Proceeding Biology Education Conference p-ISSN:2528-5742
Vol. 17, No.1
Page:133-140 July2021

Students' Responses and Expectations about the Opportunity of Virtual Laboratory Using in Genetics Courses

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Abstract. This study was conducted to describe students' perceptions about the genetic course, laboratory experiment, laboratory facilities, and also students'expectations about the development of the virtual laboratory as an alternative experiment in Genetics Courses. A descriptive quantitative method was used in this study. The participants involved were 49 students enrolling in a genetics course at a public university in Banten, Indonesia. Data were collected through a set of questionnaires. To analyze the data,we employed a descriptive quantitative approach in the form of a percentage. The results showed that the genetic course was considered difficult by the students. The reason is that the material is abstract, and the source of learning is difficult to understand. The most commonly used learning media in the lecture is Power Point.Learning strategies are oftenused,i.e.,the discussions and laboratory work in the laboratory. Students need interesting, communicative, and interactive learning media. The student response is enthusiastic about virtual laboratory development. The expected virtual laboratory criteria are can be used offline, looks interesting, easy to operate, and containsaudio-visual.

Keywords: Students responses, Genetic courses, virtual laboratory.

INTRODUCTION

In science education, laboratory experiments have been given a prominent and distinct role.Students can acquire theoretical knowledge through classroom learning, but they will only gain experience and practical knowledge through hands-on laboratory activities. Through hands-on activities, students could develop and deep en scientific knowledge, the basics of scientific work, the ability to think in complex ways, and connect theory with practice. Hands-on activitiesalso can result in skills, such as manipulating instruments and objects that cannot be achieved through other methods of schoolwork [1].

Genetics is one of the branches of biological sciences that is involvingexperiments activities. Genetics is the study of heredity, which means the study of genes and factors related to all aspects of genes[2].The sophistication of the issues highlighted in Genetics necessarily requires comprehensive investigation, appropriate laboratory techniques, and learning strategies that can encompass the concept proficiency of students [3].Besides, students would better understand the concept of genetics through experiments activities.Unfortunately, the limitations of laboratory facilities become an obstacle to the implementation of experiments in genetics courses, particularly those related to population genetics and molecular genetics topics.

The application of virtual laboratory media to integrate information and communication technology into learning can be an alternate way of overcoming the restraints of the laboratory infrastructure[4].A virtual laboratory is an interactive computer-based virtual laboratory that integrates various multimedia components into text, images, animation, sound, and video[5]. Virtual laboratories are simulation learning environments that allow students to conduct experiments in the real laboratory [6]. The virtual laboratory allows the structure of the material model to be represented, a prerequisite for a good understanding of the structure of the hardware partition[7].Students' understanding of using a virtual laboratory is better than science classes without visualization elements[8].The virtual laboratory enables interactive learning about the frameworks and protocols of biological and biochemical studies, the function of appropriate apparatuses, including the adjusting variables, and the creation of findings[9].

Laboratory laboratory has been applied in several academic higher educations, mainly in life sciences, includes chemistry[10], [11], Physics[12], [13], [14]and biology[3], [4], [15].A pilot study suggests that using a virtual laboratory to teach chemistry experiments can be beneficial[10].The use of virtual labs in electrical concept learning aids students' ability to solve physics problems[13]. Unfortunately, so far, no research has been found on how students respond and are expected to virtual labs, especially in genetics courses.Whereas, this information is important as the basis for being able to develop a virtual lab that suits the interests and needs of students. Utilizing virtual labs has the potentialto increase student achievement, foster conceptual change, and improve students' attitudes towardsbiology if they are designed according to students' learning needs[16].Therefore, this research is needed toassess students' perceptions of genetics courses, experiment activity, and laboratory infrastructure. Alsoto assess students' expectations of virtual laboratory developmentas an alternative experiment in Genetics courses.

METHOD

This research using a descriptive quantitative method.The present study recruited 49 students enrolling in the genetic course of Biology Education Department of Universitas Sultan Ageng Tirtayasa, Banten, Indonesia. Students’ responsesand expectationswere measured using a questionnaire sheet. The questionnaire consists of 30 questions which include 12 closed questions with a choice of yes or no answers, 8 semi-closed questions by providing several alternative answers, and 10 open questions that will explore students' perceptions of genetics learning, experimental activities,laboratory infrastructure facilities, and also students’ responses and expectations of the development of the virtual lab.This questionnaire has been validated by a senior lecturer of the Biology Education Department of Universitas Negeri Malang, Indonesia. The data were analyzed using a descriptive quantitative approach in the form of a percentage refers to each criterion of students' responses.

RESULT AND DISCUSSION

Students’ Perceptions of Genetic, Experiments, and Laboratory Infrastructure Facilities

Theanalysisshowedthat,accordingto52%ofstudents,geneticwasdifficulttounderstand(Figure1).This finding is in line with the results of other studies that genetics is one of the difficult subjects for many undergraduate students majoring in biology[17], [18].Even though genetic concepts are frequently covered in high school and college biology courses, college students struggle to understand genetics[19].Students' difficulty in studying genetics leads to low mastery of concepts and learning outcomes in genetics courses. Despite the importance of genetics in everyday life, biology undergraduates students have a poor understanding of some key genetics concepts[20].

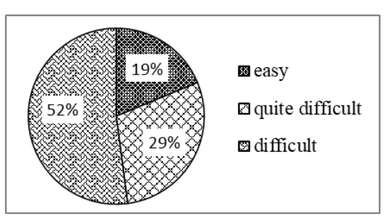

FIGURE 1. Student’s perceptions of genetic course

Most of the students (55.1%) contended that the abstract characteristic entailed in genetics had been the most challenging issue in understanding the course. In addition, 44.9% of the students argued that the learning resources used are also difficult to understand. Besides, the learning media used by the lecturer is less interesting for the students (40.8%) (Figure 2). The abstract character entailed in genetics hampered students from understanding the genetics course [21], [22]. Many foreign terms used in genetics also hinder students' understanding[23]. Students are generally unfamiliar with the biology terms and are often confused with certain terms that seem similar [24]. Furthermore, many students are having difficulty connecting genetics concepts at the macro, micro, and sub-micro levels[25]. The provision of learning materials is rarely linked with issues relevant to life, therefore, students were less motivated by biological material.

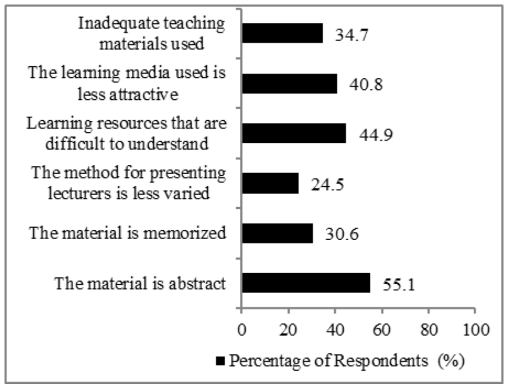

FIGURE 2. Factors hampering students' understanding in a genetics course

The results of the questionnaire analysis showed that the concept of genetic engineering was considered the most difficult concept (59.2%) (Figure 3). This concept is very abstract and hard to imagine. This concept is also complex and complicated because it includes the basic concepts of genetics that play a role in genetic engineering technology and the techniques that play arole in genetic engineering technology. This abstract and complex conceptual character makes it difficult to understand the concept of genetic material engineering. Genetics is a complex subject and uses many foreign terms so that students often encounter difficulties[24].Whereas proficiency in genetics language is required for involvement in most genetics classrooms[19].

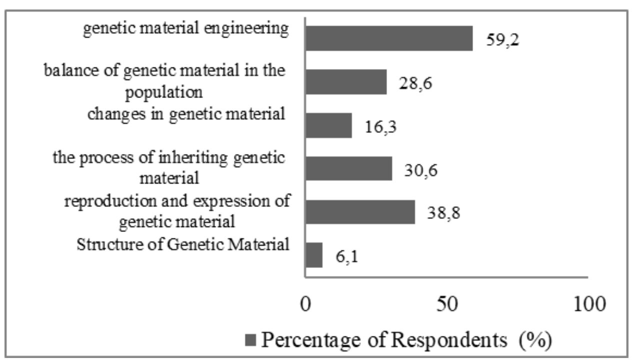

FIGURE 3. Genetics concepts that are considered problematic by students.

Several reports attempt to identify alternative genetics learning designs capable of overcoming the problem in the genetics subject. There are some design criteria for genetics courses that can help overcome the abstractness and complexity of genetics concepts. One of the criteria is that students should be able to recognize a familiar phenomenon while learning [26]. Experiment activity is one type of learning activity that can bring a phenomenon into the classroom. In terms of practical activities, a good practice allows students to perform activities similar to those performed by real researchers[18].

The experiment activity on a genetic course included an experiment on the concept of genetic diversity by observing the diversity of colors and the number of rose petals. In the concept of opportunity, the experiment is done with coins.While in the concept of population genetics (The Equilibrium Law of Hardy Weinberg), studentswere used genetic buttons. The experiment of the concept of genetic material engineering has never been implemented because of the constraints of laboratory facilities and infrastructure. In the laboratory, there is no equipment and material necessary for the internship in genetic engineering. This is consistent with the response of students that the available infrastructure laboratory in their university department is incomplete (69,40%) (Figure4).

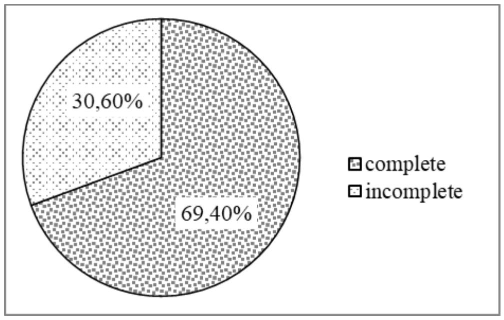

FIGURE 4. Students' perceptions of laboratory infrastructure facilities.

The lack of experiments on the genetic material engineering concept leads to an incomplete understanding of the students. Factual, conceptual, principled, and procedural knowledge of students has also become unmet. Students will difficult to understanding the experimental procedure and the research methodology without doing any experiment [27]. Conversely, through hands-on activities, students can improve their understanding of the concept. Through laboratory experiment activities, students can observe the nature of science that is very important to improve their understanding of scientific concepts.

To overcome the problem of learning difficulties, students propose alternative solutions in the form of the use of interesting multimedia learning (87.8%) (Figure 5). Multimedia learning should increase student motivation and interest in genetics. Multimedia can also improve students' understanding of genetics concepts. Multimedia provides a rich learning experience and allows students to focus and engage in learning. In the learning process, multimedia applications not only provide concrete experiences but also assist students in integrating old and new experiences. Multimedia technology strengthens the educational process by increasing interaction between teachers and students. During practice, the use of multimedia technology applications can help students understand the material being taught in greater depth while also overcoming the limitations of space, time, and equipment.Multimedia is dynamic, when it is integrated into education, it creates a new learning concept that combines an educational and entertaining approach[28].

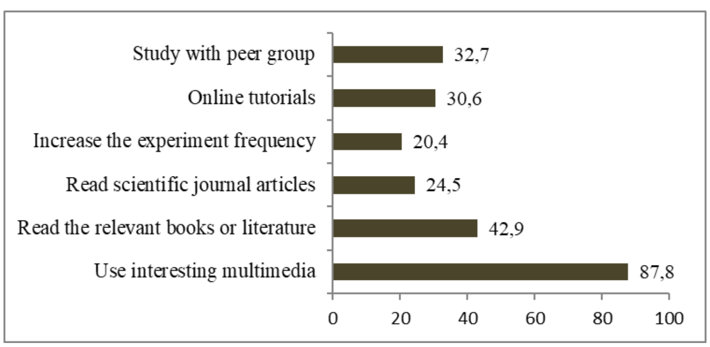

FIGURE 5. Students' proposed activities to overcome the problem of genetics learning difficulties

The learning media that students believe can help them understand the concepts of genetics are Power Point (53.1%), Internet(49%), handout (44.9%), and virtual laboratory (34.7%) (Figure6). Power Point media is often used by speakers in genetics courses. The PowerPoint medium used by the speaker, in addition to containing descriptions of material, also contains animate dimages and videos that help students understand the abstract concepts of genetics. Speakers also distribute materials to students to study independently. In addition, students also use internet media to deepen the course content. The virtual course materials were also used by genetic teachers during the 2016/2017 school year. However, the use of all these media did not improve the cognitive learning outcomes of the students. The cognitive capacity of students is still low, with an average score of 66.3,the highest score of 91,and the lowest of 48. Not all these media have been able to develop the concept, the principle, the procedure the delivery of the material is informative. The poor understanding of the concept of genetics in students is due to learning that requires only the ability to recall factual information[17].

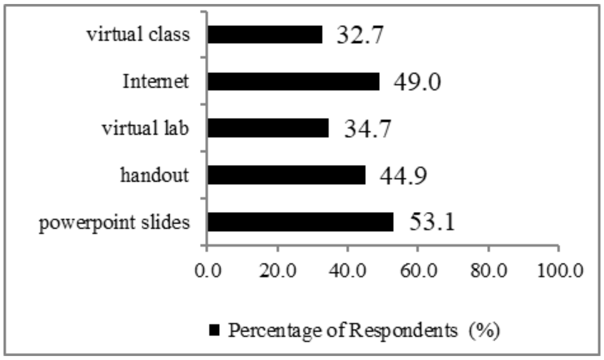

FIGURE 6. Media used by lecturers in the learning of genetics

Students' Responses and Expectations of the Development of Virtual Laboratories

The results of the questionnaire analysis showed that 75.5% of the students were don't know about the virtual laboratory (Figure 7). The remaining 24.5% of the students find out about the virtual laboratory. According to students' knowledge, the virtual laboratory is laboratory learning activities or laboratory using off-line or online multimedia, without contact with teachers, and must be connected to the internet. Students also said that virtual laboratory is learning through interactive multimedia as if they were doing laboratory work in a wet laboratory. Students feel considerably more competent and comfortable using laboratory equipment after completing cases provided in a virtual laboratory, which has the potential to improve pre-laboratory preparation [3]. Therefore, virtual labs can be used in place of hands-on activities as an alternate way of overcoming the restraints of the laboratory infrastructure [11].

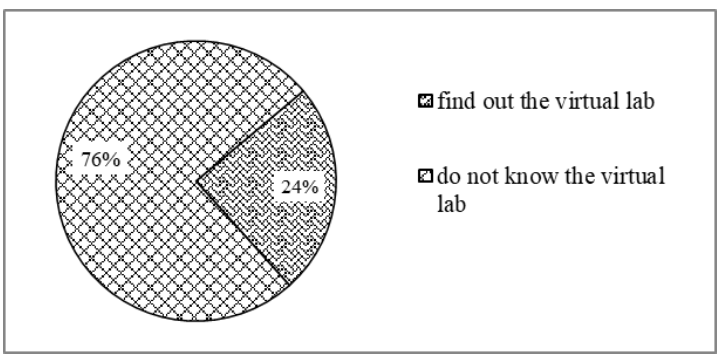

FIGURE 7. Student knowledge of virtual laboratory

About 45% of students agreed and 43% strongly agreed with the development of the virtual laboratoryas an alternative experiment in Genetics courses(Figure 8). According to the students, a virtual laboratory is very well developed to enrich the student experience. Most of the students responded positively to the virtual lab in the study of Genetics. The virtual laboratory is also considered to support learning in the 21st century. Students also indicate that with a virtual laboratory, learning will be more interesting, imaginative, effective, and efficient. The virtual laboratory can also increase students' curiosity, so they do not get bored in their learning. Besides that, the virtual laboratory is considered to be able to motivate the min class.The virtuallaboratorycanimprovestudents'understandingofconceptsandmotivation[29], strengthen theoretical understanding, and increase enthusiasm for learning[30]. Moreover, the virtual laboratory can increase student interest and learning motivation[31]. Virtual laboratories for biology can support students to explore and visualize abstract concepts in learning biology[15].

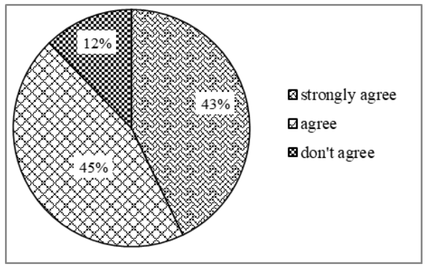

FIGURE 8. Student Response on Virtual Laboratory Development

The student expectations are the virtual laboratory that will be developed will be communicative,have audio-visual, look attractive,usable offline,easy to operated, interactive and have animation(Figure9). A communicative and interactive virtual laboratory should increase the motivation and enthusiasm of students. The ability to provide interactive learning experiences is the best virtual laboratory character[29]. The interactions and interactivity in technology-based instructional materials have become synonymous with enhanced learning quality[28].

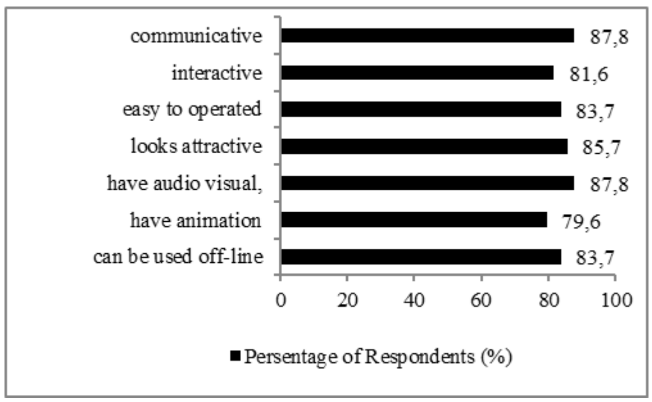

FIGURE 9. Students' expectations of Virtual Laboratory

The animation in a virtual laboratory is very important to change the character of the genetic material that is abstract into concrete because the animation can describe the structure of very small genes and that we cannot see with thenakedeyeinimagesanimateddirectlyvisible.Theanimationcanalsodescribetheimportantprocessesthatoccur in cells, related to DNA replication, gene expression, and genetic engineering. This important process is difficult to understand without images or animation. Animated visualization that shows both structure and process can help studentsunderstandtheconceptsandimportantrelationshipsbetweentheconceptsofmolecularbiologymaterial[32]. Students had a good understanding of the mechanisms of the experimentsthrough using the virtual lab.Although students were not able to physically conductthe experiments, they were able to use their computers tocarry out the experiments through simulation activitiesin which they had to complete the experiments step-by-step[33]. Animation visualizes molecular processes and thereby helps the student to understand the theory. Moreover, an actual virtual lab with visualization of equipment and techniques can help students to know the procedures of the experiment activity.The virtual lab is an effective supplement to traditional teaching activities[34].Therefore, a virtual lab must be designed in such a way as to meet all student expectations for its development goals to be achieved. Virtual labs should also be able to help students understand experimental procedures, particularly on the concepts of population genetics and molecular genetics.

CONCLUSION

This study has documented that the genetic course is considered difficult by the students (52%). The main cause of students' difficulties in genetics courses is the abstract characterof genetic material (55.1%)and the source of learning is difficult to understand (44.9%). The concept considered the most difficult is genetic material engineering (59.2%). PowerPoint is the most commonly used learning media in lectures. Learning strategies such as discussions and laboratory work in the laboratory are frequently used. Students require learning media that is engaging, communicative, and interactive. Approximately 45 % of students agree, and 43 % strongly agreeing, that a virtual laboratory should be developed as an alternative experiment in Genetics courses. Students expected that the virtual laboratory that will be developed is communicative and interactive, easy to operate, looks attractive, has visual and animated videos, and can be used offline.

ACKNOWLEDGEMENTS

This work was supported by the Indonesia Endowment Fund for Education (LPDP), Ministry of Finance of the Republic of Indonesia, through Indonesian Domestic Lecturers' Leading Scholarships (BUDI-DN) by contract number: 219619141081862.

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