

Integrated Digital Module Learning Management System (LMS) Development in Microbiological Practices

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ABSTRACT

Digital modules are virtual learning environments as learning media that encourage learners to innovate and put learning content that can be obtained anywhere and anytime through digital learning. This development aims to design and develop digital modules that are a source of learning media for students to carry out digital practicum (PRAKTAL), integrated with the Learning Management System (LMS) in the Microbiology course with a blended learning strategy. The development of this digital module goes through the Analysis, Design, Development, Implementation, and Evaluation stages. The product results have been declared valid and feasible with the criteria, 98.13% of material experts, 96.74% of media experts, and 97.00% of education practitioners. The trial implementation resulted in 93.06% individual criteria, 92.64% small group trials, and 98.10% classical trials. Learning media shows effectiveness with an indication of the students' learning success rate, an average of 96.00%.

Keywords: Blended Learning, Digital Module, Learning Management System, Microbiology Practicum.

INTRODUCTION

The presence of the 4.0 industrial revolution brought rapid, complete, and unpredictable changes, with the contribution of the virtual world becoming its dominance. One of the impacts is the emergence of such fast changes that technology disruption has created. To respond to this era as much as possible to produce innovations that do not result in lags, as is the education case. Educational challenges in the 4.0 era require strengthening skills or life skills: Creativity, Critical Thinking, Communication, and Collaborative. Learning trends can be directed by utilizing virtual learning environments, namely online and openly. Integrating the use of technology in learning allows an impact on that learning. Higher education in Indonesia must also remain committed and respond to technological developments that impact learning. This needs to be done to overcome problems in managing and improving the quality of competitive graduates and has advantages in the global market. This is regarding; a) improving the quality and impact of lecturer learning innovations on students, b) increasing the competence of students who can implement superior scientific fields and learning practices, and c) strengthening the function of the study program curriculum in achieving the expected outcome values.

In answering the challenges above, one effort that continues to be developed in learning is to create a virtual-based learning environment. One of the innovations is to take advantage of an e-learning environment that can present a variety of digital modules that students can widely access. Permenristekdikti No. 44 of 2015 has explained to the National Higher Education Standards that the learning process standards are the minimum criteria for learning in study programs to obtain graduate learning outcomes. Thus, whether or not the educational goals are achieved will depend on implementing the learning applied.

The description above can encourage lecturers or educators to design, develop, and arrange the objectives, content, teaching materials, and methods used in learning. As an answer to the challenges of learning in the 4.0 Industrial Revolution era, universities must, of course, be able to compete and master this learning which refers to 4.0 skills, namely; 1) Information, media, and technology skills, 2) Learning and innovation skills, 3) Skilled in life and career and leads to practical communication skills. These skills are values that every university cannot ignore to compete globally. Therefore, to achieve these skills, it is appropriate to master new learning patterns through developing learning by implementing virtual learning environments such as digital modules. Such a learning environment can encourage new literacy skills, namely data, technology, and human literacy. So that the aspects of the learning experience will open widely and further improve. The application of digital modules is an innovative skill that can be cultivated through an innovative, dynamic, creative learning process full of diverse media, which challenges students to produce various alternative problem solutions together and challenges students to be tough. The innovative skills mastered by students will become helpful knowledge and skills throughout their lives. One of them is in lectures, for example, biology lab activities. This learning activity is necessary for learning innovation for mastery of existing theory and practice. However, students as practitioners have not been maximally skilled in implementing practicum offerings with superpower skills. This aspect of mastery is very vulnerable to being mastered by students because the presented learning environment only entrusts the laboratory as a study dominated by students. The opportunity to gain learning experience is only found in the practical print module, which requires a large enough budget to print every semester. Thus, the broadest possible learning opportunity to take advantage of various learning resources is minimal.

Another problem is that laboratory management personnel are minimal, where laboratory assistants are not proportional to the number of practicum subjects and practitioners. This condition affects the effectiveness of delivering and assisting the practicum process. Furthermore, the practicum process still looks traditional. It does not take advantage of digital sources to strengthen the practicum. The practicum management system is not organized in a unitary system that can control the input and output of student practicum results.

A digital module is appropriate to provide solutions to the above problems by creating a more diverse learning environment. Digital modules are nothing but the term e-learning learning, which is learning that utilizes technology and information. Modules

have two types, namely print modules and digital modules. Digital modules are a source of learning media for learners that not only can this material be obtained in class, but the material can be received anywhere and anytime through digital learning. Digital modules can be called e-module learning media (Farenta et al., 2016), effective for use in learning activities, evidenced by student learning outcomes that always increase learning outcomes between before using e-module and after using the e-module. According to (Suyasa et al., 2017), digital modules can help in class and outside the classroom. So that the technical quality aspects of digital modules need to be considered (Irwandani et al., 2017); digital modules have quality aspects that are easy to use, the order of material delivery is consistently systematic, concepts are presented coherently, and are interactive and participatory. Learning by utilizing digital modules will certainly have impact-oriented learning by design. According to (Rusman, 2012), the teaching process centered on goals or goal-directed teaching is a process that can be planned (pre-planned) in many ways. Such learning is found in applying the digital module as a learning resource model, which puts forward the process of behavior change in the context of experiences designed in the framework of a digital module.

The digital module has advantages that can be applied in learning because (Irwandani et al., 2017) describe, namely, 1) Able to present learning material by displaying videos, simulations, and animations about the concepts being studied; 2) Has a good and attractive visual appearance so that it can attract students to learn it; 3) The module is equipped with a quiz that presents questions interactively so that it helps students test their abilities and evaluate independently. Similar to the research results (Adwiah et al., 2016) found several advantages possessed by this developed e-module, namely (1) it is equipped with pictures, videos, and audio to make student learning activities more fun and engaging, and helpful. Students in understanding the material presented in the program; (2) the learning process can be used independently and adjusted according to the learning speed of each user; (3) e-module can be used linearly or non-linear (random); (4) e-module provides student worksheets can be used during observation activities; (5) this e-module contains evaluation in the form of multiple-choice questions which are completed with feedback; (6) e-module is arranged with a display and navigation system is as efficient as possible, consistent and straight forward to make it easier for users to learn the e-module.

With some of the advantages of digital modules above, the concept in digital modules must unify content that can be defined as units, chapters, topics, or segments of instruction (Kidd & Lonnie R. Morris, 2017). The digital module must contain at least two critical aspects: resources and existing activities. More clearly can be seen in the following picture;

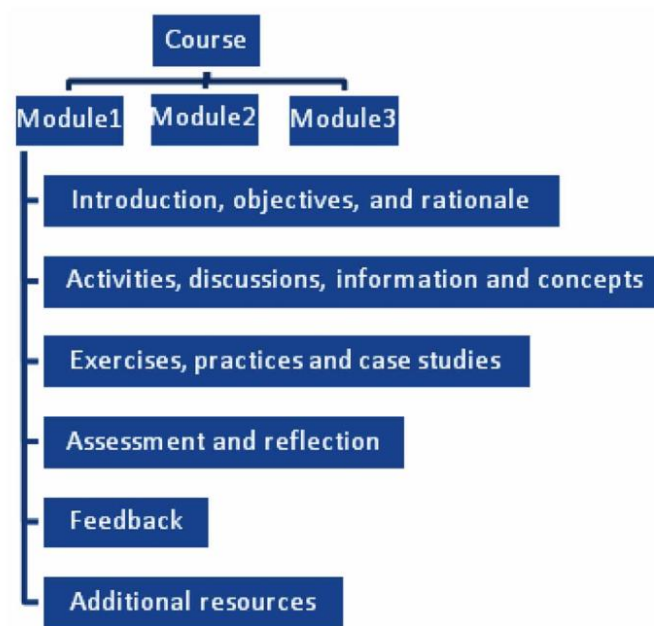


Figure 1. Digital module structure (Kidd & Lonnie R. Morris, 2017)

Developing digital modules can be presented online (in a network) through the Learning Management System (LMS) facility. LMS features have several advantages that can affect students' learning activities. According to (Kidd & Lonnie R. Morris, 2017), LMS provides a student manager and their profile, tracks their progress, facilitates collaboration, or schedules learning activities. This LMS is an e-learning system that usually handles heterogeneous groups of students. An example of the application of e-learning learning is blended learning. The concept of blended learning is inseparable from e-learning as an umbrella for all types of learning assisted by information and communication technology (Chaeruman, 2017).

In particular, e-learning is online learning which is a technology-based student-centered learning approach, referring to teaching and learning settings that use networked computer-mediated communication technology (CMC), which includes the World Wide Web (Internet) and course management systems (CMS).) and can be accessed via satellite, cable, broadband, or wireless technology (Kidd & Lonnie R. Morris, 2017). In the explanation presented (Chaeruman, 2017), e-learning is a generic and broad term that uses various electronic technologies to convey learning. E-learning is the electronic delivery of learning, training, or education programs (Suryawanshi & Suryawanshi, 2015). E-learning is an educational process that utilizes information and communication technology to mediate learning and teaching activities that are not synchronous (Naidu, 2006). E-learning is instruction delivered via digital devices such as computers or mobile devices to support learning (Clark & Mayer, 2011). Based on some of the theories above, it can be concluded that e-learning is a learning resource media that use electronics in the form of mastery of information and communication technology to deliver digital-based student-centered learning. Hence, the use of the term digital module is inseparable from e-learning. This can be explained by the fact that the digital module is a learning resource that is applied electronically and utilizes digital

devices such as an LMS. According to [Thorne \(2003\)](#), a web-based LMS provides online courses and event management, content, resource management, comprehensive assessments, enhanced skills gap analysis, content writing, email notifications, and real-time integration with human, financial, and systems resources. ERP. In implementing digital modules electronically, one of the e-learning categories is blended learning.

There are several definitions of blended learning. According to [\(John Watson, 2008\)](#), blended learning combines online learning content and direct interaction in class to personalize learning, enable thoughtful reflection, and differentiate student-to-student instruction in different groups of students. Blended learning combines traditional face-to-face and online learning with flexible timing ([Su, 2019](#)). Blended learning is an expression introduced by the distance learning community in recognizing the value of synchronous learning activities, such as face-to-face interaction with instructors and collaborative work with peers, complement activities carried out simultaneously by each learner ([Howard et al., 2006](#)). With several definitions of blended learning, it can be concluded that blended learning is a learning strategy that combines various learning delivery strategies both face-to-face and in a network by utilizing technology as a virtual learning environment. The application of blended learning impacts the formation of students' higher-order thinking skills ([Ningsih et al., 2018](#)). So the most crucial thing in building a blended learning strategy is the certainty of the learning object selected for the appropriate learning setting.

METHOD

This development research method applies a modified ADDIE model developed and adapted by [\(Branch, 2009\)](#) with stages, namely; (1) Analysis, (2) Design, (3) Development, (4) Implementation, (5) Evaluation. Developing this digital module uses trial subjects, namely expert validation on the material and media aspects and an expert validation of educational practitioners. The material validator is from a postgraduate lecturer with a Ph.D. in Microbiology, while the media validator is from a lecturer with a doctoral science in learning technology. A competent professor validates educational practitioners in learning theory and practice by focusing on validating the quality test of the digital module innovation process. Furthermore, in this development, research data collection involves 60 (sixty) student respondents and the results of student learning tests who program the microbiology course practicum. Validating this digital module is first carried out on material validation. After obtaining information on the results of material validation, then validation is carried out by media experts. Whereas for the audience trial design, the individual test was carried out on two students, the small group trial was carried out on five students in the practicum group, and the field test was carried out on all 60 students. The types of data used in the development of the digital module are qualitative data and quantitative data. Qualitative data is shown in responses from media expert respondents, material experts, education practitioners, and students responses.

Meanwhile, quantitative data were obtained from scoring a validation questionnaire from material experts, media experts, education practitioners, and

audiences (students). Also, it manages test scores for student learning outcomes in the following practicum. The formula used to analyze the validation data is as follows.

$$P = \frac{\sum x}{\sum x_1} \times 100\%$$

Information:

P: Proportion $\sum x / \sum x_1$

$\sum x$: The number of respondents' answers in one item

$\sum x_1$: Total ideal value in one item

100%: Constants

Table 1. Eligibility Level Criteria (Arikunto, 2021)

Category	Level	Qualification	Equivalent
A (4)	80% - 100%	Valid	Well worth it
B (3)	60% - 79%	Quite Valid	Decent enough
C (2)	50% - 59%	Less Valid	Not worth it
D (1)	≤ 49%	Invalid	Not feasible

After testing the eligibility criteria by validating material and media experts and measuring the impact on student learning outcomes during the practicum, the instrument used tests learning outcomes. This is used to assess student learning outcomes using digital module learning media. Using learning outcome tests is to measure success in achieving learning objectives through practicum activities. The learning outcome test that was applied was an objective test consisting of fifty multiple-choice questions. The data analysis technique for student learning outcomes tests using the reference is the Minimum Completeness Criteria (KKM), ≥ 2.66 . The formula used is as follows.

$$\bar{x} = \frac{\sum x}{\sum xi} \quad P = \frac{\sum x}{\sum x_1} \times 100\%$$

Information:

\bar{x} : Average overall student score

$\sum x$: The total number of students who do not meet the KKM

$\sum x_i$: The total number of students

P : Percentage

$\sum x$: The total number of students who have completed or not

$\sum x_i$: The total number of students

100% : Constants

Table 2. Criteria for Success Rate (Arikunto, 2021)

Category	Percentage Range	Qualification
A	80% - 100%	Effective
B	60% - 79%	Effective enough
C	40% - 59%	Less effective
D	<40%	Ineffective

Learning using a digital module is categorized as effective if the number of student learning outcomes tests in one class reaches the KKM in categories A and B. Data on

student learning outcomes must be greater than 75% for this digital module to be effectively used in learning.

RESULTS AND DISCUSSION

Result

The results of this development research obtained output from a PRACTAL design flow based on a digital blended learning system. The PRACTAL flow (digital practicum) leads to a blended learning collaboration between direct practicum in the laboratory by combining digital elements. The model and design adapt to the PEDATI system (Chaeruman, 2017). The flow of learning settings can be seen in the following figure.

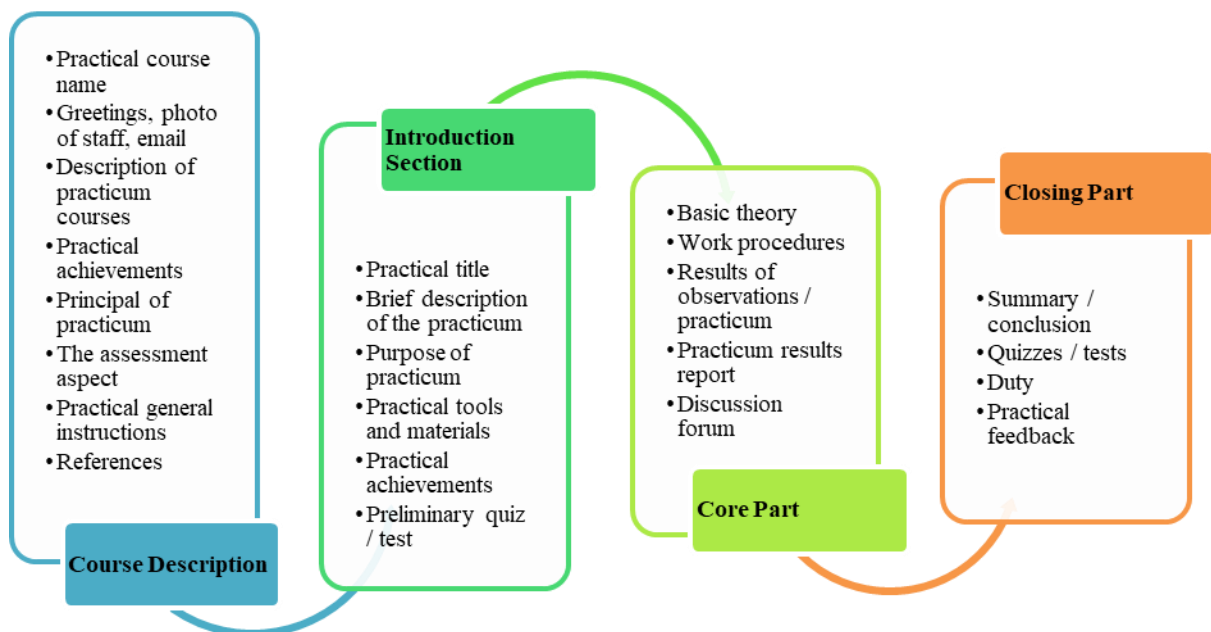


Figure 2. The Flow of Learning Settings for The Digital Practicum Module

Also, other outputs produced are in the form of resources and existing activities originally designed by lecturers and laboratory assistants. The two components are part of the design learning developed in the PRAKTAL design flow. The description of each of these components is as follows;

- a) Resources: digital material by design and digital material by utilization and practical presentation, summaries, and references.
- b) Existing Activities: Assignments, tests/quizzes, discussion forums, feedback, and surveys.

Meanwhile, the form of digital module content development in microbiology practicum can be seen directly on the LMS page: www.kuliahdaring.ung.ac.id.

1. Validation Results

- a. The Results of Material Expert Validation

Based on the data analysis results of material expert validation, 98.13%. Based on the predetermined criteria, it can be explained that the development of a digital microbiology practicum module is included in the valid criteria and is feasible to use. The yield of each item can be explained in the following table:

Table 3. The Validation Results The Digital Module Innovation Material

No.	Component	Score (%)	Category
1	The suitability of the material with the achievements of the practicum	98.85%	Well worth it
2	Features conformity to material	99.71%	Well worth it
3	Delivery strategy	97.75%	Well worth it
4	Language component	98.50%	Well worth it
5	Quality material with discussion facilities, assignments, and tests	95.85%	Well worth it
Total score		98.13%	Well worth it

b. Media Expert Validation Results

Based on the data analysis by media experts, the result was 96.74%. Based on the predetermined criteria, it can be explained that developing a digital Microbiology practicum module is included in the criteria of being valid and feasible to use. The yield of each item can be explained in the following table.

Table 4. The Validation Results The Digital Module Innovation Media

No.	Component	Score (%)	Category
1	Quality content	95.85%	Well worth it
2	Feedback and adaptation	96.77%	Well worth it
3	Motivation	95.75%	Well worth it
4	Presentation design	98.56%	Well worth it
5	Usability of interactions	95.85%	Well worth it
6	Accessibility	97.65%	Well worth it
7	Reusability	96.65%	Well worth it
Total score		96.74%	Well worth it

c. The Results of The Expert Validation of Educational Practitioners

Based on the results of the data analysis, the education practitioner expert obtained a result of 97%. Based on the predetermined criteria, it can be explained that developing a digital Microbiology practicum module is included in the criteria of being valid and feasible to use. The yield of each item can be explained in the following table.

Table 5. Validation Results in Digital Module Innovation Education Practitioners

No.	Component	Score (%)	Category
1	Assessment of the lesson plan	95%	Well worth it
2	Assessment of online learning activities	100	Well worth it
3	Online learning strategies	100%	Well worth it
4	Media and learning technology	96%	Well worth it
5	Study assistance services	93 %	Well worth it
Total score		97 %	Well worth it

2. Product Trial Results

Individual-scale trials were carried out on two practical student participants, and for the small-scale group, trials were carried out on five students who practiced according to the number of each practicum group, and wide-scale trials were carried out on all the practical students, totaling 60 students by filling out the sheet assessment questionnaire. The questionnaire data from the trial results can be presented in the following tables.

a. Individual scale trials

Table 6. The Results of The Trial on The Individual Scale Using The Digital Module

No.	Component	Score (%)	Category
1	Quality of content	87.50%	Very interesting
2	Digital display module	98.00%	Very interesting
3	Engineering Quality	91.45%	Very interesting
4	Language	95.30%	Very interesting
Total score		93.06%	Very interesting

b. Small-Group Trial

Table 7. The Results of The Small Group Trial Using The Digital Module

No.	Component	Score (%)	Category
1	Quality of content	91.25%	Very interesting
2	Digital display module	93.75%	Very interesting
3	Engineering Quality	93.04%	Very interesting
4	Language	92.50%	Very interesting
Total score		92.64%	Very interesting

c. Wide-scale trials

Table 8. The Results of A Wide-Scale Trial Using Digital Modules

No.	Component	Score (%)	Category
1	Quality of content	97.77%	Very interesting
2	Digital display module	96.02%	Very interesting
3	Engineering Quality	98.60%	Very interesting
4	Language	100.00%	Very interesting
Total score		98.10%	Very interesting

3. Student Trial Learning Outcomes

Based on the results of data analysis through test trials, student learning outcomes, acquired or rank of the ability to control theory and practice in the

microbiology laboratory have fulfilled the value of the average minimum completeness criteria equal to 96.00 %. More details can be explained in Figure 3 below.

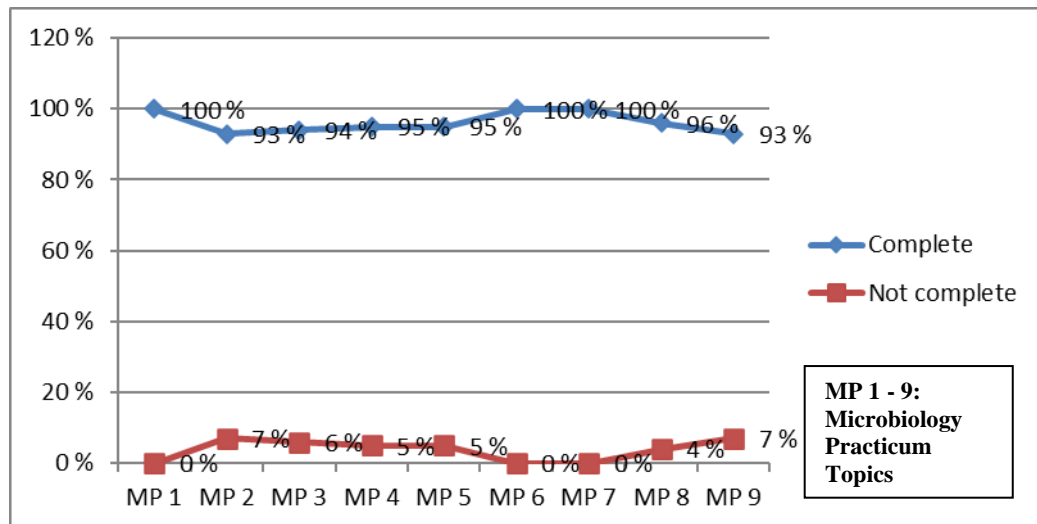


Figure 3. Percentage Diagram of The Microbiology Practicum Learning Outcomes Test

The picture above explains the acquisition of student learning outcomes in each practicum title. It is known that from PM 1 to PM 2, the average completeness value is > 75%. In comparison, the overall average success rate is obtained with a completeness value of 96%, which means that the value is > 75% of the KKM standard.

Discussion

Based on the validation results that material experts have carried out, a percentage of 98.13% is obtained. It can be interpreted that the digital modules developed are valid and suitable for use in microbiology practicum learning. Similar to the validation results on media experts, the total percentage is 96.74%. It can be interpreted that the digital module of the Microbiology practicum is a valid qualification and suitable for learning. Likewise, the results of the expert validation of educational practitioners obtained an overall percentage of 97.00%, which means that the quality of the digital module innovation process developed is feasible to be applied in microbiology practicum learning. Based on the results of the product trials conducted, there is a difference in the percentage of attractiveness. However, this difference was not too significant. Each obtained a percentage of > 80% based on the three trials. So it can be concluded that, in general, the assessment based on product quality trials is feasible on an individual scale, a small group scale, and a broad or classical scale. So it can be interpreted that the developed digital Microbiology practicum module is a valid qualification and suitable for learning. In addition to data from expert validation and audience trials (students), data on learning outcomes were also obtained. Through the test of learning outcomes, this digital module learning media is declared effective in learning with details that have met the SKM of 95% and which have not met 4%. Thus, according to predetermined criteria,

student learning outcomes on mastery of theory and practice in microbiology practicum can be interpreted by applying digital modules that are very effective for learning.

Therefore, this development research proves that a virtual learning environment can include a new set of literacy patterns (data, technology, and humanism) that greatly encourage learners to innovate. This means that the digital modules presented in blended learning contribute to developing online critical literacy skills (Fola-Adebayo, 2019). Therefore, this environment can offer learning that identifies a source. According to (Ramadani et al., 2019), in implementing blended learning, some factors influence its application to run according to its objectives. These factors are 1) guidelines, 2) human resources, and 3) learning environment. In connection with the learning environment, it is further explained that it needs to be designed to support learning activities to increase the comfort of individuals who occupy the environment to carry out learning activities. Also, learners can increase their creativity when they work independently or in groups (Kuswandi et al., 2017). The digital module is a source of media that encourages learners to innovate independently to identify, gain experience, and control. It is proven that the tendency for independent learning of students has positive learning independence. Students are not dependent on others and tend to be more independent in all things (Aslamiyah et al., 2019). With blended learning, interaction and communication between students and teachers can continue, which is the attraction of learning in the 21st era (Wardani et al., 2018). Through this media, learners can access learning content anywhere, anytime, online, and openly. The entire series of processes is presented digitally as complete modules or instructions and is practiced directly and evaluated independently and in groups. This will create an academic atmosphere that is more conducive and the learning process becomes participatory, attractive, creative, effective, efficient, and learner-centered.

The impact of implementing this digital module is inseparable from the role of the E-Module being developed, which must follow the syntax of the desired model or learning approach (Farenta et al., 2016). Therefore, the developed digital module follows the PEDATI learning approach or setting developed (Chaeruman, 2017). This learning flow emphasizes independent learning, starting from studying the material, exploring, practicing, and evaluating it. Combining blended learning with this learning setting makes the role of digital modules more influencing student learning, especially for practical aspects.

CONCLUSIONS AND SUGGESTIONS

This digital module was developed by integrating the Learning Management System (LMS) and implementing a blended learning strategy in the microbiology course practicum. The first stage of developing this digital practicum module is designing a digital module. The design stage compiles the flow of practicum based on blended learning, namely the PRAKTAL design, and flow. This design consists of:

1. Formulate practical achievements
2. Designing a practicum competency map
3. Organizing practicum material
4. Designing practicum activities
5. Designing the flow of practicum activities

Furthermore, the second important thing is the digital module content development stage. At this stage, the activity focuses on producing online learning in the LMS by collaborating between the design and learning flow. It has been compiled by managing the content development of blended learning courses at the LMS. The form of collaboration developed is from resources and existing activities designed by lecturers and laboratory assistants. The content developed, namely;

1. The source of digital material
2. Practical service
3. Tests / Quizzes
4. Assignments
5. Discussion forums
6. Feedback
7. Survey

This digital module has been validated and tested on the material, media, education practitioner experts, and audience. These students show that this digital module is valid and suitable for use as a learning medium. This series of digital module development processes have been refined through a revision process starting from the Analyze stage to the Evaluate stage of the ADDIE model based on input or results of expert validation and audience trials.

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