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Microbiology Handout Development Based on the Laboratory Research Results of "Medicinal Plant Extract Antibacterial Effect" to Improve Science Process Skills of Biology Students

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ABSTRACT
This study is a research and development project on a microbiology handout on the topic of "Antibacterial Test of Medicinal Plants," using *Chromolaena odorata* L. as the content material in the learning media to improve science process skills.This study aims to produce a valid, practical, and effective learning media to support the Microbiology learning process. The handout development uses the ADDIE development model. Handout validation was carried out by media and learning experts, material experts, practitioners of Microbiology learning experts, and student respondents. The handout trial was conducted through three stages of trials, namely one-to-one trial of 3 students, a small group trial of with 8 students, and field trial of with 20 students. The effectiveness of handouts in improving SPS (Science Process Skills) can be seen through pretest-posttest gain scores analyzed using the ANACOVA test. The research results showed the scores from the media and learning process experts is 90.4%, from the material experts is 100%, from the practitioners of Microbiology learning is 98.57%, and from the student respondents is 96% as well as efficiency results of 0.00.

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1. INTRODUCTION

The university aims to produce graduates who are able to understand the problems in the surrounding environment and solve problems. Students must have a lot of cognitive knowledge in order to solve problems (Manoppo, 2020). Besides that to cognitive abilities, students also need to have science process skills. This is in accordance with Permendikbud No. 49 of 2014 concerning National Higher Education Standards which states that graduates who come from undergraduate or diploma four must at least master certain skills and theoretical concepts in more depth (Kemendikbud, 2014). Based on this, research it is in accordance with the situation of undergraduate Biology students who are required to be able to understand various concepts and must have skills in order to support the development of skills, knowledge, and attitudes of students, so that they able to solve problems in everyday life.

Kognitive skill is give more priority compared with the psychomotor skill, but the psychomotor skill is needed by student in learning process. So it is important to give the students the opportunity to make observations, measure, calculate, data analyze, and make discussion with their friends and make the conclusions. This activity can be obtained through practical activities to improve Science Process Skills (SPS) (Rustaman, 2003; Hamidah, 2022). Through practical activities that carried out by the learning outcomes in the Semester Program Plan, that student not only can improve SPS but also can improve cognitive skill obtained through the practical activities.

Science Process Skills (SPS) can train the learning skills in order to gain students' cognitive skill through practical activities (Rohmatul *et al.*, 2022). Practical activity can improve SPS because in the practical activities students are trained to develop all their sensory skills (Suryaningsih, 2017). Through practical activities, the students get the opportunity to carry out their own skill in, observe, measure the data, discuss the practical results practical and to analyze the practical data and make conclusions (Dari & Nasih, 2020). Besides that, SPS is needed by students because it not only important to improves their science literacy skills, but also supports their teaching skill when they become researchers or lecturers (Artayasa *et al.*, 2021). Based on the research result by Dari & Nasih (2020) it proved that SPS can be improved through practical activities.

The results of the needs analysis conducted by researchers through questionnaires to undergraduate Biology program students at the Faculty of Mathematics and Natural Sciences, State University of Malang who have taken Microbiology courses as many as 35 students using instruments in the form of multiple choice questions. The questionnaire was distributed in June 2024 and showed that the Science Process Skills (SPS) of Biology students were still low, it was proved on their average presentation is 33.33%. The low SPS is also proved by the needs analysis result on students that showed the difficulties found in learning, namely the learning materia is difficult to understand and the teaching materials are not interesting for students. Besides that, the needs analysis result conducted to the lecturers using a questionnaire conducted in June 2024 shows that. The Microbiology lecturer have trained SPS, but there are still several SPS indicator that have not been trained optimally. Therefore, it is necessary to empower SPS to the students.

The attempt to empower SPS is by developing learning media that completed with illustrations to make the material be more interesting and clear. One of the learning media is handouts, because handouts are specific to certain topics, practical, and completed with practical instructions, evaluation questions, and structured assignments related to the practical activities that have been carried out by the students (Laela & Risnaningsih, 2021; Sari *et al*., 2022). Handouts are completed with basic theories about the medicinal plants, the role of antibacterial secondary metabolite in medicinal plants for pathogenic bacteria biological control, factors that affect the inhibition of bacterial growth, and the role of medicinal plants as natural antibiotic material. Handouts can be completed with various illustrations that can help students understand the Microbiology concept. The concept is especially in antibacterial effect of medicinal plants to inhibite the pathogenic bacterial growth (Dhamayanti & Ishafit, 2021). The developed handout is based on the of laboratory research results conducted by the researcher on "Antibacterial Effect of Angguni Plant Extract (*Chromolaena odorata* L.) as a Medicinal Plant". This handout is intended to serve as an alternative material learning to support the learning process of Microbiology, especially on the topic of "Medicinal Plants Extract Antibacterial Effect". Through the use of this handout, it is hoped that the science process skills of undergraduate Biology students can be improved.

2. RESEARCH METHOD

The research and development model used in this research is the ADDIE development model which consists of five stages, namely analysis Analyze, Design, Develop, Implement, and Evaluate (Branch, 2009). The content presented in the handout is based on the results of research conducted by researchers in the laboratory and the handout is designed using the Canva application. The subjects in this study were 56 undergraduate Biology students at State University of Malang, which were divided into two classes, namely the experimental class and the control class. The type of research used was a quasi-experiment using a Non-randomized Control-Group Pretest-Posttest Design (Leedy & Ormrod, 2015). The research instruments and data analysis techniques uses in this study are qualitative data. The criticis and suggestions obtained from the validators, and student respondents quantitative data, from the assessment results were obtained from the student respondents to evalute the handouts and pretest-posttest. Quantitative data analysis is based on the results of validity, practicality, and effectiveness tests by media and learning eqiupment experts, material experts, Microbiology learning practitioners and student respondents. Quantitative validation data were analyzed using the following formula.

$$\text{Vah} = \frac{TSe}{TSh}\, x\; 100\%$$

Source: Akbar (2017:82)

Description:

Vah : Results of expert validity
TSe : Total empirical score (validation results from validators)
Tsh : Total maximum expected score

The criteria for the validity of the handout based on the assessment by the validator can be seen in the percentage results in Table 1.

Table 1. Criteria for Handout Validity

No.	Validity Criteria	Level of Validity
1.	81,00%-100,00%	Very valid, can be used without revision
2.	61,00% - 80,00%	Valid, usable but needs minor revisions
3.	41,00% - 60,00%	Fairly valid, can be used but needs revision
4.	21,00% - 40,00%	Less valid, needs major revision
5.	00,00% - 20,00%	Invalid, cannot be used

Source: Modified from Akbar (2017:82)

Data on the results of handout practicality using test results based on questionnaires that have been filled in by students and expert field practitioners. Handout practicality data was analyzed with the following formula.

$$\text{Vp} = \frac{TSe}{TSh}\ x\ 100\%$$

Source: (Akbar, 2017:82)

Description:
Vp : Results of expert validity
TSe : Total empirical score (validation results from validators)
Tsh : Total maximum expected score

The calculation results from the questionnaires that have been filled in by students and expert field practitioners are then adjusted to the level of product practicality criteria in Table 2.

Table 2. Product Practicability Criteria

No.	Validity Criteria	Practicality Level
1.	81,00%-100,00%	Very practical, can be used without revision
2.	61,00% - 80,00%	Practical, usable but needs minor revisions
3.	41,00% - 60,00%	Practical enough, can be used but needs revision
4.	21,00% - 40,00%	Less practical, needs major revision
5.	00,00% - 20,00%	Not practical, not usable

Source: Modified from Akbar (2017:82)

Uji Keefektifan

Data analysis of the effectiveness of Microbiology handouts developed to improve science process skills, can be known based on the pretest and posttest scores with ANACOVA test with a significance level < 0.05. But before that analysis, prerequisite tests must first be carried out, namely the normality test with the Kolmogorov Smirnov test and the homogeneity test with Levene's Test of Equality of Error Variance. Besides that, the descriptive analysis techniques is also done based on the results of pretest and posttest scores on SPS. The results of the pretest and posttest improvement were calculated using the N-Gain score as follows.

$$N\text{-}gain = \frac{\text{Spost} - \text{Spre}}{Smax - Spre}$$

Sumber: Hake (1997:65)

Description:
Spost : Posttest score
Spre : Pretest score
Smax : Ideal maximum score

3. RESULT AND DISCUSSION

The research and development results data are described below in detail which refers to the ADDIE development model by (Branch, 2009).

1. Analysis

Based on the results of the needs analysis questionnaire for undergraduate Biology students, it was found that students' understanding of the topic "Medicinal Plants Extract Antibacterial Effect" was still very lacking, so this had an impact on the Science Process Skills possessed by students. Therefore, learning media is needed that can help lecturers in Microbiology courses to support the learning process on the topic of "Medicinal Plants Extract Antibacterial Effect" based on research that contains contextual material, so that students can apply the concepts that have been obtained to solve problems in daily life. The handout contents is compiled based on the research results conducted by researchers in the laboratory.

2. Design

The objective of this stage is to produce a Microbiology handout based on laboratory research results, which will be presented as content in the developed handout. The research results are used as a learning medium to assist lecturers and students in supporting the learning process, particularly on the topic of "Medicinal Plants Extract Antibacterial Effect." The developed microbiology handout is equipped with theoretical foundations and original documentation from researchers to provide students with a clear understanding of the activities to be conducted. The objective is to enhance SPS among undergraduate biology students at UM who are taking the microbiology course.

3. Develop

At this stage, the learning media design which has been prepared previously is then developed. At this stage, validation is also carried out by validators which aims to assess whether the learning media is valid, practical, and effective. Validation is carried out by media and learning device expert validators, material experts and Microbiology learning practitioners. The results of validation can be seen in Table 3. The validity criteria given by the validator is 90.4% which indicates that the Microbiology Handout is completely valid according to Akbar (2017).

Table 3. The Handout Validation by Media and Teaching Material Experts

No.	Assessment Criteria	Average	Percentage (%)	Category
1.	Content Eligibility	4,7	94	Very valid
2.	Handout Cover Design	4,6	92	Very valid
3.	Handout Content Design	4,9	98	Very valid
4.	*Self Instructional*	4,8	97	Very valid
5.	*Self Contained*	4	80	Valid enough
6.	*Stand Alone*	4	80	Valid enough
7.	*Adaptive*	4	80	Valid enough
8.	*User Friendly*	5	100	Very valid
9.	Language Eligibility	4,5	90	Very valid
10.	Handout Integration with the Dependent Variable	4,6	93	Very valid
Average Percentage of Validation Results (%)			**90,4**	**Very valid**

The validity criteria given by the material expert validator is 100% which indicates that the Microbiology Handout is completely valid according to Akbar (2017), because it has compiled all aspects of the assessment criteria (Table 4), so it can be used in the learning process, especially Microbiology. It can be seen that the user friendly aspect achieved 100%, indicating ease of use for students. Besides that, the content design aspect of the handout, which received the second highest score, achieved 98%, indicating an attractive and well-structured design. These criteria indicate that the Microbiology handout is suitable and useful in the trial stage to students before being implemented in learning activities in Microbiology courses. The validation results by material expert validators was shown in Table 4.

Table 4. Results of Microbiology Handout Validation by Content Expert Validators

No.	Assessment Criteria	Average	Percentage (%)	Category
1.	Aspects of Material Description with CPMK and Sub CPMK	5	100	Very valid
2.	Accuracy of Material	5	100	Very valid
3.	Breadth of Material	5	100	Very valid
4.	Up-to-date Material	5	100	Very valid
5.	Encourage Curiosity	5	100	Very valid
6.	Presentation Technique	5	100	Very valid
7.	Presentation Support	5	100	Very valid
8.	Presentation of Learning	5	100	Very valid
9.	Coherence and Order of Thought	5	100	Very valid
Average Percentage of Validation Results (%)			**100**	**Very valid**

The validity criteria given by the educational practitioner expert validator is 98.57% and the response from students for the practicality test of the handout with the average percentage is 96% with all practical category, indicating that the Microbiology Handout is completely valid and practical according to Akbar (2017). Since it has compiled all aspects of the assessment criteria (Table 5 and Table 6), so it can be used in the learning process, especially Microbiology. The validation results by expert validators of Microbiology learning practitioners are shown in Table 5 meanwhile student responses to the practicality of handouts are shown in Table 6.

Table 5. Microbiology Handout Validation Results by Microbiology Learning Practitioner Validator

No.	Assessment Criteria	Average	Percentage (%)	Category
1.	Breadth of Material Description	5	100	Very valid
2.	Clarity of Material Presentation	5	100	Very valid
3.	Up-to-date Material	4,7	95	Very valid
4.	Language Eligibility	5	100	Very valid
5.	Presentation Support	4,7	95	Very valid
6.	Presentation Support	5	100	Very valid
7.	Usage	5	100	Very valid
Average Percentage of Validation Results (%)			**98,57**	**Very valid**

Table 6. Results of Student Response to the Practicality of Microbiology Handout

No.	Student	Average Percentage (%)	Category
1.	Student ke- 1	95	Very practical
2.	Student ke- 2	90	Very practical
3.	Student ke- 3	100	Very practical
4.	Student ke- 4	98	Very practical
5.	Student ke- 5	95	Very practical
6.	Student ke- 6	95	Very practical
7.	Student ke- 7	98	Very practical
8.	Student ke- 8	100	Very practical
9.	Student ke- 9	95	Very practical
10.	Student ke- 10	95	Very practical
11.	Student ke- 11	97	Very practical
12.	Student ke- 12	95	Very practical
13.	Student ke- 13	98	Very practical
14.	Student ke- 14	96	Very practical
15.	Student ke- 15	96	Very practical
16.	Student ke- 16	97	Very practical
17.	Student ke- 17	95	Very practical
18.	Student ke- 18	96	Very practical
19.	Student ke- 19	96	Very practical
20.	Student ke- 20	97	Very practical
Average Percentage (%)		**96**	**Very practical**

4. Implement

At this stage the researcher acts as a lecturer in implementing the Microbiology handout which has been developed. Besides that, lecturers prepare undergraduate Biology students class who are taking Microbiology courses. There are 56 students with a division of 28 students as an experimental class that will be implemented using Microbiology handouts based on guided inquiry learning models and 28 students as a control class that is not loaned handouts for the Microbiology learning process, but learning using PPT (PowerPoint) with a learning model that is often applied by lecturers teaching Microbiology courses.

The effectiveness of Microbiology handouts in improving Science Process Skills in students can be seen through pretest and posttest scores. The pretest and posttest scores were analyzed for gain score to determine the increase in score on each variable and analyzed inferentially using ANACOVA test on each variable to test the comparison between pretest and posttest scores in experimental and control classes.

Data from descriptive analysis on students' science process skills for experimental and control classes are shown in Table 7.

Table 7. Mean Pretest-Posttest Score and Difference in Improvement of Science Process Skills in Each Class

No.	Class	Science Process Skills			Description
		Pretest	*Posttest*	Difference in Improvement	
1.	Experiment	51,4	78,5	27,1	Increased 52,72%
2.	Control	52,8	65	12,2	Increased 23,10%

Table 7 shows an increase in learning towards Science Process Skills. Based on the data in Table 6, it can be seen that in the experimental class a difference is 27.1 was obtained, with a pretest value is 51.4 and a posttest is 78.5, resulting in an increase is 52.72%. Meanwhile, the control class obtained a difference is 12.2 with a pretest value of 52.8 and a posttest is 65, resulting in an increase of 23.10%. The higher learning improvement on science process skills. In experiment class based on the average pretest and posttest scores data, is higher that the control class. The interpretation of the average pretest and posttest scores and the difference in the improvement of SPS in each class is shown in Figure 1.

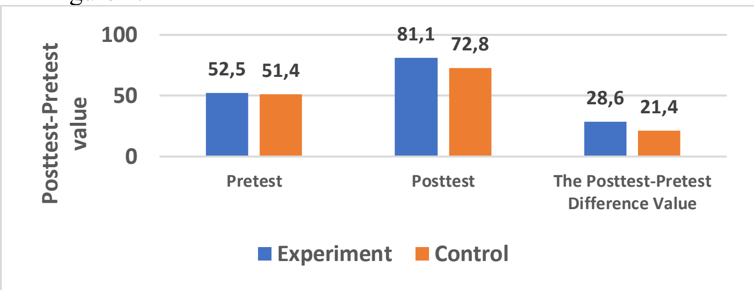
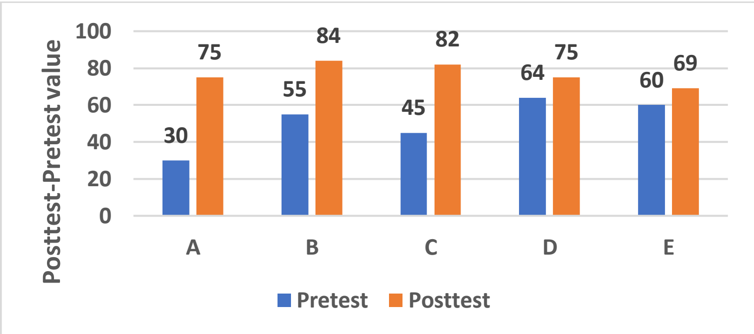


Figure 1. Mean Posttest-Pretest Value and Difference in SPS Improvement

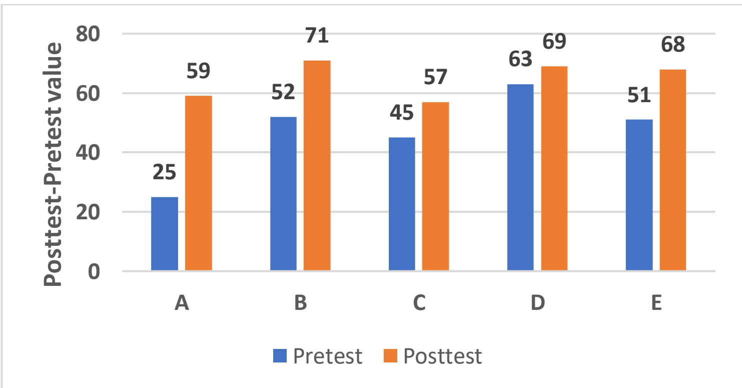
The pretest and posttest value of the control class on Science Process Skills (SPS) on each indicator are shown in Figure 2.



Caption:
A : Information interpretation
B : Investigation Activity
C : Experiment Plan
D : Concept Implementation
E : Communication

Figure 2. Science Process Skills Value in Each Indicator in the Control Class

The experimental class pretest and posttest value on Science Process Skills (SPS) on each indicator are shown in Figure 3.



Caption:
A : Information Interpretation
B : Investigation Activity
C : Experiment Plan
D : Concept Implementation
E : Communication

Figure 3. Science Process Skills Values in Each Indicator in the Experimental Class

The percentage increase in SPS in each indicator for the control class and experimental class is shown in Table 7.

Table 7. SPS Improvement

Science Process Skill Indicators	Control			Experiment		
	Average Value		Percentage Improvement (%)	Average Value		Percentage Improvement (%)
	Pretest	*Posttest*		*Pretest*	*Posttest*	
Information Interpretation	25	59	34	30	75	45
Investigation Activity	52	71	19	55	84	29
Experiment Plan	45	57	12	45	82	37
Concept Implementation	63	69	6	64	75	11
Communication	51	68	17	60	69	9
Average	**47**	**64**	**17**	**50**	**77**	**26**

Based on the data in Table 7, the average pretest value of Science Process Skills (SPS) in the control class was 47, while in the experimental class is 50. After the posttest, both groups showed a significant increase, with the SPS value in the control class is 64 and in the experimental class is 77. The posttest is 17% for the control class and 26% for the experimental class. From these data, it can be concluded that the treatment given to the experimental class can significantly improve the science process skills of students compared to the control class.

5. Evaluate

At this stage, inferential analysis is carried out by conducting prerequisite tests before conducting hypothesis testing using the ANACOVA test. prerequisite tests are normality test and homogeneity test. The results of the prerequisite tests are shown in Table 8 and Table 9.

Table 8 Normality Test Results of Science Process Skills

Variable	Test	Class	df	Sig.	alpha	Description
Science Process Skills (SPS)	*Pretest*	Experiment	28	0.087	0.05	Normal
	Posttest	Experiment	28	0.066	0.05	Normal
	Pretest	Control	28	0.077	0.05	Normal
	Posttest	Control	28	0.103	0.05	Normal

Based on the data presented in Table 8, it shown that the data is normally distributed because the significance value > 0.05.

Table 9: Homogeneity Test Results of Science Process Skills

Variable	Test	df1	df2	alpha	Sig.	Description
Science Process Skills (SPS)	*Posttest*	3	108	0.05	0.780	Homogeneous

Based on the data presented in Table 9, it shown that the data is homogeneous because the significance value > 0.05. This shows that the variance between the two treatments in the experimental class is homogeneous. The data that has been normally distributed and homogeneous is the basis for researchers to continue statistical analysis, namely ANACOVA.

Hypothesis testing was carried out after it was known that the Science Process Skills (SPS) data were normally distributed and homogeneous. The ANACOVA test results on SPS can be seen in Table 10.

Table 10. ANACOVA Test Results of Science Process Skills

Source	Type II Sum of Squares	df	MS	F	Sig.
Corrected Model	5513.372[a]	2	5756.686	27.525	.000
Intercept	5227.642	1	5227.647	52.197	.000
Pretest	2934.801	1	2934.801	29.303	.000
Kelas	2893.741	1	2893.741	28.893	.000
Error	5308.056	53	100.152		
Total	299400.000	56			
Corrected Total	10821.429	55			

Based on Table 10, the ANACOVA test results show a significance value <0.05. This indicates that the Microbiology handout has a significant effect to improve the student’s Science Process Skills (SPS), the

Microbiology learning presented with a guided inquiry learning model can give a chance for the students to think and work by them selves. These activities can improve student SPS. Students can find answers to solve the problems formulated through the learning process, think creatively and think critically to find conclusions based on their observations from their search activity. The number of learning activities with the guided inquiry model will produce more learning experiences for students (Fitriani & Firdaus, 2020). Therefore, the more learning activities that are carried out, the more learning outcomes are obtained. Besides that, it can also be seen from the corrected mean scores for the experimental and control classes shown in Table 11.

Table 11. Corrected Results of Science Process Skills

Class	Corrected Average
Experiment	78,57
Control	65

Based on Table 11, the corrected results shown that the experimental class obtained a corrected mean value is 78.57 which shows that this value is higher than the corrected mean value obtained in the control class which has a value is 65.

Besides that to prerequisite tests and ANACOVA tests, the N-Gain Test was also conducted to determine the effectiveness of Microbiology learning in improving SPS based on pretest and posttest scores. Assessment of Potential Improvement Criteria Pretest and posttest scores according to Hake (1997) is described below.

Table 12: Criteria for Potential Improvement of Pretest and Posttest Scores

Value Achievement Criteria	Effectiveness Level
n-gain ≥ 0,7	High effectiveness
0,3 < *n-gain* ≥ 0,7	Medium effectiveness
n-gain ≤ 0,3	Low effectiveness

Source: Hake (1997:65)

The N-Gain test on SPS in this study is shown in Table 13.

Table 13. N-Gain Test Results of Science Process Skills

Variable	*N-Gain*	Value	Category
Science Process Skills	Experiment Class	0,565	Medium effectiveness
	Control Class	0,244	Low effectiveness

Based on Table 13, the results of the N-Gain test on Science Process Skills (SPS) can be seen that the results of the N-Gain test show a score of 0.565 in the experimental class on SPS, so it can be seen that the guided inquiry-based Microbiology handout is classified in the medium effectiveness category. The use of this handout is quite effective, because the score is in the range of 0.3 < n-gain ≥ 0.7 and is able to increase student's SPS, compared to the control class which has a score of 0.244 which shows that the effectiveness of learning without Microbiology handouts is classified in the low effectiveness category with n-gain ≤ 0.3.

6. CONCLUSION

Based on the results of the study, it is known that microbiology handouts can support the microbiology learning process, especially on the topic of "Medicinal Plants Extract Antibacterial Effect", which was deemed practical based on the results of a questionnaire from validators consisting of lecturers, field practitioners, and students. The effectiveness of microbiology handouts in improving science process skills through microbiology handouts has been proven through pretest and posttest results analyzed using the ANACOVA test. The research results showed the scores from the media and learning process experts is 90.4%, from the material experts is 100%, from the practitioners of Microbiology learning is 98.57%, and from the student respondents is 96% as well as efficiency results of 0.00.

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