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Development of Microbiology E-Books Based on Laboratory Research Results as Teaching Materials to Improve Students' Science Process Skills

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Abstract

This study aims to: Produce teaching materials in the form of microbiology e-books based on research results on the isolation of styrofoam degrading soil bacteria. Testing the effect of using e-books on improving students' science process skills. The e-book preparation method refers to the Lee and Owens development model and is implemented in learning with the PBL model in the experimental and control groups. The results showed that: e-book material feasibility, e-book teaching materials and e-book practicality with very valid criteria. E-books are proven effective in improving students' science process skills with high criteria, so e-books are suitable for use as teaching materials to support learning. Can be used to solve problems that may be encountered in everyday life.

Keywords: Microbiology E-book, Teaching Materials, Science process skills.

Introduction

The development of science and technology in the 21st century has brought rapid changes in everyday life (Benesova & Tupaa, 2017; Hartmann & Bovenschulte, 2013; Osman, Hamid, & Hassan, 2009). The 21st century can be addressed by organizing educational processes in various aspects of human life, both formal, non-formal and informal. It is hoped that the equitable distribution of learning outcomes can achieve the goal of equity in the world of education and produce undergraduate graduates who are ready to face the world of work, because they are required to have abilities in the fields of science and technology, theoretical mastery and be able to make decisions according to their respective fields to solve problems in their environment, which realized through certain skills, namely: science process skills (Wibisono.et al., 2015). Skills integrated in science education (Agolla, 2018)

Science process skills are very important to be integrated into learning, because science learning must involve content and components of the science process (Gultepe, 2016). The content and components of the science process are an inseparable unit. The content consists of subject matter and science concepts while science process skills are important skills that students need to acquire (Inan, 2010, 2011; Inan, Inan, & Aydemir, 2014). Science process skills involve thinking skills that can be used to obtain scientific information and can use, conduct scientific research, and solve problems (Karamustaoglu, 2011; Aktamis & Ergin, 2008). Science process skills are very important for the world of education so the government and institutions make various efforts to improve, but the science process skills of Indonesian students are in a low category, this is reflected in the low average percentage as evidenced by previous researchers (Haryono, 2006; Sahyar, 2017) . Irwanto et al (2018), revealed that low science process skills were found in Tribhuwana Tunggadewi University students in Malang who got an average percentage score ranging from 24-40. This shows that students have a low level of application of process skills to produce effective results (Ihejiamaizu and Ochui, 2016).

One of the efforts that can be made to improve students' science process skills is to carry out practical activities in the learning process, especially learning Microbiology. The existence of practicum activities will provide opportunities for students to observe themselves, discuss in practicum groups and conclude the results of their own discussions. Furthermore, students can understand the concepts studied in lecture activities, especially "The Role of Bacteria in the Styrofoam Biodegradation Process". The concept of styrofoam biodegradation needs to be applied in the learning process for students, because this is one of the problems in real life, so it is factual.

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Packaging products made from styrofoam are currently widely used by the public as food wrappers, because styrofoam is practical, clean, resistant to hot and cold food or drinks. The large use of Styrofoam in urban areas, only making a major contribution as waste in urban areas, will have an impact on environmental pollution problems and threaten public health (Farrelly & Shaw, 2017). In connection with this, it is necessary to study the use of styrofoam decomposing bacteria to deal with styrofoam waste. Therefore, it is needed to hold Styrofoam waste management that is more efficient and environmentally friendly. One way to reduce the amount of styrofoam waste is to degrade styrofoam waste using biological agents in the form of indigenous bacteria that live in soil mixed with styrofoam. Styrofoam biodegradation by microorganisms with extracellular enzymes produced from microorganisms has an important role in the biodegradation process, microorganisms change long polymer chains to become shorter and then into small molecules that are easily absorbed and undergo metabolism in the cells of microorganisms with intracellular enzyme biocatalysts (Tokiwa, Calabia, Ugwu, Aiba, 2009; Atiq, et al., 2010).

The amount of information obtained by students cannot be separated from the quality of the learning process carried out by lecturers. One of them is using multimedia in the learning process. Quality learning materials will produce effective and enjoyable learning in order to achieve student competency standards, namely teaching materials in the form of multimedia (digital books/e-books) (Connor et al, 2018). Ebied and Rahman (2015) state that students who study using e-books can increase their learning motivation and are able to develop their academic achievements compared to students who study using textbooks. The advantage of e-book-based learning devices is that they can be integrated through sound, graphics, images, animations, and videos so that the information presented is more varied.

The e-book developed based on research results is contextual, deeper and more interesting because the material presented does not only contain basic concepts but facts obtained through research conducted in the laboratory or outside the laboratory. The research conducted is; about the isolation of styrofoam degrading soil bacteria. To find out the activity of bacteria that degrade styrofoam, observations were made using SEM, the results of these observations were presented in an e-book for students to study, besides that the e-book was equipped with learning outcomes, learning objectives, instructions for use, practicum activities supplemented with videos. , structured assignments, evaluation and glossary.

The e-book material is prepared based on the results of laboratory research that has been carried out by researchers. Furthermore, the e-book is validated by material experts and teaching materials experts, so that it can be applied in the Microbiology learning process. The application of e-books in learning uses the help of the Problem Based Learning (PBL) learning model. The PBL learning model is one of the innovative learning models that makes real-world problems the first step in learning. Students actively carry out investigations to solve a problem through the stages of the scientific method (Ward & Lee, 2002). Suherman (2008) emphasized that PBL is a learning model that trains and develops the ability to solve problems based on real problems that exist in students' real lives.

Literature Review

E-books are textbooks that are converted into digital form, e-books can be interpreted as a learning atmosphere that has applications containing multimedia databases of instructional facilities that store multimedia about certain material in a book (Shiratuddin, Landoni, Gibb & Hassan, 2003). Multimedia in e-books consist of sound, image, animation and video components which can be integrated into learning tools in the form of e-books so that the information presented in e-books is more varied. E-books are important in learning because students can be motivated to learn independently, creatively, effectively, efficiently, and are able to overcome student boredom so that they are more enthusiastic about learning (Candra, 2016)

Science process skills are activities needed to generate and utilize scientific information, conduct scientific research, and solve problems (Aktamis & Ergin, 2008). Science process skills are used by students as a tool to investigate the surrounding environment and build science concepts, which will later be used in problem solving and developing student knowledge (Shaw, 1983; Harlen, 1999).

Learning Biology is learning related to how to find out and understand nature systematically so learning Biology is not only mastering a collection of knowledge in the form of facts, concepts, but also a process of discovery, so students are required to be able to think critically (Tanjung, 2016). Someone who has completed his Biology study must understand the concept of Biology, its implementation to solve real world problems and the process of scientific investigation. Finally, individuals who are literate in Biology must be able to think creatively, formulate problems about nature, have logical and critical reasons, use efficient technology and make ethical personal decisions related to biological problems. Reinburg (2009, p. 29).

Methods

Research Design

An experiment was conducted at the microbiology laboratory, FMIPA, Universitas Negeri Malang before developing the product at Universitas Tribuana Tunggadewi, Malang. The product was tried out to two groups of students, namely experimental and control groups. Each group had to complete a pretest and a post-test. The research design is presented in Table 1.

Table 1: Research Design

Group	Pretest	Treatment	Post-test
Control	P_1	X_1	P_2
Experimental	P_3	X_2	P_4

Remarks:
X1: Problem-Based Learning without using the microbiology e-book developed in this study
X2: Problem-Based Learning using the microbiology e-book developed in this study
P1, P3: Pretest
P2, P4,: Post-test

Sample and Data Collection

The research sample contained 60 students from the Department of Bio industrial Technology at Universitas Tribuana Tungga Dewi, Malang, Indonesia. These students were divided into two groups, namely the experimental and control groups. Each group comprised 30 students. This sampling method was considered the most suitable with the study's objective.

The experimental group learned using the microbiology e-book that had been developed based on the results of prior laboratory experiments. Meanwhile, the control group was not introduced to the microbiology e-book. Both experimental and control groups received treatment in the form of Problem-Based Learning model. Both groups were required to take a pretest prior to intervention and a post-test following completion of the lesson. The outcomes of the tests were then compared between the two groups. Statistical analysis was performed to find out the significance of increase in students' scores from pretest to post-test.

Data Analysis

The microbiology e-book was designed using the results of a laboratory experiment. The e-book was then implemented for online learning at the Department of Agricultural Industrial Technology, Universitas Tribuana Tunggadewi, Malang, Indonesia. The development of the e-book followed the procedures for developing a product suggested by Lee dan Owens (2004). The e-book was developed in five stages, namely: 1) Assessment/analysis, which covered needs assessment and front-end analysis; 2) Design; 3) Development; 4) Implementation; and (Evaluation).

The e-book effectiveness test is measured based on the n-gain score, and the t-test of learning outcomes data. Both components were analyzed to determine the effectiveness of e-books as alternative teaching materials in improving students' science process skills.

RESULTS

This research went through several stages based on Lee and Owens, namely: Needs assessment was done to elucidate the issues underlying students' needs for biology learning, so that the product generated could meet those needs. According to the needs assessment, 100% had never studied or participated in practicum activities about "Utilization of Soil Bacteria in the Styrofoam Degradation Process." All students (100%) agreed and expressed an interest in studying using a research-based Microbiology e-book on this subject.

The Design stage consisted of activities that resulted in the compilation of an e-book on Microbiology based on research on the isolation of Styrofoam-degrading soil bacteria. The cover of the e-book was designed using Corel Draw X8, while the contents were created using Microsoft Word 2013. Times New Roman is the font used in the e-book, with the required size and 1.5 spacing. The book is illustrated with pertinent images and then printed on 80-gram A5 format paper. The electronic book is divided into three sections: the front (cover, preface, and table of contents), the content (introduction, material, practical instructions, evaluation questions, and structured assignments), and the conclusion (glossary, list of references, and author's curriculum vitae). The research-based Microbiology e-book that was designed as an instructional tool for college students is presented in Figure 1.

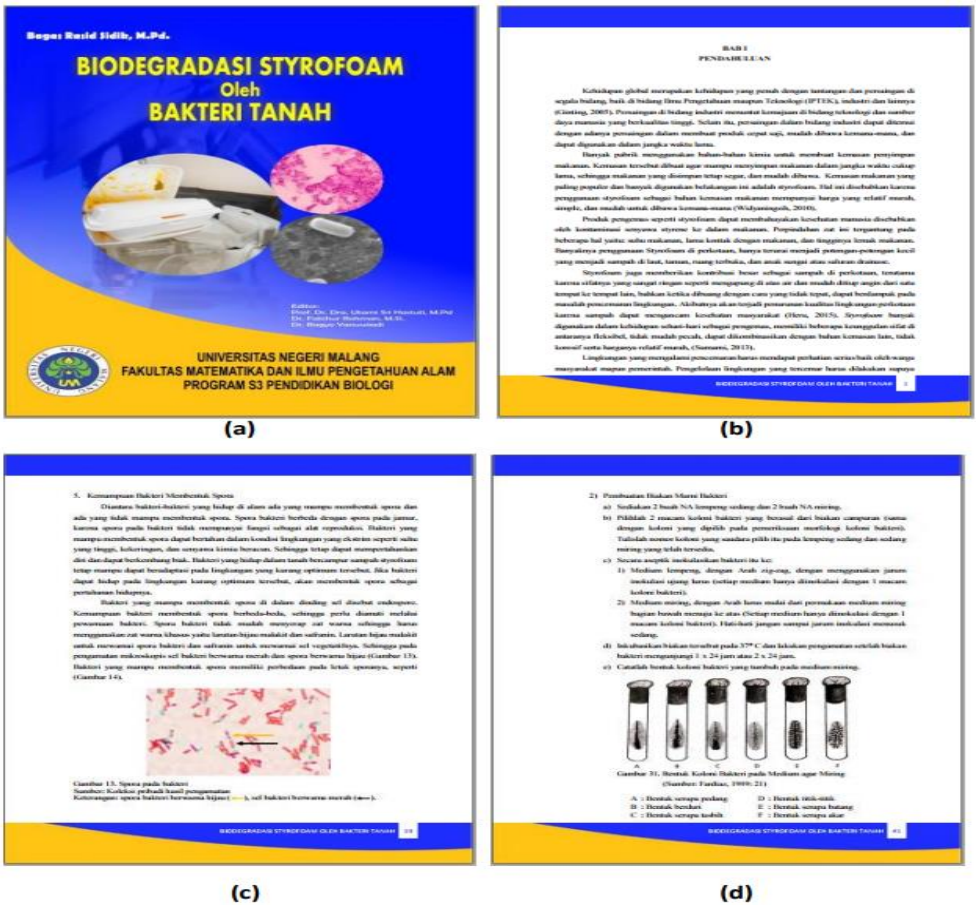

Figure 1: Research-based Microbiology e-book
Remarks:
(a) Cover (c) Core Material
(b) Introduction (d) Instructions for Practicum Activities

The Development stage produced the e-book content based on laboratory study findings. At this stage, the e-book prototype that had been designed at the Design stage was developed as needed. Furthermore, expert validation was done to see the feasibility and practicality of the e-book.

Figure 2 illustrates the results of the laboratory study on the role of bacteria in the Styrofoam biodegradation process. At this stage, soil bacteria were extracted from Styrofoam debris. Then, the bacterial isolates were tested for their ability to degrade Styrofoam.

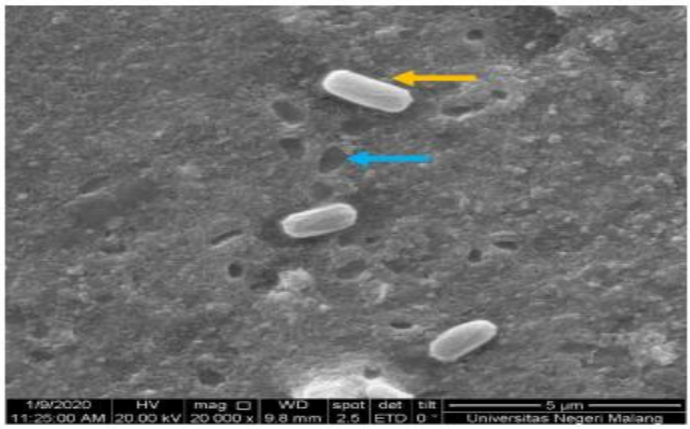

Figure 2: Electron micrograph of soil bacteria Styrofoam degradation
Remarks: Damaged Styrofoam surface (Blue) dan Styrofoam-degrading bacteria (Orange).

Figure 2 shows bacterial activity in the Styrofoam degradation process. The holes in the Styrofoam biofilm are the result of bacterial activity when utilizing the carbon source in the Styrofoam.

The feasibility and practicality scores of the e-book obtained from validation testing are shown in Figure 3.

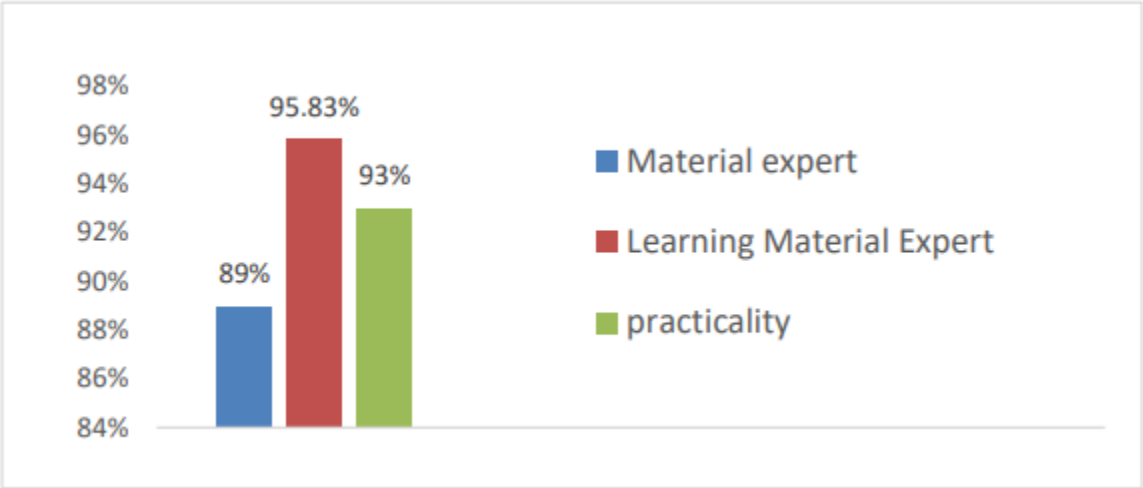

Figure 3: Feasibility and Practicality of the e-book
Remarks: the expert validation and practicality test by students showed high percentages

In Figure 3, the expert validation results showed that the e-book content was highly valid (89%), requiring minor revisions. Furthermore, the feasibility of the e-book as an instructional tool was very high (95.83%), thus requiring minor revisions as well. The practicality test showed that the e-book was very practical (93%) and can therefore be used as a supplementary material in a biology classroom.

The e-book was deployed and evaluated for fifth semester students majoring in Bio-industrial Technology, Universitas Tribuana Tungga Dewi. The process of adopting the e-book was conducted online, which eliminated the need for face-to-face learning or practicum tasks. Online instruction was provided on the Zoom application. The experimental group was assigned the Microbiology e-book with the PBL learning model. Meanwhile, the control class conducted Problem-Based Learning (PBL) without the use Microbiology e-book. Practicum activities were done online via assignments in which students were requested to observe the Gram's properties of bacteria and their ability to generate spores in images from pre-pandemic research. The students' science process skills were examined by a pre-test conducted before the treatment. The students were also invited to watch a video of the practical activities during the test. The participants took a post-test and viewed a video of the completed practicum activity at the conclusion of the treatment.

The effectiveness of the e-book implementation in learning was measured by calculating the difference between the pretest and post-test scores of the students (Figure 4)

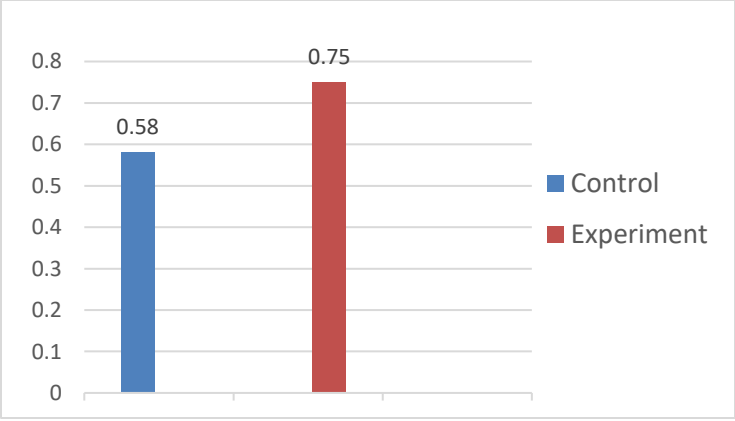

Figure 4: The difference in N-Gain scores between the control and experimental groups
Remarks: The experimental group's N-Gain score was higher than that of the control group

Figure 4. above shows the N-Gain score based on the criteria according to Hake (1998), the N-Gain score of science process skills for the control class (only using the PBL learning model) is 0.58 included in the medium category, with an

average value the average N-Gain score of the science process skills of the experimental class (using e-books and the PBL learning model) is 0.75 which is included in the high category, so that the module is effective in improving students' science process skills.

Table 1: Tests of Normality

	Respondent	Kolmogorov-Smirnov[a]		
		Statistic	df	Sig.
Science Process Skills	Control	.172	23	.076
	Experiment	.173	23	.073

Based on the results of the normality test, it can be seen that the significance value in the control class is 0.076 > 0.05. In the experimental class, the significance value is 0.073 > 0.05. So it can be concluded that the data of the two classes are normally distributed.

Table 2: Test of Homogeneity of Variance

		Levene Statistic	df1	df2	Sig.
Science Process Skills	Based on Mean	.001	1	44	.972
	Based on Median	.001	1	44	.980
	Based on Median and with adjusted df	.001	1	43.999	.980
	Based on trimmed mean	.001	1	44	.973

Based on the results of the homogeneity test, it can be seen that the significance value in the control class is 0.972 > 0.05. So it can be concluded that the data is homogeneously distributed. Data that is normally distributed and homogeneous can be continued to the t-test.

Table 3: Independent Sample Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Science Process Skills	Equal variances assumed	24.788	.000	-5.081	44	.000	-10.277	2.022	-14.353	-6.201
	Equal variances not assumed			-5.081	27.048	.000	-10.277	2.022	-14.426	-6.127

Based on the independent sample test, it is known that the significance value (2-tailed) is 0.000 <0.05. So that there is a significant difference in point scores between the control and experimental classes, meaning: there is a significant effect on the learning process using e-books using the PBL model on improving science process skills.

Discussion

This study shows the effective results of using the Microbiology e-book and the PBL model in improving students' science process skills. In the experimental group, students used a microbiology e-book which was equipped with practical steps and videos that they could see like the original activity, while students in the control group only used videos of practicum activities but without the Microbiology e-book. The use of video in the learning process, especially in practicum activities, can improve science process skills so that it can affect student learning outcomes.

Learning Microbiology requires educators, especially lecturers, to build the ability of students to develop new ideas through science process skills. Science process skills are basic skills in thinking and conducting investigations (Mutlu & Termiz, 2013). Science process skills are very important as a basic foundation of thinking, so they need to be integrated into science learning, because science learning must involve content (subject matter) and components (skills) of the science process (Gultepe, 2016).

Several researchers have demonstrated the advantages of science process skills and their application to learning, as reported by Aktamis & Ergin (2008) that providing science process skills training can improve student academic achievement. Learning can be said to be successful if the implementation of the learning has a positive impact on students. This impact is indicated by an increase in student learning outcomes, including attitudes, knowledge, and skills

(Prince, 2004). The initial science process skills possessed by UNITRI students are low. This situation is due to the lack of equipment in the laboratory and student learning media still using printed books. Based on these facts, students have a shortage of teaching material resources, making it difficult to master science process skills.

Based on the results of the study, there was a significant difference between the experimental class and the control class. The experimental class experienced a better increase in science process skills compared to the control class. Increasing student skills is a reflection of mastery of the material. The skills developed by students in science education are science process skills, skills that can be used to solve problems in real life situations, which are integrated with science education, including Microbiology (Bobadilla, 2016). This condition can be achieved by using teaching materials that can help improve students' science process skills. E-books based on laboratory research results are an example of teaching materials that are prepared based on relevant materials and are equipped with pictures, videos, descriptions and assignments that are factual in nature, and based on student needs are the best way to improve students' science process skills.

Students' science process skills can be increased according to the indicators of science process skills, namely: 1) Observation. Through the Microbiology e-book, students are invited to observe factual phenomena around them, for example, the phenomenon of styrofoam waste which can damage the environment. 2) Classification. Students group data based on observations that have been made. 3) Interpretation. Students associate data that has been grouped. 4) Predictions. Students express what happens in circumstances that have not been observed. 5) Ask questions. Students ask several questions related to styrofoam degrading bacteria, how to handle styrofoam waste, the dangers of styrofoam, during the learning process. 6) Hypothesis. Students realize that an explanation needs to be tested for truth by obtaining more evidence or doing problem solving methods.

This Microbiology e-book is applied to learning using the PBL learning model. Learning using the PBL model will train students (Jailani, Sugiman & Apino, 2017) to carry out systematic, critical investigations, so that students find their own solutions to factual problems such as styrofoam waste pollution. Factual problems can be presented to students in the form of media, one of which is a microbiology e-book from laboratory research which contains environmental problems and how to overcome them. The learning process using e-books can reduce student boredom in learning and increase motivation in learning (Liesaputra and Witten, 2012), so as to improve students' science process skills. Science process skills are emphasized in the e-book on practical instructions in the form of videos, as well as practice questions and assignments at home by forming working groups. This is evident from the results of research conducted by researchers in the experimental class, students who use e-books that contain environmental problems, especially styrofoam waste pollution and how to overcome them and use the PBL learning model get an N-gain value of 0.75 (high criterion) higher compared to the control class that does not use e-book teaching media with an N-gain value of 0.58 (medium criterion).

Conclusion

In conclusion, this study revealed that the e-book developed in this study was feasible, valid, and practical with a score of 89% (highly valid) for the e-book feasibility, 95.83% (highly valid) for the e-book content, and 93% (very practical) for its practicality. The implementation of the e-book and Problem-Based Learning (PBL) in online classroom was effective in increasing students' science process skills, indicated by a high N-Gain score (0.75). Therefore, it can be concluded that the microbiology e-book can be used as a supplementary material in online or offline (face-to-face) Microbiology courses.

Suggestion

Based on the conclusions obtained, several suggestions can be put forward as follows:

For agencies engaged in the environmental sector, they can use bacterial isolates that have been found by researchers to degrade styrofoam waste in an environmentally friendly manner.

For lecturers who develop Microbiology courses that discuss "Utilization of Soil Bacteria" can use this e-book in the learning process, to help improve students' science process skills.

Limitation

The limitations of this study are determined by the following factors:

This research was applied in the fifth semester of the 2020/2021 academic year.

The research was conducted on Tribuana Tungga Dewi University students.

E-book development research using Lee and Owens development model

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