The Effects of Virtual Laboratory on Biology Learning Achievement: A Literature Review

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ABSTRACT

The use of virtual laboratory in e-learning technology increasing. However, in reality, there are still many teachers/lecturers who are still unable to develop effective and efficient learning media, especially for biology education. So, it is necessary to analyze articles from the results of previous studies to understand suitable media for learning biology. One of the learning media that can be developed is a virtual laboratory. This study aims to analyze technological developments which are used as learning media in the form of virtual laboratories which include: (1) the level of education; (2) the type and research design; (3) relative frequency (%) based on the material used as learning content; (4) Research results related to virtual laboratory media in biology learning; (5) variables that are influenced by the use of virtual laboratories in learning. This research method is a literature review with 20 articles analyzed and 12 articles that meet the criteria conducted in national and international journals. The result of this literature review study indicate; (1) The level of education in senior high school using virtual laboratori more than 50%; (2) The dominant type of reseach in experimental reseach, namely RnD, which is 33,33%; (3) the use of virtual laboratories is material excretion system; (4) Nine out of eleven randomly selected articles suggested that the development of virtual laboratory media was suitable to support practicum activities; (5) variables that are influenced by the use of virtual laboratories in learning is more than 50%, namely achievement student, which is 57.14%.

Keywords: Learning achievement, Virtual laboratory, Biology bearning, Literature review.

1. INTRODUCTION

The development of science and technology which is increasingly fast requires the world of education to improve the quality of education. Benchmarks for the quality of education can be seen from the learning outcomes of students. Good learning will certainly result in good learning achievement. However, so far students still experience several problems in the process of learning science (biology).

Biology learning has some material that must be understood through an observation. So that learning directly in a unidirectional form makes it difficult for students to understand the material. The lecture method used makes learning look monotonous. Too often using the lecture method without using media makes students bored with learning. The impact is that the learning achievement of students can decrease.

The low learning achievement of students does not mean that they are caused by an error in the model or method used but the need for variations in learning. The application of technology in the learning process has a positive influence on the learning achievement of students. There are still many educators who have not used the existing technology maximally and even haven't known the new technologies in education. Even though with existing technology, educators are able to present more effective and efficient learning. The use of learning media is maximized in supporting students' learning achievement.

Learning media are anything that can be used to transmit messages (learning materials), so as to stimulate attention, interest, thoughts, and feelings in learning activities students to achieve learning goals. Biology learning media developed from media in the form of animal/plant preserves, torso, pictures, videos, powerpoint, interactive multimedia, until now the development of virtual reality or augmented reality. The development of biology learning media is currently also developing towards the use of the internet and big data so as to facilitate the spread of biology to all corners of the world, one of which is the virtual laboratory.

A virtual laboratory is defiend as a laboratory experiment without a real laboratory with walls and doors. This allows students to connect theoretical and practical aspects, without paper and pen. In addition, the virtual laboratory is defiend as a virtual learning and learning enviroment aimed at developing student laboratory skills. Usually, the virtual laboratory page has the main page & many links, which are related to laboratory activites & their achievements

Virtual laboratories are considered as the main support in electronic learning in scientific & applied fields [1]. This is through the use of different electronic programs that simulate experiments on a computer using different images, which express the experiment to be performed. The specific characteristics of the virtual laboratory are as follows, creating new intellectual models in educational is better than real, and more beautiful than the imagination; build knowledge and impart information; encourage and guide students; registers student information and evaluates it automatically [2]. Virtual laboratories cannot completely replace physical experiments in traditional laboratories [3].

In this literature review, a study of research articles that discuss virtual laboratory media in biology learning has been carried out in the last ten years which have been published in ISSN-reputed national journals and DOI. The articles used are all articles that discuss virtual laboratory media in biology learning in Indonesia and abroad, by searching online through SINTA and Google Scholar. Then the classification is carried out based on the type/research design used, the level of education, the content/material used, and the research results as content in the media being studied.

Based on this, the research problems of this literature review were formulated, including: (1) the level of education; (2) the types of research and design related to virtual laboratory media for biology learning; (3) relative frequency (%) based on the

material used as learning content; (4) Research results related to virtual laboratory media in biology learning; (5) variables that are influenced by the use of virtual laboratories in learning.

2. METHODS

This study uses a literature review design in which this research uses various kinds of literature in the form of books, journals, articles, news, and other relevant sources. Literatur review that which is a statistical technique that combines the results of previous studies with similar problems, so that a quantitative and systematic data mix is obtained, with the aim of drawing a conclusion. In analyzing journals/articles for literature reviews, 4 steps are used, namely problem formulation, search for literature, data evaluation, and analysis and interpretation.

In this literature review, data collection was carried out by collecting research result from scientific articles related to virtual laboratories ans their use in learning by searching for journals, theses, essays, scientific articles related to virtual laboratories via the internet. All studies published between 2009 and 2019 are the last 10 years of research whose research results are to strengthen authors in analyzing them and focus on developing virtual laboratories in Biology learning.

Data were collected by identifiying the observed variables through coding methods. The coding is carried out in accordance with the research variables: "the level of education, the type and research design, the content/learning material, the research results and variable that are infuenced". Furthermore, the collected data were analyzed using descriptive statisticsal techniques.

The population in this study are all written documents regarding educational research that discuss virtual laboratories. The sample used was 12 research articles. The research samples were taken using a purposive sampling technique. This is because the data or information to be obtained from the sample is determined based on it's suitability with the theme of this research The data analysis used was quantitative data analysis with percentages and qualitative data analysis for data from the results of narrative study of the studies encountered. The articles analyzed were 20 articles, but those that met the criteria were 12 articles taken from national and international journals. The distribution of the 12 research subject articles can be seen in the groups in Table 1.

Table 1. Distribution of sample articles

No.	Reference	Year	Education Level	Content/ Material	Type / Research Design
1.	[4]	2016	High school	Excretion System	*Reflective, Recursive, Design, and Development* (R2D2), with quasi-experimental methods (quasi-experimental methods)
2.	[5]	2016	Junior High	Blood group	ADDIE (Analysis, Design, Development & Production, Implementation, and Evaluation).
3.	[6]	2018	High school	Invertebrates	*weak experimental design.*
4.	[7]	2019	High school	Tissue Culture (Biotechnology)	4D (define, design, develop, disseminate)
5.	[8]	2018	High school	Internal organ	*Research and Development* (R&D). Plomp development MODEL
6.	[9]	2009	College	Basic Biology	*Participant Perception Indicators (PPI) survey*
7.	[10]	2018	High school	Food Substances	R&D (Research and Development).
8.	[11]	2012	College	Basic Biology	*Information and communication technologies* (ICT)
9.	[12]	2017	High school	Excretion System (Urinalization)	R&D (Research and Development).
10.	[13]	2014	High school	Bacteria	R&D (Research and Development).
11.	[14]	2015	High school	Excretion System	R2D2 (Reflective, Recursive, Design, and Development)
12.	[15]	2016	College	Biotechnology	*3-dimensional (3D) graphics (Web)*

3. RESULTS AND DISCUSSION

The researches on the development of virtual laboratory media obtained were 12 research articles. These studies were obtained from various sources, namely: articles (research results) in research journals and research reports. The analysis of articles was carried out based on the level of education, the type and design of the study, the content/learning material, and the research results.

3.1. Based on The Level of Education

The relationship between the educational level and virtual laboratory media in biology learning very important because of the compatibility of the virtual laboratory media used by students to achieve maximum learning goals. The results of the analysis for the educational level can be seen in Table 2.

Table 2. Educational level results

No.	Education level	Frequency	Relative Frequency (%)	Reference
1.	Junior High school	1	8.33	[5]
2.	Senior High school	8	66.67	[4], [6], [7], [8], [10], [12], [13], [14]
3.	College	3	25	[9], [11], [15]

Based on Table 2, it can be explained that of the 12 articles that were research samples there were variations in the use of virtual laboratory media. The level of education using virtual laboratory media, namely junior high school, senior hih school, and college. It can be seen that more than 50% of those who use virtual laboratory media are senior high school level, which is 66.67%. The best implementation of learning media is obtained from research at the high school education level, at junior high and college a more in-depth needs analysis can be carried out so that the virtual laboratory media used is truly effective and in accordance with the psychology and the tendency of learning patterns.

3.2. Based on The Type and Research Design

The type and design of research in a study is an important bridge to achieving research objectives. A study will not run well if there is no match between the type and design of the research and the research objectives. The research results will also not be valid if they are not accompanied by the right method. The results of the virtual laboratory media meta-analysis with the type and research design used can be seen in Table 3.

Table 3. The results of the type analysis and research design

No.	Types and Designs	Frequency	Relative Frequency (%)	Reference
1.	(Research and Development) quasi method experiment (quasi-experiment).	4	33.33	[8], [12], [10], [10]
2.	Reflective, Recursive, Design, and Development (R2D2) model,	2	16,66	[4], [14]
3.	(Research and Development) which using a 4D-model design	1	8.33	[7]
4.	(Research and Development) which using the ADDIE-model design	1	8.33	[5]
5.	*Information and Communication Technologies (ICT)*	1	8.33	[11]
6.	*Participant Perception Indicators (PPI) survey*	1	8.33	[9]
7.	*Weak Experimental* Design	1	8.33	[6]
8.	*3-dimensional (3D) graphics (Web)*	1	8.33	[15]

Based on Table 3, it can be explained that the types of research for virtual laboratory media research are quite varied. The type/research design used is (Research and Development), the quasi-experimental method (quasi-experiment), the weak experimental design, 4D-model, ADDIE Model, information and communication technologies (ICT), Participant Perception Indicators (PPI) survey, and Reflective, Recursive, Design, and Development (R2D2) models. The dominant type of research is experimental research, namely (Research and Development using quasi-experimental research that is 33.33%.

The accuracy of developing learning media with the types and characteristics of the material is very important to produce an optimal learning process in addition to the needs of students. Not all types of

media are efficient for all types of biological material, it really depends on the characteristics of the material. The excretion system as a material that involves a lot of concepts and descriptions is very good using video media, images, which are complemented by tests of understanding the concepts contained in multimedia. Apart from that, the learning styles of students also need to be considered in making learning media. Learning media provide opportunities for students to learn more independently, do repetitions after evaluation, and enrich their understanding by further exploring the material being studied. This causes the application of biology learning media to improve student learning o

3.3. Based on The Content/Learning Material.

The relationship between the development of virtual laboratory media used and learning materials is very important. Not all virtual laboratory media are suitable for all materials. The match between virtual laboratory media and material is an important factor in achieving maximum learning goals. Therefore, it is necessary to analyze the materials that have been used in virtual laboratory media as in Table 4.

material most often used in media development research. virtual lab. This is because the excretion system material is difficult to understand directly by students.

The results of the analysis in terms of the suitability of the material and the model show that some materials are suitable using virtual laboratory media. One of them is the excretory system material which is rich in experiments. At the level of understanding, students are able to state problems in their own words and are able to provide examples [17]. This is suitable for virtual laboratory media that helps students to be active, collaborative, and creative in learning. In general, virtual laboratory media is indeed very helpful for practicum-based learning processes. The steps in the virtual laboratory media direct students to be able to find themselves and carry out investigations. Therefore, materials that are suitable for using virtual laboratory media are materials that have sub-topics for conducting experiments and will greatly help improve the skills of students. The learning process of biology is often faced with material that cannot be visualized directly so that it is difficult for students to understand [18]. Some that are difficult to visualize directly include human anatomy and physiology, tissues, cells, evolution, genetics,

Table 4. Results of content analysis/learning materials

No.	Content / Learning Materials	Frequency	Relative Frequency (%)	Reference
1.	Excretion System	2	16.66	[4], [14]
2.	Basic Biology	2	16.66	[9]
3.	Invertebrates	1	8.33	[6]
4.	Internal Organs (High school)	1	8.33	[8]
5.	Bacteria	1	8.33	[13]
6.	Excretory System (Urinalysis)	1	8.33	[12]
7.	Plant Tissue Culture	1	8.33	[7]
8.	Blood group	1	8.33	[5]
9.	Food substances	1	8.33	[10]
10	Biotechnology	1	8.33	[15]

Based on Table 1, it can be explained that of the 12 articles that were the research samples, there were variations in learning materials that used virtual laboratory media. The learning materials used are excretion system, basic biology, invertebrate internal organs (high school), bacteria, excretion system (Urinalysis), plant tissue culture, biotechnology, blood type, and foodstuffs. The excretion system is the

taxonomy, and the origin of living things. This difficulty was then overcome by using learning media. The learning process of biology is often faced with material that cannot be visualized directly so that it is difficult for students to understand. Some that are difficult to visualize directly include human anatomy and physiology, tissues, cells, evolution, genetics, taxonomy, and the origin of living things. This

difficulty was then overcome by using learning media. The learning process of biology is often faced with material that cannot be visualized directly so that it is difficult for students to understand. Some that are difficult to visualize directly include human anatomy and physiology, tissues, cells, evolution, genetics, taxonomy, and the origin of living things. This difficulty was then overcome by using learning media [19].

Table 5. Analysis of research results

Reference	Outcome Indicators	Research Result
[4], [14]	Virtual Laboratory validity and student motivation	**Validity results:** 93.05% in terms of material experts, 90.62% in terms of experts in developing teaching materials, 94.16% from in terms of Virtual Laboratory media experts, 93.88% in terms of teachers (users). **Student's motivation to study:** the value of the motivation of students using the Virtual Laboratory the highest which was 43.32%
[5]	Validity, Practicality and effectiveness	Learning in identifying 34.00% cell processes, 38.00% mitosis in life, 06.0% application of mitosis through cloning, and 36.0% variation of mitosis
	Validity, Practicality and effectiveness	respondents to the quality of this product is 3.34.
	Student scientific attitude	(N-Gain X-7 = 0.10; X-8 = 0.16)
	Virtual Lab media practice	The average practicality of the teacher is 3.5 (very practical) The average practicality of students is 3.28 (practical)
[6]	Validity and student response	Valid and fit for use: RTVTK 3.55 Student response is positive with an average percentage of 84, 15%
[7]	Validity, Practicality and effectiveness	The average pretest value is 85.09 and the average post-test score was 94.50. The feasibility test by media experts got the highest average score (93.33%) on the sub components of motivation and attraction.
[8]	Validity, Practicality and effectiveness	**Teacher assessment:** Material coverage: 25.75; artistic and aesthetic: 16.5; 23.25 overall functions ease of navigation; 20.25 **Student assessment:** Material coverage: 6.1; artistic and aesthetic: 16,35; 24.25 overall functions ease of navigation; 17.6
[7]	Validity, Practicality and effectiveness	**Validity:** the material expert was 84.72%, development expert was 80.73%, media experts 79.73%, and teachers 91.67%. The average rating of the trainers was 84.21%. **Practical student response:** (1) cognitive aspects by 89.27%; (2) interactive aspect of 88.92%; (3) interesting aspects reached 83.08%, (4) the efficient aspect reached 90.57%, and (5) the creative aspect was 90.35%.

Reference	Outcome Indicators	Research Result
		Effectiveness: The mean pretest score was 24.05; The mean posttest score was 80.8 with a difference of 56.75 and Normalized values *Gain* reaches 0.74 with high criteria.
[11]	Validity, Practicality and effectiveness	70%of students responded positively that the lab videos were effective in increasing student knowledge, experience, and understanding of lab procedurs.
[13], [7]	Motivation of students	The trial results show Virtual Excretion system laboratory significantly increased effect (p = 0.00) on motivation student learning.
[15]	Practicality and effectiveness	The virtual lab that can be used by Hhmi BioInteractive, Virtual Biology Lab, WOW Biolab. The current use of v-lab is very useful for macro and micro biotechnology.

3.4. Based on Research Results

The virtual laboratory media used greatly affects the learning outcomes of students. The media is used as a guide by the teacher in the learning process. Therefore, if the guidelines are not correct, it can lead to poor learning outcomes. The results of the research which are informed from the 12 articles analyzed can be seen from 2 categories. Experimental research in

media is suitable to support practicum activities. The other three articles are independent variables, namely in the form of student learning motivation, student scientific attitudes, and student learning responses. The application of virtual laboratory media is expected to improve student learning outcomes. This is because the phases in virtual laboratory media lead students to find and carry out investigations so that the learning

Table 6. Variables that are influenced by the use of virtual laboratory in learning

No	Variable	Total	Relative Frequency (%)	Reference
1	Achievement	8	57.14	[5], [6], [7], [8] [9] [10], [11], [15]
2	Motivation	4	28.57	[4], [7], [13], [14]
3	Student scientific attitude (skills)	2	14.28	[5], [10]

The form of competency knowledge, attitudes, and skills. Development research in the form of validity, practicality, and effectiveness of the media developed can be seen in Table 5.

Based on Table 5, it can be explained that many aspects can be discussed in research on the development of virtual laboratory media. The existing research results from 12 sample articles are in the form of learning outcomes, student motivation, student responses, results of validity, practicality, and effectiveness of the products developed. Each aspect studied has a quantitative data processing process and a qualitative explanation of meaning.

Nine out of eleven randomly selected articles suggested that the development of virtual laboratory

process becomes more meaningful [18], [19], [20], [21] [22] [23]. The average post-test of students increased and the percentage of classical abilities also increased. This is in line with previous research.

3.5. Based on Variabel That Are Influenced

The aspects related to virtual laboratory are dependent variables that can be influenced or increased thouugh the use virtual laboratories. These aspects were found based on the analysis 12 journal articles. The results of the analysis can be seen in Table 6 below.

Based on Table 6 above, it can be seen that the use of virtual laboratories has the most influence on

learning achievement, mentioned by 8 articles [5], [6], [7], [8] [9] [10], [11], [15] out of 12 articles found (57,14%). Learning achievement is the result obtained through practice and experience supported by awareness. Learning achievement is said to be perfect if fulfills there aspects; cognitive, affective and psychomotor. Therefore, learning achievement can be said to be the result of changes in the process. Different methods used by teachers csan cause differences in the learning process which will also affect student achievement.

Based on the data that has been collected, there were 4 scientific articles [4], [7], [13], [14] of the 12 articles analyzed showed that the use of virtual laboratories had a positive effect on students' motivation, which is 28.57%. The last, it can be seen that the use on student scientific attitude (skills), mentioned by 2 article [5], [10] which is 14.28%.

The results of research conducted by Osman and Kaur showed that the learninf outcomes of the experimental group using virtual media were higher than the control group who did not use virtual media [24]. This shows that learning using virtual laboratory media can improve students'achievement.

Based on the relates to the real problem faced in everyday life, students will be able to know the purpose for studying the topic chosen. Students can actively participate in the experiments and proceed with the decision that they are required to make. Virtual laboratory also considered to be a very halpful tool for both teachers and students who previously have limited opportunities or time to conduct experiments in the biology labs. The ability to instantly see the result of an experiment ia an advantage over the conventional laboratory practice, which can extend over several day, and can allow students to not worrying too much if they happen to forget the experimental details or lose interest in the results of a particular experiment.

4. CONCLUSION

Based on the results and discussion, it can be concluded that:

a. The level of education in senior high school using virtual laboratory is more than 50%, namely 66,67% is in the highest category;

b. The dominant type of research is experimental research, namely (Research and Development using quasi-experimental, which is 33,33%;

c. The use of virtual laboratory media in biology learning is based on the widely used material, namely the excretion system;

d. Nine out of eleven randomly selected articles suggested that the development of virtual laboratory media was suitable to support practicum activities.

e. variables that are influenced by the use of virtual laboratories in learning is more than 50%, namely achievement student, which is 57.14%.

The other three articles are independent variables, namely in the form of student learning motivation, student scientific attitudes, and student learning responses. The application of virtual laboratory media is expected to improve student learning outcomes. For further research, it is recommended that: (1) research on learning media be developed with R&D with more complete and better testing; (2) the best implementation of learning media is obtained from research at the high school education level, at junior school and college a more in-depth needs analysis can be carried out so that the virtual laboratory media used is truly effective and in accordance with the psychology and trend of learning patterns.

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