

What is a Virtual lab?

As an intermediary solution for practicum materials, a virtual lab is an interactive environment for creating and conducting simulated experiments involving experiments with domain-dependent simulation programs (Larby-Apau, 2020). A virtual laboratory can also be explained as one where the student interacts with an experiment or activity that has no immediate physical reality or is intrinsically remote (Haltherly, 2009).

The virtual Lab (Virtual Laboratory) in biology was first used to assist students in learning abstract concepts or difficult-to-visualize topics (Dyrberg et al., 2016). Virtual Lab has many benefits for students. Virtual Laboratory offers students to get the individual experiences as additional material to prepare a manual laboratory or provide experiences similar to the conventional laboratory. It was helpful to show science as a process, emphasize scientific concepts and build students' understanding of the phenomena, objects, also environment. It also makes students manipulate and observe variables, objects, and processes. They can also understand the relationship between discovery, science theory, and empirical evidence (Vincenti et al., 2014; Whittle & Bickerdike, 2015; Hotaling et al., 2018).

Types of virtual Lab

The virtual Lab has several designs in its implementation. Kyle et al. (2017) mention 3 types of virtual Lab, which are commonly discussed in pedagogical research: supplemented virtual Lab or hybrid, remote Lab, and simulated Lab or completely virtual.

In remote Labs, students conduct the experiment outside of the physical Lab by utilizing web applications that enable actual equipment to adjust the feedback directly from the commands and inputs of the user (Waldrop, 2013). The use of remote Labs also fosters students' lab usage outside the campus, potentially mitigating their fears in the hands-on Lab and broadening their skills development (Alves et al., 2016). Similarly, remote Lab also improves the distance-learning potential, which improves the accessibility of disabled people and it increases laboratory safety. (Heradio et al., 2016). Brinson in Viegas et al. (2018) explained that these resources might offer students to observe unobserved phenomena, minimizing distraction, facilitating faster results, and taking less time to organize.

In an entirely virtual (simulated) lab, the student can conduct an experiment on web applications, animations, and user inputs to customize the different parameters to observe theoretical results with visual representations on a particular piece of technology, such as a tablet, smartphone, and computer) without coming into contact with actual samples or equipment (Tatli and Ayas, 2010). Another type of virtual laboratory has supplemented Virtual Lab. Virtual lab blends some of the simulation aspects with physical experiments by using take-home laboratory kits. Kits consist of various materials and equipment that students use to finish the experiments (Flowers, 2011). Supplemented virtual Lab are also known as hybrid lab.

Virtual laboratories can also be distinguished based on their forms, namely virtual reality, augmented reality, and mixed reality.

Virtual reality (VR) is the engineering of a real environment projected on a tool. The sensation of using virtual reality will be felt by the human senses so that users will be able to immerse themselves in a 3D artificial world.

Novak (2014) presents four basic elements of virtual reality: Virtual Presence, Virtual Environment, Sensory Feedback, and Interactivity. The virtual environment is an environment that is simulated by a computer, in the form of an actual environment that is imitated or an environment that only exists in the imagination. Virtual presence is defined as a person's feelings while in a virtual environment. Users interacting with virtual objects should interact with real objects. Therefore, the user represents their feelings in a virtual environment (Putro et al., 2015). On the other hand, a virtual environment is an environment simulated by a computer, in the form of an actual environment that is imitated or an environment that only exists in the imagination (Novak, 2014).

The next basic element is sensory feedback. Sensory feedback is a very important component of virtual reality. Virtual Reality will provide direct sensory feedback through visual information. The system provides direct sensory feedback to users based on their physical location. The use of virtual reality is certainly inseparable from the element of interactivity. Interactivity is one of the most talked-about new media features, gaining a special place on the internet.

Jancowski et al. (1996) define interactivity as the degree of participation in communication that has control and can exchange roles in mutual discourse. By using the concept of mutual discourse, interactivity can be divided into three levels, namely: 1. User-to-user conversations. Conversations

between people with mediums or people with systems where content can be manipulated (e.g., videotex); (user to the system) 3. Conversations that occur between users to change the content (e.g., teletext) (user to document).

Virtual reality has been widely applied in various fields, including as listed in the following Table 1.

Table 1: Diverse applications of Virtual Reality in a variety of fields (Mathew, 2014)

Fields	Description
Military Application	Air Forces VR research program at Wright-Patterson AFB leads to the development of heads-up displays (HUDs) for flight simulators.
Commercial Applications	Virtual tours can be induced for the building, which is still in the process of using the architectural design.
Virtual Sets Text-Based VR	Text-Based Virtual Reality Construction of virtual worlds with readily available materials-a computer keyboard.
Medicine	It helps in the docking of molecules using auditory and visual displays.
Marketing	It draws people to exhibits and involves them with a product much more than standard displays.
Entertainment	Includes video arcades based on a Virtual Reality system

The second form is augmented reality (AR). Augmented Reality (AR) is a technology that involves the overlay of computer graphics in the real world. The concept of Augmented Reality was first introduced by Thomas P. Caudell in 1990 with the term 'Augmented Reality'. Augmented Reality is developed on Virtual Reality's techniques. It interacts not only with a virtual world but has a degree of interdependence with the real world (Mekni, n.d., 2014). There are some aspects of the consideration to design an Augmented Reality: (1) There must be a combination of virtual and real worlds; (2) there are interactivities in a real-time; (3) Registration in 3D (Silva et al., 2017). Silva (2017) also explained three components of Augmented Reality such as scene generator, tracking systems, and display. Augmented Reality has its own advantages. Speicher & Hall (2019) said that it's mainly characterized by an expert environmental understanding as well as interactions. Both the virtual objects with the user and the environment with the virtual objects. Pemanfaatan media Pendidikan menggunakan Augmented Reality (Mustaqim, 2016) can stimulate the mindset of students to think critically of problems and events that exist in everyday life because the nature of the educational media is to help learners in the learning process with the presence or absence of educators in the educational process.

Another form of virtual laboratory is mixed reality. As the term, mixed reality is a combination of Augmented Reality and Virtual Reality technology. Mixed Reality systems are planned to give the illusion for the about the digital objects where is in the same space as physical ones (Costanza et al., 2009). A Mixed Reality system has been aimed to provide navigation guidance. It means that the users can see the virtual signs anchored to the physical world. It has a similar concept to a compass that indicates the right direction regardless of the device's orientation (Costanza et al., 2009)

Urogenital System Characteristics in Biological Practicum

The urogenital system is built on two systems, namely the urinary system (excretion) and the genitalia (reproduction) system (Figure 1)

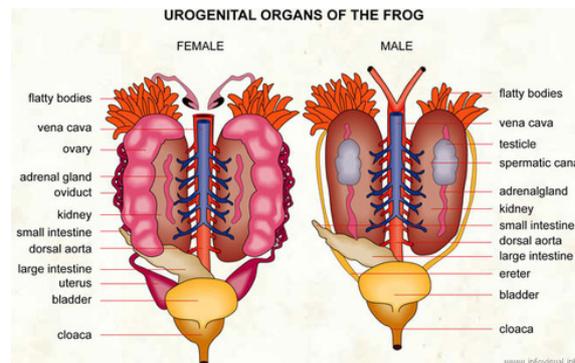


Figure 1. Urogenital Organs of The Frog (Dery, Bernard, 2016)

The urinal system removes unnecessary or harmful waste from the body in the form of a solution by intermediary kidney organs. The genitalia system produces genital cells (gamete) and the proliferation of organisms (Haryani et al., 2016). Biological practicum related to the topic of the urogenital system is typically implemented in groups through wet laboratories in collaboration with Universitas Terbuka. However, during the covid-19 pandemic, some students in the are become constrained in practicing this topic, requiring additional teaching materials that can provide an overview of the urogenital system.

Research Method

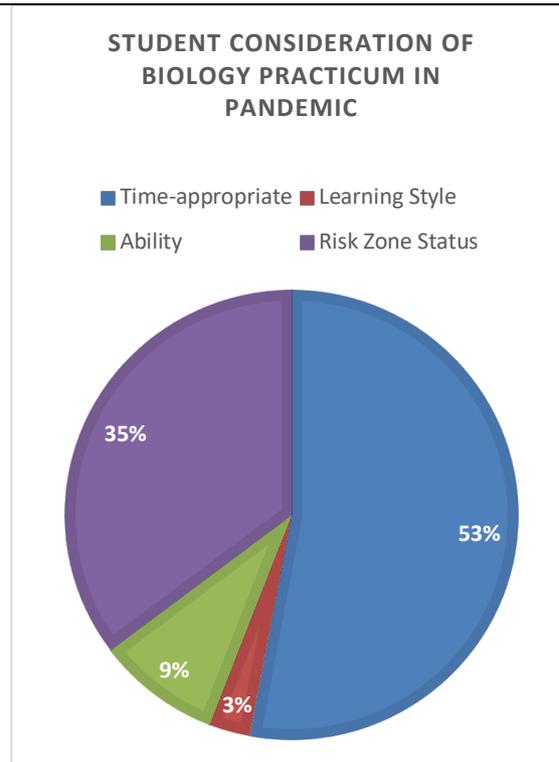
This research is qualitative in a meta-analysis of various works of literature, including journals and articles obtained from various sources. There are about 17 journals and articles used, starting from 2001 to 2021. The journal is related to the use of virtual laboratories in learning.

In this study, preliminary data contains the experience of biology education students at Universitas Terbuka who have followed biology during the Covid-19 pandemic, using blended methods and face-to-face methods (with some prerequisites). The samples of students in this preliminary data are 33 students. The samples were taken through purposive sampling techniques, with several considerations such as (1) the samples are the biology education student at Universitas Terbuka; (2) the samples have followed one, two, or three courses of biological practice (biology practicum 1, biology practicum 2, practicum IPA); (3) Samples have been registered to follow the biology practicum during the registration period 2020.2 or 2021.1. The instrument used to obtain the preliminary data is a self-reflection questionnaire with open and multiple-choice questions. The data is analyzed descriptively to overview the student experience and how far students know about the virtual Lab.

FINDINGS AND DISCUSSION

1. An Overview of Students' experiences in the Biology Practicum Courses

Since the Covid-19 pandemic, biology practicum at Universitas Terbuka has been implemented through three modes, namely Webinar Tutorial mode (Tuweb), face-to-face mode, and blended mode (combined Tuweb mode and face-to-face mode). Biology education students at Universitas Terbuka can choose one of the three mode options according to the consideration of the covid-19 risk zone map. Some of these obstacles are contained in Figure 1 below.



Based on Figure 1, there are some students' considerations in following practicum activities. Most (53%) of them are constrained by the limited time they have. It is known that students of the Faculty of Teacher Training and Education of Universitas Terbuka are status as teachers. Therefore, of course, it has limited time when participating in practicum activities with learning modes other than face-to-face, for face-to-face learning mode is also done simultaneously in several meetings. The second biggest obstacle chosen by students is the risk constraint of the Covid-19 spread zone. Most students prefer practicum activities directly. Student ability and further learning style are mentioned as other obstacles recognized by students who experienced them when following the practicum. Brown's learning style (2000) is defined as a way of perceiving and processing information when in a learning situation. One's learning style, in this case, students can be distinguished into several types such as auditory learning style, namely students who are more receptive to lessons through hearing, and visual learning style, namely students who easily understand and capture learning concepts by looking (visual), then there is also the kinesthetic type that is students. It is easier to directly practice what is heard or seen (kinesthetic) (RudiHartono, 2013).

Due to the many learning constraints in the pandemic period, including in practicum activities, Universitas Terbuka responded by providing three modes of learning for biology practicum courses. The three learning modes are web-based tutorial teaching us mod (Tuweb), us mod face-to-face learning, and blended mode (a combined learning model between us tuweb mod and face-to-face u mod). Biology education students at Universitas Terbuka can choose one of three fashion options according to the consideration of the covid-19 risk zone map. Figure 2 below illustrates the participation of biology education students in the biology practicum during the Covid-19 pandemic.

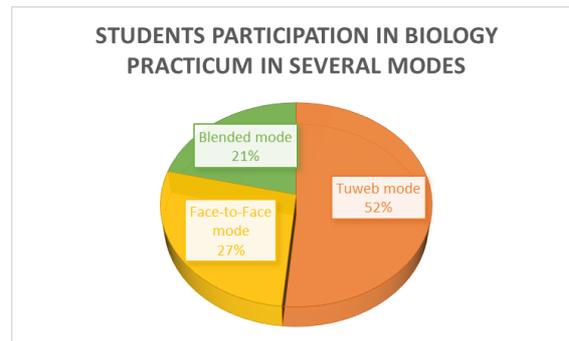


Figure 2. Students' Participation In Biology Practicum In Several Modes

Figure 2 describes the mode of biology practicum chosen by 33 Universitas Terbuka biology education students during the 2020.2 registration period and the 2021.1 registration period. The sample of students follows one or both or all three types of practical courses held during both registration periods. The three practical courses are biology practicum 1, biology practicum 2, and science practicum.

Based on the data, most of the students who filled out the questionnaire have chosen Tuweb mode for biology practicum learning; there are as many as 17 students (52%), nine students who chose face-to-face mode (27%), and other students (21%) choose to use blended mode. Some students state if they are given a choice and possible situation, then they will certainly have a face-to-face biological practicum. This is in line with the results of Koşar (2021), which explains that in distance teaching practicum, the participants had no idea about how to improve the quality of distance teaching practicum as they did not believe that practicum courses could be conducted through distance education. So that, according to their perspective, it should be done face-to-face than held by tuweb.

Tuweb Mode, introduced by Universitas Terbuka in 2020, is a biology practicum mode that is widely chosen by students. Tuweb is one of the distance learning solutions that can be used safely to reduce the spread of Covid-19. Tuweb is also used in mixed mode. That is, some practicums are done face-to-face, but others are done through Tuweb. In addition, face-to-face practicum mode also remains an option for students in the safe zone. Krihti Meta (2020) describes the description of a safe zone (*green zone*) as a zone with no confirmed positive cases or within a certain time range. While in the other two zones, called red zones (*RedZone*), is an areas classified as a hotspot with many confirmed positive cases, and the orange *zone* is an area with several confirmed positive cases (moderate risk). Nonetheless, each mode of biological practicum has constraints for the student. Some of these obstacles are contained in Figure 3 below.

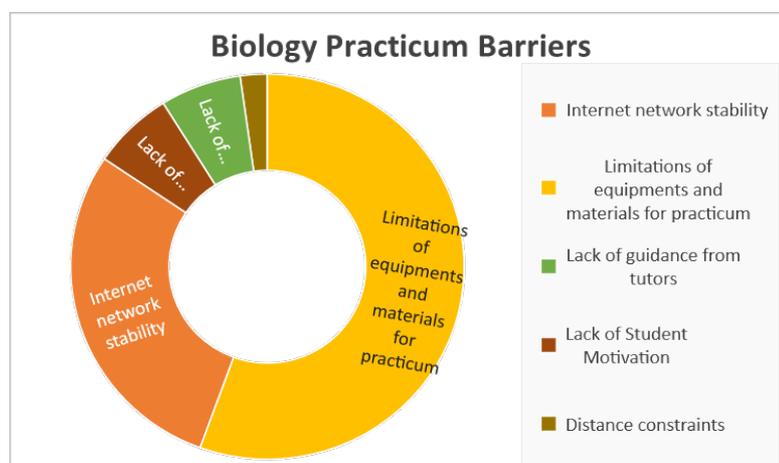


Figure 3. Biology Practicum Barriers

Based on figure 3, there are several obstacles to biology practicum learning through the three practicum modes offered (Face-to-face, Tuweb, and *Blended Mode*), including students who choose to use Tuweb and *Blended Mode* learning modes. , then the obstacle experienced is 55% in the form of difficulty getting equipment and practicum materials. In Tuweb mode, students often complain about the stability of the internet network because many of them are located in less stable areas to follow online learning. In addition, they may experience a lack of guidance from tutors and be confused due to the absence of other learning media that can give an idea to perform practicum activities independently. The face-to-face learning mode also has its own obstacles, namely the distance constraints of student residence locations with partner laboratory locations in the area. The other obstacle comes from the student himself, namely motivation. Motivation is defined as a conscious effort made to move, disturb and maintain one's behavior in order to be encouraged in achieving certain results or goals (Hamdu, 2011). Motivation to learn is very influential in determining the success of students in learning. (Nashar, 2011) because students who have high motivation will get high learning results as well. Thus, realized that the higher the student's learning motivation, the effort efforts made will be the maximum that will increase student learning achievement.

Some of these obstacles occur in several topics of biology practicum, both in the courses of Biology Practicum 1, Biology 2 Practicum, and Science Practicum.

2. Suitable Design of Virtual Lab for Urogenital Practicum

Based on the preliminary data analysis from students' experience following a biology practicum during the pandemic period, Virtual learning media is needed to support online practicum learning. This is in line with the results of the study. Efendi & Sartika (2021) that practicum cannot be done directly in the laboratory, so it requires a virtual laboratory to perform practicum activities. Virtual Reality (VR) has been recognized and proposed as a significant technological advancement that supports lifelong education for individuals along with a flexible workforce. (Kfir, 2005). One of the unique characteristics of Virtual Reality is the successful of abstract concepts translation into visualized events, along with the users' interaction in real life could be limited due to safety, time, and distance factors (Alexiou et al., 2004).

The virtual lab planned to represent the practicum of the urogenital system is a 3D simulation of a natural laboratory where learners can do the experiment on urogenital organ dissection equipment by carrying out specific learning scenarios. Virtual Reality is being accessed in study mode. In the study mode, the user can interact with the environment without the presence of other users. Intelligent learning modeling makes it easier for users to perform dynamic actions on available virtual space equipment.

By using virtual reality, virtual learning in virtual laboratories allows for the creation of virtual tours. A virtual tour is a simulation of a real environment, consisting of a collection of videos or panoramic photographs, a collection of images connected by hyperlinks, or a virtual model of an actual location that, in this case, is the laboratory where the user works.

CONCLUSION

From the exposure described above, it can be concluded some of the following:

1. A virtual lab provides many benefits as a medium of learning in biological practicum because it can represent the dissection of animal urogenital organs so that students will more easily understand the material. The use of virtual labs will provide a real-life picture that will guide students to perform difficult practicums. 3D simulation in Virtual Reality should provide an exciting and meaningful learning experience for students.
2. Virtual Laboratory design that is appropriately used in the biology practicum of the urogenital system is a form of Virtual Reality (VR) that is a 3D simulation that can represent the dissection of an animal's urogenital system.

LIMITATIONS AND FURTHER RESEARCH

This research is the initial stage of research on the development of virtual laboratory learning media that can be used as a supporting learning medium for biology practicum courses for Open University students. Further research is the development of virtual laboratory media as a medium of learning for biology practicum courses.

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