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Developing Microbiology Digital Handout as Teaching Material to Improve the Student's Science Process Skills and Cognitive Learning Outcomes*

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ABSTRACT

Purpose: This research aimed to examine the usefulness of a microbiology digital handout as a teaching material validated by experimental research in the improvement of science process skills and cognitive learning outcome of students. **Methodology:** The study comprises two methods**:** experimental research and development research. The experimental research at Microbiology laboratory of Faculty of Mathematics and Natural Science State University of Malang, while the development of teaching material in the Department of Agricultural Industrial Technology, Faculty of Agriculture, UNITRI Malang. A digital learning model was devised with ADDIE approach and implemented along with PBL model on experimental and control groups.
Findings: Findings revealed that the improvement in student's science process skills and cognitive learning outcome in the experimental class was higher than those in the control class**. Implications for Research and Practice:** Learning by using a digital handout could increase students' activities and achievements, particularly in scientific learning. It would be very useful to solve the problems that might be encountered in the daily life. It could trigger the curiosity of students to examine and observe more on problems in the real life.

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Introduction

Scientific education is a conscious and planned effort which creates a learning environment and a learning process, so the students can actively develop their self-potential. Besides, the educational skills, students also develop psychological characteristics including self-control, personality, intelligence, noble character, and skills needed for self, community, society, and state (Wahyudin et al., 2017). This statement infers that education does not merely build the cognitive realm, but it also shows special concern for realms of attitude and skills. The Regulation of Minister of Research, Technology, and Higher Education, 2015 elaborated National Standards of Higher Education which stipulate those graduates of diploma programs and undergraduate programs should master the basic theoretical concepts of science manifested through certain skills. One of these skills is science process skill (Wibisono et al., 2015).

Science process skills involve skills that require a high category of complex skills like observation (calculation, measuring, and classification), problem formulation, hypothesis development, variable identification and operational definition of variables, research planning with proper procedures, analysis, interpretation, inference, and research result delivery (Tek et al., 2005; Verawati et al., 2014). Mutlu et al. (2013) describe science process skills as a learning process which should be a developed as a learning activity (Yakar, 2014). Several efforts have been made, both at the government and at the institutional levels, yet science process skills in Indonesian students are still of a low category, as reflected in the average and below average percentages proven by a number of previous research findings (Nuzulia et al., 2017; Putri et al., 2018; Titin, 2013).

Kurniawan et al. (2016) found that 59% of students in Open University of Surakarta have low science process skills. Similar results about science process skills were found in students of University of Tribhuwana Tunggadewi Malang, who scored the average percentages, approximately between 24 – 40 (Irwanto et al., 2018). Such low levels of science process skills can affect students' cognitive learning outcomes. reported a strong relationship between science process skills and students cognitive learning outcomes. The higher is the science process skills, the greater will be the improvement in the cognitive learning outcomes of students. Reversely, the lower are science process skills. the lower will be the cognitive learning outcomes of students (Agustina et al., 2013; Ilma et al., 2020).

One of attempts to improve science process skills is by conducting practical activities. Practical activities are actually an attempt to provide real experience to students in the implementation of their theoretical learning. Existing theories have emphasized to make practice as an integral part of science (Duda et al., 2019). Santyasa (2004) explained that practical-based learning is a good learning strategy for students to develop their skills, as it helps them to actively solve problems, analyze and implement facts, and find concepts and principles to be more valuable. Salomon (2016) argued practical activities help both the teacher and the students to teach and learn the concepts. Moreover, practical activities are also helpful to improve learning motivation, increase student skill, and raise scientific behavior. The implementation of practical learning helps the students to develop observation, experiment, and tools used in the laboratory. The cognitive learning output of Engineering Technology students in Department of Agricultural Engineering Technology, University of Tribhuwana Tunggadewi, revealed an average percentage of 30% - 32%. One of the reasons for this low learning output was that a majority of students had not used the scientific methods to solve their problems. This was surprising because students of agricultural engineering should be able to think scientifically, and should develop the competence of solving agricultural problems by applying scientific principles. For instance, it was observed that students could not even identify mold microorganisms on plants, which was an elementary subject in agricultural sciences. The course on 'mold microorganisms' was listed in their learning plan and students were expected to understand the concept of mold as well as identify its characteristics, its role in daily life, and analyze diseases caused by mold on plants.

Digital handouts are designed to ease the student access everywhere as they are developed after a holistic research in the laboratories. They are so advanced that their illustrations show factual images, videos and real time practical guidelines to help in working and implementation of exercises. Owing to these advanced features, digital handouts can prove to be most useful teaching materials that can help students improve science process skills and subsequently support in improving the students' cognitive learning skills as well. A digital handout is designed with an attractive content, color, and image display, in order to motivate students in their learning and also acquire learning smoothly (Nerita et al., 2017). An experimental-based digital handout is usually designed with the help of a development model for its implementation.

One of the development models popular in pedagogical domains is Problem Based Learning (PBL) model. It is a learning model which is initiated by a certain problem as the first step to collect and integrate facts related to the problem. The implementation of PBL model is helpful for teachers in assessment, conception, as well as practice. Since the PBL model can be implemented in a class situation, it can stimulate students in decision making and selecting the best strategy to grasp the learning content and develop professional, social, and behavioral skills (Ribeiro, 2011). Akınoğlu et al. (2007) assert that PBL model is a combination of theory and practice; it is also capable of integrating and associating students' previous knowledge of science with the newly accumulated one. It is also capable of developing skills in multidisciplinary sciences. Studies have reported that PBL model is an effective way to develop science process skills, cognitive abilities, problem solving skills, team work, and good oral communication skills (Ribeiro, 2011; Warnock et al., 2016).

Based on this background, this research aimed to examine how to improve students' learning achievements in order to help them reach the graduation stage (bachelor degree). This learning achievement can be reached with the assistance of teaching materials that could support students' learning. One of teaching materials to support the agricultural engineering students in their learning is the use of digital handouts. The objective of this study was to design and experiment with a valid, practical, and effective microbiology digital handout. The digital handout prepared in the microbiology laboratory of FMIPA, State University of Malang, was subjected to a validity test and factor analysis. The digital handout represented the entire learning content while during its implementation, the practical and the effective factors were observed to ensure the development of the science process skills and cognitive learning outcomes of students.

Method

Research Design

This research utilized a laboratory experimental research design. The experimental research step was conducted at microbiology laboratory of FMIPA, State University of Malang with two groups, experimental and control. Each group was given a pretest and a posttest. Table 1 explains the research design.

Table 1. *Research Design*

Group	Pretest	Treatment	Posttest
Control	P_1	X1	P_2
Experimental	P3	X2	P4

Explanation:

X1 : PBL learning without the use of developed microbiology handout

X2 : PBL learning with the use of a well-developed microbiology digital handout

P1, P3 : Pretest before the treatment

P2, P4 : Posttest after the treatment

Research Sample

The sample comprised 60 students of the Microbiology laboratory of Faculty of Mathematics and Natural Science State University of Malang, Indonesia. The sample was divided into two groups, experimental and control, with 30 students in each group. The purposive sampling method was chosen for the study as the most convenient method.

Data Collection Instruments and Procedures

The subjects were divided into two groups, experimental and control, each group having 30 students. The experimental group used the microbiology digital handout, which was prepared by using the experimental research. The PBL model was exerted during the learning process. On the other hand, the control group was taught without the media of developed microbiology digital handout though PBL learning model was used with this group as well. Both the groups were given a pretest before starting the learning and a posttest after the learning ended. The learning outcomes from both groups were compared and a significant increase was seen in the posttest score. The N-gain score was calculated along with a statistical analysis test to identify the effects of digital handouts on the science process skills as well as cognitive learning outcomes of students.

Data Analysis

The data obtained from the experimental treatment were recorded in the form of digital learning material called a digital handout. This digital handout was implemented online in the Department of Agricultural Industrial Technology of Tribhuwana Tunggadewi University. The next step of developmental research was based on the learning model adopted from ADDIE: 1) Analyze, 2) Design, 3) Develop, 4) Implement, and 5) Evaluate, as recommended by (Branch, 2009).

Findings

The results of the experimental phase can be categorized into three steps: (1) Analysis Step (2) Design step (3) Development Step. After completing these three steps of experimental phase, the study moved to the implementation and evaluation phase. This section summarizes the findings of both the phases.

The Analysis step acted as a background search and it was revealed that none of the students had learned about the given topic: *The Antagonism of Antagonistic Fungi on Pathogenic Fungi,* nor had done any practice on this topic. Though as many as 95% of students had used practicum manual as the learning media in their practice of science skills. All the students (100%) admitted that they felt the need of a research based and result-oriented digital handout on the topic under study. The students' initial ability on the given topic (i.e., *Antagonism Power of Antagonistic Fungi on Pathogenic Fungi)* is presented in Table 2 which suggest low and average results:

Table 2

Mean Value of Student's Initial Ability Based on Student's Test Score

Class	Variable	Score		Mean
		Lowest	Highest	
Control	Science Process Skills	20.00	70.00	45.00
	Cognitive Learning Outcomes	25.00	33.00	29.86
Experimental	Science Process Skills	18.00	26.00	24.12
	Cognitive Learning Outcomes	25.00	45.00	32.29

The next step of Design resulted in the production of a learning material in form of a microbiology digital handout under the title "Test on Antagonism Power between Antagonistic Fungi and Pathogenic Fungi in *Mangifera caesia* Jack Plant". This digital handout was designed and developed through Microsoft Word 2016 and turned into Flip PDF Builder. The digital handout developed for this research can be seen on this link https://online.flipbuilder.com/ggrc/xsgx/.

The Development step was the last step of experimental research before the study could enter the implementation phase. The learning material product, i.e., the digital handout designed was now tested for its feasibility and legibility. The feasibility test on the handout was tested by two validators, one who was a material expert in microbiology and the other was a learning media expert. The legibility test was done by respondent students who participated in this experiment.

The following data were the result of feasibility and legibility test on learning material:

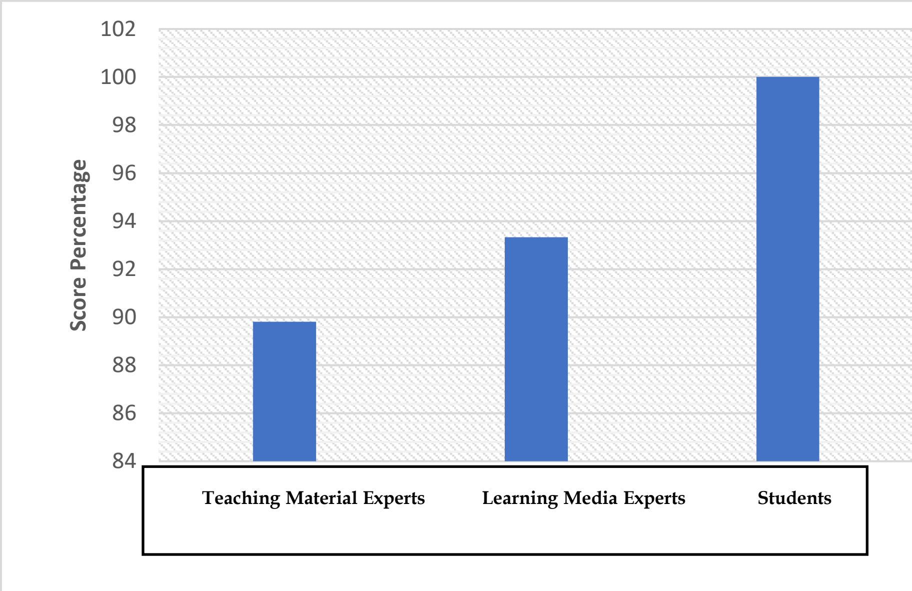

Figure 1: Feasibility and Legibility Test Result on Digital Handout

Figure 1 presents graphically the feasibility and legibility test results on digital handout prepared for the current study. The feasibility test on the handout by teaching material expert showed the percentage of 89,81% rated as valid; who provided a few suggestions on the digital handout: (1) to add a few questions on evaluation; (2) to match the list of tools and materials with the number of points on practicum manual section; (3) to add goals of the first practicum activity; (4) to fix the explanation of figures on practicum manual. The feasibility test on the handout by learning material expert showed the percentage of 93.33% with very valid feasibility. The following suggestions and comments were given by the teaching material expert: (1) add the author's and editor's name on the cover section; (2) fix the image color; (3) fix certain typos in the text. The result of legibility test on digital handout showed a full percentage of 100% showed that the digital handout was both practical and comprehensible for the students. Thus, both the feasibility and legibility test proved that the teaching material in the digital handout was valid, practical and comprehensible and could be sued in the learning process.

The implementation and evaluation phases (of the ADDIE model) witnessed a few statistical tests and statistical evaluation. Right at the outset, two prerequisite Tests (Normality Test and Homogeneity Test) were conducted. The normality and homogeneity test are conducted in order to determine parametric statistical analysis. The homogeneity test facilitates determining whether or not the distribution of data from two or more variants comes from a homogeneous population. This also requires comparison of two or more variants (Riadi, 2016). The Kolmogorov-Smirnov tool is used to perform this test. This tool allows to compare data distribution with the normal standard distribution (Riadi, 2016). Table 3 illustrates that the data was normally distributed of both the control and experimental groups (Sig. Experimental = 0.920, and Sig. Control 0.950).

Table 3

Homogeneity Analysis (Kolmogorov-Smirnov test)

		Experimental	Control
N		30	30
Normal Parameters[a,b]	Mean	164.29	166.19
	Std. Deviation	28.60	29.71
Most Extreme Difference	Absolute	.088	0.85
	Positive	.048	0.52
	Negative	-.018	-.016
Test Statistic		.501	.603
Asymp. Sig. (2-tailed)		.920	.950

Likewise, The Levene test was used in this study to test the homogeneity as presented in Table 4 which shows that the variables came from a homogeneous population (LS = .085, Sig = .879).

Table 4

Normality Analysis (Levene test)

		Levene Statistic	df1	df2	Sig.
Scores based on	Mean	.085	1	240	.710
	Median	.071	1	251	.879
	Median and with adjusted df	.078	1	248	.860
	Trimmed mean	.036	1	256	.821

The test results indicated that the data related to science process skills and cognitive learning outcomes fulfilled homogeneous prerequisites. These tests also enabled the researchers to determine the effectiveness of the teaching material in form of a digital handout which was designed and developed in order to develop the science process skills and cognitive learning outcomes.

To determine the effect of treatment of utilizing a digital handout with PBL model, a pre-test and a post-test were carried out for each of these groups. Table 5 summarizes the N-gain score, showing the difference in the Mean and SD of the two groups before and after the experiment. The table presents that N-gain score value for the experimental class was higher in the posttest as compared to the pretest. This is an evidence of the feasibility of the digital handout for the development of science process skills and cognitive learning outcomes.

Table 5

Summary of N-Gain Score (General)

Variable			Experimental	Control
Science process skills	Pre-Test	Mean	86.25	41.25
		SD	12.01	11.34
	Post-Test	Mean	88.21	55.63
		SD	7.45	8.24
Cognitive Learning outcomes	Pre-Test	Mean	69.45	42.0
		SD	11.0	9.34
	Post-Test	Mean	82.51	54.63
		SD	8.56	9.12

In continuation with calculating the N score of both the groups, a further comparison of the test results of students' Science Process Skills and Cognitive learning outcome was made for their factors. This comparison was between the scores before treatment (pre-test) and after treatment (post-test) in both experimental and control groups. It is evident from Table 6 and table 7 that there is an increase in the score in the posttest in both variables of both the groups. The experimental group which used the digital handout along with the PBL model of learning shows in the pre-test scores M = 2.19, SD = 1.16, and the post-test score of M = 3.75, SD = 1.35 in science process skills. The cognitive learning outcomes on the pretest score shows M = 2.18, SD = 1.29 and there is an increase in the post-test score, namely M = 3.56, SD = 1.45.

The control group which did not use the digital handout but was given the treatment with the traditional practical manual and the PBL model of learning showed a lesser improvement in comparison with the experimental group. Table 7 shows the Science process skills in the pre-test having a score (M = 2.12, SD = 1.10, and the post-test gets a score of M = 2.75, SD = 1.35. The cognitive learning outcomes on the pretest score shows M = 2.08, SD = 1.09 and there is an increase in the post-test score, namely M = 2.96, SD = 1.15. After all the assumptions and prerequisite analysis had been carried out and had met the requirements of the parametric test, the ANOVA test was performed. ANOVA test is used to determine the mean difference between several groups using analysis of variance (Riadi, 2016). Table 8 shows the results of the ANOVA test which suggests that there is a significant difference between the experimental and control groups (MS = 240,143, F = 52,995, Sig = .000).

Table 6

Comparison of Variables of The Experimental Group (Pretest and Posttest)

Variable		Pre-test	Post-test
Science Process Skill	Mean	2.19	3.75
	SD	1.16	1.35
Cognitive learning outcomes	Mean	2.18	3.56
	SD	1.29	1.45

Table 7

Comparison of Variables of The Control Group (Pretest and Posttest)

Variable		Pre-test	Post-test
Science Process Skill	Mean	2.12	2.75
	SD	1.10	1.35
Cognitive learning outcomes	Mean	2.08	2.96
	SD	1.09	1.15

Table 8

ANOVA Calculation Results of the Two Groups

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	40.3	1	40.14	42.95	.000
Within Groups	132.57	50	4.31		
Total	172.87	51			

The next and final step in the ADDIE model was evaluation. Based on the learning process of both the groups during the implementation phase, averages of initial, final and improved stages for science process skill and cognitive learning outcomes were calculated. Table 9 presents the mean values of both the experimental and control groups for both variables science process skills and cognitive learning outcomes. The purpose of this comparison was to identify the skill improvement phases, from initial to the improved state. The experimental group had used the digital handout with PBL learning model whereas the control class entered the implementation phase of learning without the use of digital handout but PBL learning model was utilized.

Table 9 presents the mean of initial value of science process skill of the experimental group equals 24.12 and the final value at 91.66, showing the improvement value of 67.54. The mean of initial value of science process skill on the control class was 40,00 and the final value was 67.50, thus it resulted in the improvement value of only 27.50. This comparison shows that the improvement of science process skills was higher in the experimental class than the control class. The mean of initial value of cognitive learning outcomes of experimental class was marked as 32.29 and final value was 88.19. Thus, it showed the improvement with 55.90. The mean of initial value of cognitive learning outcome of control class was about 29.86 and final value was about 75.17, with the improvement value of 45,28. This comparison also shows that the improvement of cognitive learning outcomes was higher in the experimental class than the control class.

Table 9

The Initial, Final, and Improvement Mean Value of Science Process Skill Based on the Learning Process in Class

No	Class	Value		Improvement
		Initial	Final	
Science Process Skill	Experiment	24.12	91.66	67.54
	Control	40.00	67.50	27.50
	Experiment	32.29	88.19	55.90
Cognitive learning outcomes	Control	29.86	75.17	45.28

The evaluation of the learning process using the digital handout was completed with a statistic test of *Mann Whitney*. Table 10 shows the resultant p value = 0,000, thus, p (0,000) <α (0,05), and with confidence level of 95%, it can be stated that the learning by using digital handout in PBL model could affect significantly the improvement of student's science process skills as well as cognitive process outcomes. The result of statistic test showed a significant effect on the use of digital handout by exerting PBL learning model to the improvement of cognitive learning outcome, on the confidence level of 95%, it was stated that the learning by using digital handout in PBL model could affect significantly to the improvement of student's cognitive learning outcome.

Table 10.

Mann Whitney Statistics

Variable	Class	Mean Rank	P value	Std. Error Mean
Science Process Skill	Control	13.11	0.000	4.35
	Experimental	32.59		2.65
Cognitive learning outcomes	Control	13.21	0.000	1.81
	Experimental	32.75		1.79

Mann Whitney, p = 0.05

Discussion

The research results have shown the effectiveness of digital handout implementation and PBL model in improving the students' science process skills and cognitive learning outcomes. In the experimental group, students were given digital handout equipped with the steps of practicum activities and videos that they could see directly, while the students in control group had practicum activities but without digital handout. Since the learning process was conducted online, practical videos were included in the digital handout. It was expected that the use of videos on practical activities could improve the level of science process skills and thus affect their learning outcomes.

Microbiology learning require the lecturer to build students' ability to explore ideas and new concepts through the students' skill in order to understand, learn, or find a new concept. The science process skills were the skills which should be owned by students. According to Feronika et al. (2009), the science process skill was referred as a whole directive scientific skill which was needed to acquire, develop, and implement science concepts, principles, laws, and theories. Yumusak (2016) asserts that science process skills comprise students' skills to observe, conclude, communicate, classify, measure, interpret, identify, do experiment, and formulate hypothesis.

A number of researches have indicated the advantages of science process skills and their implementation on learning, as were reported by Ekici et al. (2020), that the activity to collect, transform, and describe the data could bring the wider and more real experiences to the students about the data complexity in a research. The implementation of science process skills could increase the student interest to learn science, develop their critical thinking skill and teach them how to solve a problem (Karamustafaoğlu, 2011). Moreover, the learning of science process skill took a significant role for the students to understand the science process. Initially, the science process skill owned by the students of UNITRI who were taking on industrial technology course was relatively poor. This condition was because of the lack of instruments and tools in laboratory, and the student's learning media was still focused on the book. Based on this fact, it referred that the students had a lack of teaching material sources to master the concept and science process skill.

Based on the findings of the research, a very significant difference was evident between the experimental class and control class. The experimental class achieved better science process skills than the control class. Therefore, it was concluded that the implementation of digital handout which was based on the experimental research finding and which applied Problem Based Learning model during the online learning was effective to develop the science process skills of students. Furthermore, the other research finding showed that the effectiveness of digital handout which was based on the experimental research finding by exerting PBL model could increase the cognitive learning outcome of students. Hence, this research proved that the cognitive learning outcome on experimental class was higher than on the control class.

These findings are consistent with those of (Akinbobola et al., 2010) who highlighted the benefits of science process skill and proved that it could be regarded as an instrument of learning. These findings also agree with Duda et al. (2019) and Jeenthong et al. (2014), who believed that science process skills could be implemented as laboratory activities directly and virtually. (Abungu et al., 2014) and Tanti et al. (2020) also believed that the science process skills could improve the student achievement cognitive learning outcomes.

The experimental group in this study was equipped with a teaching material in form of digital handout that had the potential to improve the students' competence to answer questions. Moreover, the digital handout contained topics that were arranged according to the experimental research result in laboratory with factual images and descriptions. The cognitive aspects within digital handout covered areas like: remember, understand, apply, analyze, evaluate, cited and based on Bloom's taxonomy. Those aspects were integrated in the student learning as problem solving, independent and group investigation, presentation of the results of observation report, and process analysis and evaluation in the problem solving.

The academic competence has a significant effect to the cognitive learning outcome of students. This research result showed that the learning by using teaching material in form of digital handout based on experimental research and Problem Based Learning model was able to increase the student cognitive skill. The learning was a cumulative process, where the students with the higher prerequisite would be more prepared acquiring the process of learning rather than those who have minimum prerequisite (Mlambo, 2011). The initial science and knowledge highly affected the cognitive learning outcome (Karmana, 2012; Mamu, 2014). This result was in line with Redd et al. (2001) who have stated that the academic achievement could be influenced by the level of student's academic skill.

The academic skill as the initial knowledge was related to the first concept that has been mapped in the student's cognitive structure. The students with various initial knowledge, skills, and concepts significantly affected their concern and interpretation to the new information in surrounding environment, on its turn, the initial knowledge could affect their cognitive skill in terms of giving reason, solving problem, and acquiring new knowledge Council (2000) . In addition, the students would understand the material better when they already have relevant knowledge to what they learned. This result was in line with the explanation stated by Council (2000) in their research that the student who has many relevant knowledges with the topic he learned, he would understand better and remember the material better than the students who have a few of initial knowledge.

The learning process through digital handout was more effective to improve the cognitive learning outcome of students than the learning process without any digital handout. This statement was based on the fact that the digital handout was arranged and designed from experimental research results and based on phenomena surround the students, thus, this handout was factual and contextual. The digital handout which was based on experimental research result, as it was in the current study, would increase the student understanding, because the students could relate the material or subject with the existing phenomena in a real life. The use of digital handout was one of strategies to create a more effective learning process, so it caused the achievement and improvement of subject mastery. Moreover, the use of digital handout could create a more effective learning environment and affect positively to the cognitive learning outcome of students.

This research result was appropriate with some previous research findings that were related to the use of handout in a learning process. The researches by Nerita et al. (2017); Astra et al. (2019); and Munyoro (2014) have shown an improvement of student learning outcome by using handout during the learning process. Nerita et al. (2017) assert that learning by using a digital handout could increase students' activities and achievements, particularly in biology learning. According to Peniati (2012), any developed teaching material like a digital handout, developed from an experimental research, was more factual. It would be very useful to solve the problems that might be encountered in the daily life. It could trigger the curiosity of students to examine and observe more on problems in the real life. Furthermore, the experimental activities could help improving the science process skill (Aydogdu, 2015).

According to the Ministry of National Education, 2010 (Wahyudin et al., 2017), the teaching material was a significant learning component that affected the process of learning. This opinion is similar to the idea stated by Behnke (2018), who stated that the learning process could be more effective and efficient when the learning source was available, for example the teaching material in the form of a digital handout. There were a lot of benefits to use a teaching material, as it was able to increase the student motivation and the achievement of learning outcome was fitted to the student capability and skill (Lestari, 2020; Prasetya, 2018). There are other advantages of digital handout use such as benefits as the source of science and knowledge which was able to help improving the student's process quality and learning outcome. According to Ardan (2016), the goals of building the teaching material included: information source in the learning process, supporting the learning process, and role of learning media. The advantages of digital handout were not only practical, but it also provided practicum activity, which the students could find from each step of their learning. Another advantage of digital handout was that the students could be more motivated during learning process, so they were able to develop their critical thinking skill, science process skills, and cognitive learning outcome. Fitriwati (2019) believed that one of factors which could affect the student achievement was motivation. Through the motivation given by the lecturer, the students would study harder, be diligent and resilient, and have a full of concentration during the learning process. The digital handout could be used via android smartphone, which enabled and eased the students to access their courses from anywhere and everywhere.

Conclusions

The current research had devised a digital handout on the topic "*The Test on Antagonism Power of Antagonistic Fungi to Pathogenic Fungi*" which provided opportunities for students to find more about the surrounding problems, especially about the disease symptoms on plants which might be caused by pathogenic fungi. This handout helped the students to solve the problem given in the experimental research. The researcher found that the pretest score achieved by the students was relatively poor, but after the implementation of developed teaching material in the form of digital handout based on an experimental research, they could improve their score. This discovery is evident in the result of student's posttest score achievement.

The learning on the topic of fungi in the Department of Agricultural Industrial Technology of UNITRI was very beneficial and significant, because generally the students had not known the concept of fungi in detail, but after they received learning through a digital handout comprising videos and practicum activities, it was proven to increase and stimulate the student curiosity. This result was based on the observation result exerted by the researcher during the virtual learning and teaching process in the class. The students seemed to be more active and curious about the answers of questions given by the teacher. The motivation was related to the student learning outcome.

The implementation of Microbiology learning on the topic: The Test on Antagonism Power of Antagonistic Fungi to the Pathogenic Fungi" could be examined due to the result of student pretest and posttest, either in the experimental class or control class. The posttest score was proven higher than the pretest score. Moreover, the students were able to solve problems in their daily life relating to the tissue damage on part of plant which might be caused by pathogenic fungi, as it was indicated by the manner in which students answered the questions in the class. This result also confirmed that the microbiology learning through a digital handout based on the experimental research could be practiced well.

Based on the research results on a digital handout on "Test of Antagonism Power of Antagonistic Fungi to the Pathogenic Fungi on *Mangifera caesia* plant" to improve the science process skill and cognitive learning outcome of students, the conclusion are as follows:

1. The microbiology digital handout which was based on an experimental research result in the laboratory is valued as a valid teaching material, due to the whole contents in teaching material. It is practical from the aspect of implementation during the learning process, and effective due to the result of N-gain score of science process skills, and the learning outcome achieved by the experimental class was higher than the control class.
2. The statistic test result referred a significant effect on the implementation of experimental research-based digital handout in the form of an improvement of

student's science process skill. The utilization of digital handout could develop the science process skill.

3. The statistic test result indicated a significant effect on the implementation of experimental research-based digital handout to the improvement of student's cognitive learning outcome. The use of digital handout could develop the cognitive learning outcome of students.

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