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Development of protist practical guides based on online learning to improve learning outcomes

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Abstract

The objective of the study was to determine the level of validity, readability, practicality, and product effectiveness in improving protist practicum learning outcomes. The product development model uses the define, design, develop, and disseminate stages. Data analysis used percentage analysis and t-tests for paired samples. The results of data analysis show that in the needs analysis was known that all students have carried out online protist practicum. In the old product, some students still find it difficult to understand the steps for implementing the practicum. In the test of the effectiveness of the new product, for a limited class and a wider class, it was found that there was a significant difference between the old product and the new product. The conclusion is that there is a significant influence on the application of new products in the implementation of online practicum.

Keywords: Learning outcomes; online; practical guide; product development; protist.

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1. Introduction

Practicum activities are proof of theories obtained by students in class. The laboratory is where elegant scientific theories meet messy everyday reality. In a laboratory, complicated scientific theories and the messy realities of everyday life collide (Corter et al., 2011). Biological data is more valuable if it can be easily communicated because so much in biology may be gained by comparing results from various species' systems, which means that measurements from one laboratory to another must be accurately reported (Janetos, 2009). In addition, students can also practice carrying out scientific-based activities.

Traditional didactic lectures (for passive learners) have been supplanted with student-centered active learning techniques (experiential learning) (Hardie et al., 2021; Huang et al., 2022; Müller & Mildenberger 2021). The traditional didactic lectures (passive learners) have been replaced by student-centered active learning approaches (experiential learning) (Powers et al., 2021), which have an important impact on research, academia, and healthcare (Muneer et al., 2021). Therefore, the existence of a laboratory and its supporting elements are expected to be able to support the implementation of practicum and research as recorded by Dam-O et al., (2023) in their research on an online physics laboratory in the United Kingdom.

1.1. Conceptual background

From December 2019 until now, the world, including Indonesia, has been hit by the COVID-19 pandemic. The COVID-19 pandemic has also spread to the Indonesian city of Samarinda. Direct human contact or aerosol pollution can be avoided while maintaining social distance through obstruction or seclusion, slowing the spread of the epidemic (Chang et al., 2021), as a result, online learning tools are encouraged to be used by both teachers and students (Maqableh & Alia, 2021; Lee et al., 2021; Auer et al., 2022; Kapilan et al., 2021). As a result of the pandemic, all learning activities at all levels of education in Samarinda City are carried out online. Practical activities for students including students of Biology Education, Faculty of Teacher Training and Education, Mulawarman University are also carried out online.

Related to protists, it is one of the courses in the curriculum at the Biology Education Study Program, Faculty of Teacher Training and Education, Mulawarman University, which discusses eukaryotic single-celled (unicellular) organisms. Algae, protozoa, and single-celled fungi are among the organisms classified as protists. Depending on whether a protozoan is exclusively heterotrophic or entirely phototrophic, it is categorized as an alga (Burki et al., 2021). Organisms that are included in protists, and laboratory observations require special treatments. Thus, these microorganisms can be observed precisely.

Although there are several meanings of the term ‘learning result’ that reflect the perspectives of equally different scholars, it is typically regarded as the pinnacle of educational evaluation (Kim & Park, 2021). For instance, employing a lab has the goal of increasing student knowledge by illustrating concepts and principles (Corter et al., 2011). The KIPPAS categories for laboratory learning objectives were knowledge and understanding, inquiry skills, practical skills, perception, analytical skills, and social and scientific communication (Brinson, 2015).

The results of the interview conducted on Wednesday, 10 March 2021, with two teams of assistant practicums for the Protists course, and one Biology Education Laboratory setup, Faculty of Teacher Training and Education, Mulawarman University, all of them (100%) said that since the emergence of the COVID-19 pandemic, all practicum themes for protist courses, are carried out online. Furthermore,

information was obtained that in 2020, the protists practicum participants in class A, Biology Education Study Program, totaling 44 people, there were 6 students (13, 64%) who obtained a final score below 50 and were declared unsuccessful. The final practicum score is obtained from the assessment components consisting of activity (30%), report on practicum results (40%), and final exam (30%). Learning outcomes (final grades) for practicum, are used by lecturers to calculate the final grade for the course exam and to determine whether or not to pass the course concerned. In addition, in calculating the final score for student graduation in courses practiced in the laboratory, the value of practicum learning outcomes is included to be calculated using a certain scheme that is prepared.

In addition, the results of online interviews with 11 students of the 2018 Biology Education study program on 1 October 2021 (students who have passed the protists course), all student respondents (100%) chose to use the application (Zoom Meeting, Google Classroom, WhatsApp, YouTube, Google Meet). From the results of interviews with these students, it is known that all respondent students (100%) experience obstacles related to quotas when using applications that take up a lot of quotas, such as the Zoom meeting application. In addition, all student respondents (100%) acknowledged that the quality of the video and audio displayed during the online practicum was still low and sometimes it was not accompanied by a detailed and operational explanation related to the technical implementation of the protist practicum activity at that time. For the implementation of the online practicum to run smoothly and validly, it is necessary to develop a protist practicum guide whose implementation is based online.

The advantage of an online implementation-based protist practicum guide is that in an online practicum situation, the contents of the practicum guide allow students to carry out practicum correctly to achieve the expected practicum goals. The contents of the practicum guide can also offer guidance on tools, resources, or media, procedures for carrying out activities that are more specific, understandable, and directed, the data collected, data analysis, conclusions, and the network platform utilized in the practicum. The best results are gained when students can use the guide at home before going to the laboratory (Genghini et al., 1996).

1.2. Purpose of study

The objective of the study was to determine the level of validity, readability, practicality, and product effectiveness in improving protist practicum learning outcomes.

2. Method and Materials

2.1. Participants

The research participants were students of the Biology Education Study Program, Faculty of Teacher Training and Education, Mulawarman University, Indonesia. Students as participants are those who are taking Protista courses and holding Protista practicums at the Biology Education Laboratory. Students consist of 2 classes, namely class A, which has 38 students, and class B, which has 36 students. Product trials in a limited class were applied to 15 students. Meanwhile, product trials in a larger class were applied to 36 students.

2.2. Procedure

The product development model uses the Four D pattern (define, design, develop, and disseminate), developed by Thiagarajan (1974). At the define stage, observations are made to find out the problems of implementing protist practicum (practicum learning outcomes, barriers to online practicum implementation, cover and the contents of the protist practicum guidebook), the use of online platforms

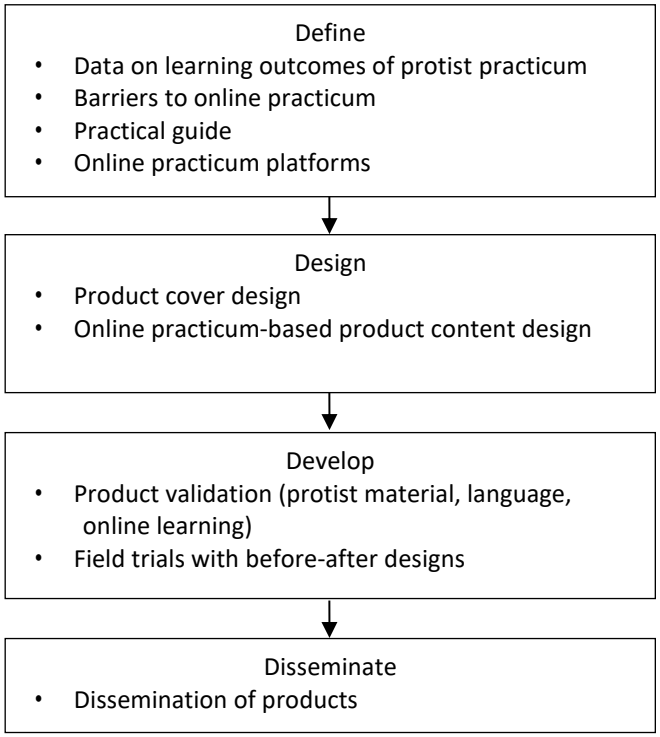
during the online practicum. In the design stage, product design is carried out (the protists practicum guidebook based on online implementation) which includes product cover design and product content design. At the development stage, it is carried out product development that includes product validation and product application trials in a limited class and a wider class. Product trials using a before-after design. The type of research in product application trials is quasi-experimental. Related to the before-after design steps during the quasi-experimental stage are:

1. Determination of student groups to be research subjects.
2. Before giving treatment, students were given a pre-test.
3. Next, students take part in practical activities using new products.
4. After students carry out all the practicum themes in the product (new practicum guide), these students are given a post-test. The pre-test and post-test questions are the same.

This before and after a design is applied to both a limited class and a wider class. The product development process flow chart is presented in Figure 1.

Figure 1

Flowchart of Product Development Guide for Online Protist Practicum



2.3. Data collection instruments

The materials used in the research are research instruments. The instruments used in the study were: (1) a questionnaire, to find out the problems of protist practicum so far, the level of product readability, and the practicality of the product and (2) test questions, to find out the results of learning protist practicum before and after giving the treatment, on the product effectiveness test. Questionnaires and

test questions were developed by the research team and have been validated by material validators, and trials have been carried out in higher classes (XIth class majoring in natural sciences).

Regarding the test questions, they were given to students before the treatment was applied (pre-test) and when all treatments were applied (post-test). Test questions are used to measure student practicum learning outcomes. Related to test questions, presented in Table 1.

Table 1

The Form and Content of the Test Questions to Measure Student Practicum Learning Outcomes

No.	Question content	Question weight
1	Sequence the steps of sterilization activities that you do!	0.5
2	Sequence the steps for preparing microorganism growth media that you do!	0.5
3	Sequence the steps for isolating fungal spores from the air that you do!	1.0
4	Sequence the steps of your mushroom coloring activity!	1.0
5	Summarize the type (name) of fungus you find based on the observational data you have!	2.0
6	Detail the morphological characteristics of the protozoa according to the results of video or image observations!	1.0
7	Summarize the position of protozoa in its taxonomy based on observational data on protozoan morphology!	2.0
8	Break down the ultra structures of the algae cells you observe!	1.0
9	Summarize the position of algae in their taxonomy based on the observed data you have!	0.5
10	Sequence the activities of making mushroom wet preserves that you do!	0.5

2.4. Data analysis

Related to the average score given by the validator in the product validation process, it will be processed and included in certain categories. The average score given by the validator is divided into five categories. The five categories are very bad, bad, moderate, good, and very good. The process of categorizing the average score is also carried out to test the readability of the product content and the practicality of using the product. The following Table 2 shows the categorization for the average score given by the validator in product assessment.

Table 2

Categorization for the Average Score for Certain Assessment Aspects of the Validator

No.	Score range	Category
1	<1	Very ugly
2	$1 > X < 2$	Bad
3	$2 > X < 3$	Enough
4	$3 > X < 4$	Good
5	$4 > X \leq 5$	Very good

To determine the level of validation, level of readability, and level of practicality, the research data were analyzed using descriptive analysis techniques. Furthermore, to determine the effectiveness of the application of the product, the research data were analyzed using a different test (paired t-test). The data processing process is assisted by using Statistical Package for the Social Sciences version 24 software.

3. Results

3.1. Needs analysis results

The results of the needs analysis to develop product designs were carried out by observation and interviews. Observations and interviews were carried out with practicum assistants, and students who had passed the Protista course, totaling 15 people (practice assistants for the Protists course = 4 people, and students who had passed the Protists course = 11 people). Table 3 shows the results of the needs analysis for the preparation of product designs, obtained through interviews with practical students and practicum assistants for protist courses.

Table 3

Results of Needs Analysis for the Preparation of Project Design

No.	Asked aspect Questions for students	%
A	***Online practicum***	
1	Use of online platforms (Zoom Meeting, Google Meet, Google Classroom, WhatsApp, YouTube)	100.00
2	Have a mobile phone or laptop, right	100.00
3	Having network difficulties, no	100.00
4	Internet quota, sufficient	100.00
5	Additional explanation from the assistant is needed for the content of the video, right	100.00
B	***Fill in the practicum guide document***	
1	Practical goals, clear	54.55
2	Step work, clear	18.18
3	Data analysis, clear	0.00
4	Reference discussion, clear	45.45
5	Contents of video media, clear	45.45
6	Contents of image media, clear	81.82
7	Tools and materials to replace tools and materials in the laboratory are easy to find	81.82
8	Interaction with lecturers or assistants with students is easy to do online	72.73
9	Protist practical guide practical, yes	45.45
10	The contents of the practicum guide, as a whole, can be understood	54.55
	Questions for the protist class practicum assistant	
A	***Online practicum***	
1	Use of online form platforms (Zoom Meeting, Google Meet, Google Classroom, WhatsApp, YouTube); yes	100.00
2	Ownership of a mobile phone or laptop, yes	100.00
3	Network difficulties, no	100.00
4	Internet quota, fulfilled	100.00
B	***Fill in the practicum guide document***	
1	Practical goals, clear	50.00
2	Step work, clear	100.00
3	Data analysis, clear	100.00
4	Reference discussion, clear	100.00
5	Contests of video media, clear	100.00
6	Contests of image media, clear	100.00
7	Tools and materials to replace tools and materials in the laboratory are easy to find	75.00
8	Interaction with lecturers or assistants with students is easy to do online	75.00

9	Protist practical guide practical, yes	50.00
10	The contents of the practicum guide, as a whole, can be understood	50.00

3.2. Product design results

After conducting a needs analysis, proceed with product design. The product design was developed by adding points that were not previously in the old protist practicum guide and developing points that already existed in the old protist practicum guide. However, the product design is directed at the implementation of an online practicum.

Related to the structure of the product content (online implementation-based protist practicum guide) is presented as follows.

1. Product cover page
2. Objective of the activity
3. Literature review
4. The facilities/materials/media used
5. Activity steps
6. Data collection
7. Data analysis
8. Discussion
9. Conclusion
10. Bibliography

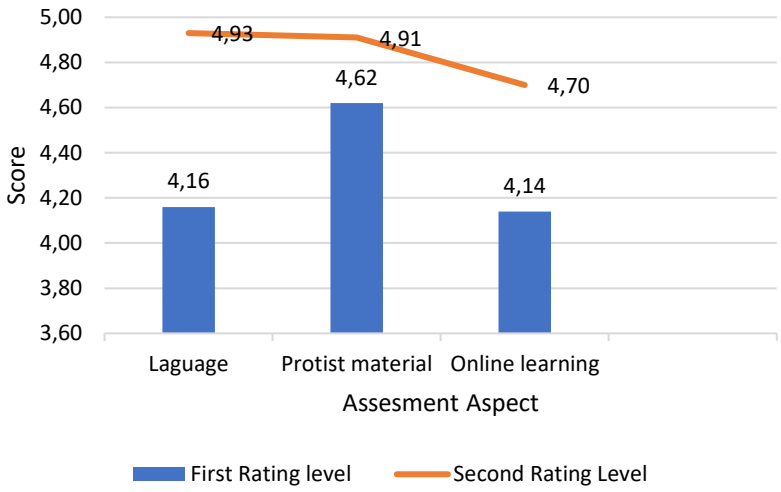
Total time spent in important lab activities (data collection, data analysis, and report writing) significantly predicted knowledge gains (Corter et al., 2011).

3.3. Product validation results

The product produced in the research is an online implementation-based protist practicum guidebook. The main specification of the book is the implementation of an online-based practicum. Therefore, the resulting product needs to be validated to be effective from the aspect of protist material, online-based learning, and language. Figure 2 shows the scores given by validators related to protist material, online-based learning, and linguistic aspects.

Figure 2

Average Score of rating from the Validator



3.4. Product application effectiveness test results

After validating the product, the next stage is conducting field trials. Field trials were carried out in a limited class or group and a wider class or group. The design used in field trials in a limited class and a wider class is before-after. Before the treatment is given in the form of a product application, students are first given a pre-test. Furthermore, after being given treatment, students in that class were given a post-test. Table 4 below, shows the pre-test and post-test scores in trials with a limited class and trials with a wider class.

Table 4

The Difference in the Increase in Cognitive Learning Outcomes of Protist Practicum Based on the Before-After Method

No.	Class	Before-after		Difference	Increase (%)
		Before	After		
1	Class A (limited group)	2.06	7.20	5.14	249.51
2	Class B (wider group)	2.09	7.59	5.55	265.55

To find out the difference between the results of the pre-test and post-test, it is necessary to do a paired t-test. The t-test was conducted at the field trial stage in a limited group (15 students) and a wider class (36 students). Tables 5 and 6 show the results of the t-test at the two stages of the field trial.

Table 5

Results of Paired Sample T-test for Class A (Limited Group)

Pair		Mean	Std. deviation	*T*	df	Sig. (2-tailed)
Pair 1	Pre-A - Post A	−5.13200	0.97551	−20.375	14	0.000

Table 6

Results of Paired Sample t-test for Class B (Wider Group)

Pair		Mean	Std. deviation	*T*	df	Sig. (2-tailed)
Pair 1	Pre-B - Post B	−5.48861	1.17009	−28.145	35	0.000

In addition to product validation and testing the effectiveness of product application at the field trial stage, this study also conducted a content readability test and a practicality test of product use. The data obtained from the readability test and practicality test were obtained from students who experienced the product application process at the field trial stage. The process of content readability testing and practicality testing of product use were carried out at the field trial stage for a limited class and the trial stage for a wider class. The following Table 7 contains scores for the content readability test and the practicality test of product use.

Table 7

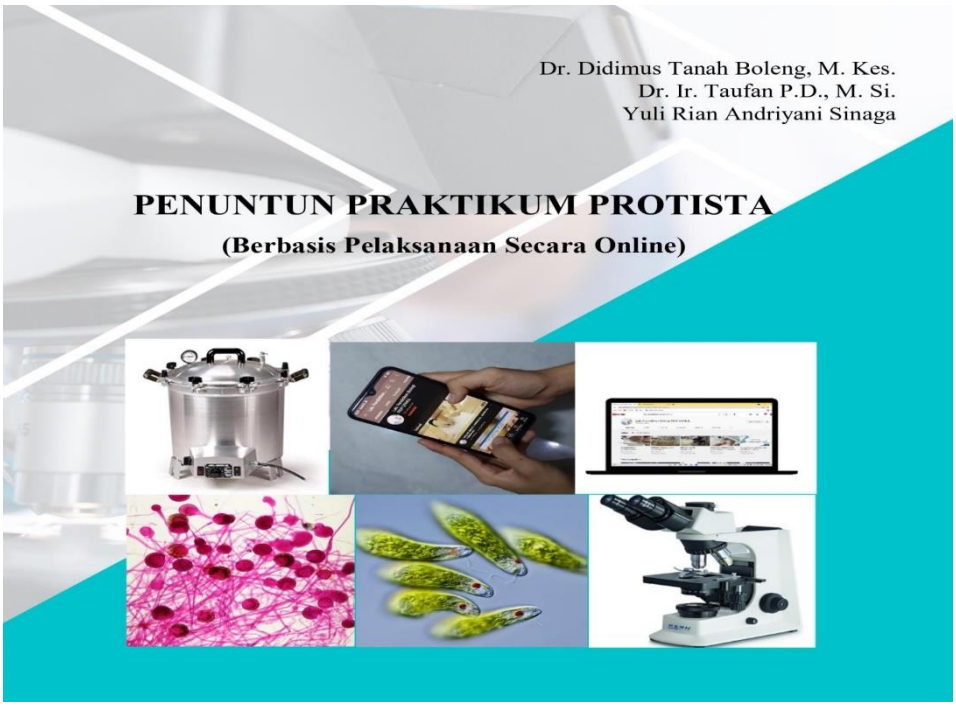
The Test Results of Reliability of Content and Practicality of Practicum Guide Products

No.	Class	Average readability score	Average practicality score
1	Class A (limited class)	4.23	4.06
2	Class B (wider class)	4.37	4.27

Related to the physical appearance of the protist practicum guide product based on online implementation, the product content consists of the cover, introduction, and product content. The product content consists of 39 pages. The number of practicum activities consists of six themes. Figure 3 shows the product cover page.

Figure 3

The Product Cover Page



4. Discussion

The results of the needs analysis show that 100% (Table 1) of students have done online practicum. Although online digital resources like video conferencing programs, e-learning platforms, and online films have been used to teach the chemical theory behind laboratory experiments, adapting practical exercises remains a major challenge. This is because the protist practicum guide does not support the implementation of the online practicum (Chan et al., 2021). Additionally, it is believed that students' love of learning would increase if they gathered personalized learning experiences during online sessions (Kim et al., 2022). Therefore, this condition becomes a reference for designing the product.

Related to the relevant research conducted by Inceçay & Dikilitaş (2022) about the platforms used during the online learning process, platforms such as MindMeister, Padlet, Google Docs, and Slideshare were used. In this experiment, MindMeister was used for brainstorming, and Padlet, and Google Docs for activities in the lesson. Technology has become a must, not an option or a choice.

In addition to being related to the implementation of online practicums in the past, the data obtained is also about the steps for implementing practicum activities. Table 1 also shows that a small proportion of students (18.18%) still do not understand the working steps of the old product. This condition is because the steps for practicum activities are still often presented in narrative form. Thus, in designing new products, efforts are made to make the work steps clearer.

Product design adapted to the results of data analysis. In the structure of the content of each practicum activity, some points are maintained and their contents are only developed; there are certain points added. Product content that allows students to carry out practical activities, collect data, discuss data analysis, and make conclusions. Thus, in addition to this product, it allows students to carry out practicum online, and it also allows students to learn to research a problem during the implementation of online practicum.

At the point of work steps, besides being narrated, it is also equipped with a flow chart. The work step flow diagram is expected to provide clear guidance for students in carrying out each step of the online practicum. Additionally, it is believed that students' love of learning would increase if they gathered personalized learning experiences during online sessions (Khan et al., 2021). Thus, students can carry out practicum, either individually or in groups, in their respective homes. Figure 4 shows an example of a flow chart of how it works on the topic of 'Isolation of Fungal Spores from the Air' in a new protist practicum guide product that was developed based on online implementation.

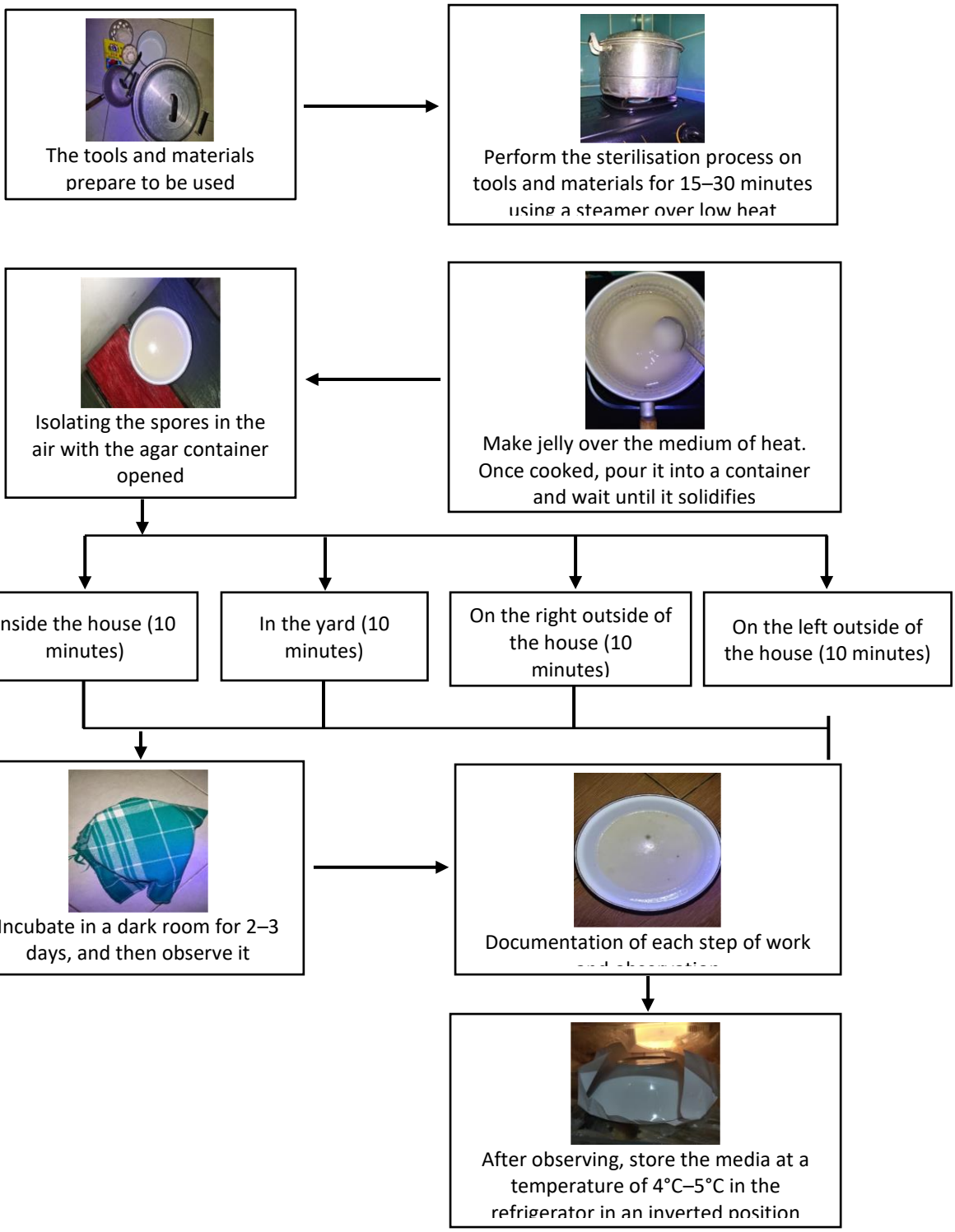
Figure 1 shows that the average rating for the three validators increased for assessments 1 and 2. This condition indicates that the suggestions for improvement given by each validator (language validation, protist materials, and online learning) were improved by the product development team. In the linguistic aspect, the revisions carried out included writing, terms, and the meaning of sentences. Aspects of protist material, the revised aspects include the suitability of practicum material with the scope of protist lecture. In the educational context, validation of such materials is required. e material, practicum terms. Such materials must be approved for use in educational settings (Limon, 2021). Aspects of online learning, revised aspects include the platforms used in online practicum, practicum media/materials, technical implementation of online practicums, and terms in online learning.

The assessment given by the validator shows the accuracy of product development. Each validator assumes that the developed product has a validation level like the given value. As a result, the validated product can be considered viable for further development at the field trial stage. Fresh test validation is typically carried out to cover all of the test steps (Santani et al., 2019). If it is seen from the average score given by each validator and adjusted to the category group (Table 1), then all of the average scores are in the very good category.

However, after carrying out the validation process, the product needs to be field-tested. Field trials are intended to determine the feasibility of applying the product in the protist course practicum process carried out by students. Thus, input will be obtained for product revision, especially related to the implementation of the online practicum.

Figure 4

An Example of a Flow Chart of How it Works on the topic of 'Isolation of Fungal Spores from the Air


The tools and materials prepare to be used
Perform the sterilisation process on tools and materials for 15–30 minutes using a steamer over low heat
Isolating the spores in the air with the agar container opened
Make jelly over the medium of heat. Once cooked, pour it into a container and wait until it solidifies
Inside the house (10 minutes)
In the yard (10 minutes)
On the right outside of the house (10 minutes)
On the left outside of the house (10 minutes)
Incubate in a dark room for 2–3 days, and then observe it
Documentation of each step of work
After observing, store the media at a temperature of 4°C–5°C in the refrigerator in an inverted position

The results of the paired t-test in the field trial with the broadest class (Table 2), showed a significant difference ($p < 0.00$). Likewise, the results of the effects test in a wider class (Table 3), showed a significant difference ($p < 0.00$). The results of the effectiveness test for the two stages of the trial, both in a limited class and in a wider class, indicate that the application of an online practice-based practicum guide product is effective in improving student practicum learning outcomes.

Test the effectiveness of the application of the product, carried out in a quasi-experimental manner with a before-after design. The aspect seen is student learning outcomes after experiencing the application of the product. Student learning outcomes before experiencing the application of the product and after experiencing the application of the product are significantly different. The product used to guide online protist practicum activities describes the stages of implementing practicum activities that allow students to understand the guide well. The practical activity steps presented in the product provide a clear and measurable understanding of what activities they perform. Thus, students can carry out practicum activities independently or in groups online. Students understand every aspect of the product, such as practicum objectives, tools and materials needed, practicum work steps, data collected, data analysis, and conclusions made. The application of the product allows students to be able to understand every point in the online practicum guide. Students can understand the tools or materials used in the practicum. In addition, the media (videos, pictures) presented in the practicum can provide a good and correct understanding of the practicum material to students. They can understand tools or materials that can be found in the environment where they live, which can replace existing tools and materials in the laboratory, which have the same function. Thus, students can carry out practicum without having to come to the laboratory.

In addition to tools and materials, students can also clearly understand the work steps which are complemented by a flow chart of work steps that can be found in the product. By using a flowchart guide of work steps, individually or in groups, students can carry out each work step. The data obtained by using the product as a practical guide is even more precise.

Thus, overall, the application of the product is more effective in providing cognitive learning outcomes of protist practicum compared to the old product. The new product can improve the cognitive learning outcomes of protists practicum from the previous protists' cognitive learning outcomes. The application of the product provides clear directions and can be understood by students both individually and in groups. In addition, the languages used in the product are easier to understand clearly and do not cause double interpretation.

Related to the percentage increase in cognitive learning outcomes in protist practicum (Table 5) in the field trial phase in a limited class, and in the effectiveness test phase in a wider class, it shows the magnitude of the effectiveness of product application in protist practicum activities. The content of the product can provide an online practical implementation guide. Clarity of practicum objectives; the need for tools, materials, and practicum media; practical implementation steps; as well and data directions to be taken; allows students to carry out practicum in their respective homes (online). The application of the product is effective in improving the cognitive learning outcomes of the protist practicum from the results of previous studies. In addition, user studies for comparison studies were carried out using qualitative evaluation techniques such as questionnaires, interviews, and observations (Chan et al., 2021).

The level of readability of the product content is included in the very good category. Students can read and understand product content very well. The sentence structure and the use of terms in the

product content can be understood well by students. In addition to sentence structures, all work instructions and pictures presented in the product, allow students to understand the content of the product. The description of the points in the product content, and allows students to understand the relationship between the points in the product. Therefore, even if they are individually or in groups, students can use the product guide in the online protist practice.

The products developed have a very high level of practicality. From the aspect of accessing the product. Students can click on the shared link. Students only need to have a cell phone or laptop. In addition, it is necessary to have a good internet network. Or students simply have a product file and open and study at home. In addition to the product, the product content is very practical in guiding students in carrying out practical. Fill in the guide on the work steps, students can read the direction of the arrows in the flow chart. In addition, the tables of observations can be filled in by students. In addition, the product content provides a choice of online platforms that students can choose if they are going to interact with practical assistants.

The advantages of the product are: (1) the practical implementation of all themes can be done online, (2) the product is also equipped with practicum video media, (3) the work steps for each theme are equipped with flowcharts, (4) the product content includes an analysis data and (5) collection of practical assignments/reports can be done online. In general, product advantages can be applied in the implementation of online practicums. Therefore, the Internet network for the implementation of online practicum needs to be treated properly.

The weaknesses of the product are: (1) not all tools and practicum materials needed in the practicum can be replaced with tools and materials at the practitioner's home/area where the practitioner lives, and (2) the contents of the video contained in the product, some are not clear so that in the implementation practicum, the practicum assistant needs to re-explain. These weaknesses can be corrected in the future. Regarding the content of the video, it is necessary to clarify the content and the tools and materials used for certain practicum themes.

The product specifications are (1) the implementation of practicum using a certain online form platform, (2) the consultation process between practicum assistants and student practitioners is carried out online, (3) collecting the results of practicum reports and other tasks is carried out online, (4) all practicum work steps are equipped with flow diagrams, (5) practicum video media development is carried out by utilizing tools and materials in the Biology Education Laboratory.

5. Conclusion

The conclusions of the study are: (1) the average value of the validator aspects of the material, online learning, and linguistic aspects, respectively, is 4.76; 4.42; and 4.55; and all of them are in the very good category, (2) the product has certain advantages, (3) the product has certain weaknesses and (4) the product has certain specifications.

Related to the suggestions are: (1) soft files need to be distributed at least one week to student practitioners, and (2) it is necessary to add new practicum themes, which are adapted to the tools, materials, and media available in the laboratory; and those around the student's house, (3) in developing practicum videos, it is necessary to use tools and materials that are by the themes discussed, and a clear and correct description of the work steps.

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