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Virtual Laboratory for Practical Learning in Vocational Education Using Nine Events of Instruction Approach

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ABSTRAK

Laboratorium merupakan tempat mahasiswa dapat mengenal dan memanfaatkan sistem kerja alat dan bahan serta memungkinkan mahasiswa memperoleh keterampilan praktis melalui eksperimen. Namun praktikum tidak selalu dapat dilaksanakan karena keterbatasan alat dan bahan. Laboratorium virtual adalah media yang dibuat serupa dan dapat mensimulasikan kondisi laboratorium nyata untuk praktik sebelum memasuki laboratorium nyata. Oleh karena itu tujuan dari penelitian ini adalah mengembangkan laboratorium virtual untuk pembelajaran praktik di pendidikan kejuruan dengan menggunakan pendekatan sembilan peristiwa instruksi. Pendekatan yang digunakan dalam penelitian ini adalah pendekatan sembilan peristiwa pembelajaran 9 peristiwa pembelajaran (9 peristiwa dalam pembelajaran) yang dapat diterapkan dalam proses pembelajaran konvensional (tatap muka) dan pembelajaran online. Pendekatan yang dilakukan dalam penelitian ini adalah pendekatan pengembangan pembelajaran berorientasi produk dan menggunakan model pengembangan. Pemilihan responden dalam penelitian ini menggunakan teknik purposive sampling. Sampel yang dipilih adalah siswa kelas XII SMK. Teknik pengumpulan data menggunakan observasi, wawancara, angket, dan tes hasil belajar. Data yang telah terkumpul perlu dianalisis dengan menggunakan analisis kualitatif dan analisis kuantitatif. Penelitian dan pengembangan ini menemukan laboratorium virtual untuk pembelajaran praktik di pendidikan kejuruan dengan menggunakan pendekatan sembilan peristiwa instruksi yang dalam pendekatan ini dalam pembelajaran merupakan proses sistematis yang memiliki pendekatan perilaku dengan fokus pada hasil atau perilaku selama proses pembelajaran.

ABSTRACT

Laboratory is a place where students can recognize and utilize the working system of tools and materials and allow students to gain practical skills through experimentation. However, practicum cannot always be carried out due to limited tools and materials. A virtual laboratory is a media that is made similar and can simulate real laboratory conditions to practice before entering the real laboratory. Therefore the aims of this study is developing virtual laboratory for practical learning in vocational education using nine events of instruction approach. The approach used in this research is the approach of nine instructional events 9 instructional events (9 events in learning) which can be applied in the conventional learning process (face-to-face) and online learning. approach taken in this research is a product-oriented learning development approach and uses a model development. The selection of respondents in this study used a purposive sampling technique. The selected sample is class XII students of vocational high school. Data collection techniques use observations, interviews, questionnaires, and learning outcomes tests. The data that has been collected needs to be analyzed using qualitative analysis and quantitative analysis. This research and development found virtual laboratory for practical learning in vocational education using the nine events of instruction approach which in this approach in learning is a systematic process that has a behavioral approach with a focus on outcomes or behavior during the learning process.

1. INTRODUCTION

Vocational education is one of the educations that build work competence (Fitriyanto & Pardjono, 2019; Sudira & Juwanto, 2019). Vocational education is one of the educational pathways to prepare students to get jobs through mastery of skills relevant to the world of work. Vocational education can help develop optimal, quality, and competitive human resources. The existence of vocational education is closely related to the social development of the workforce and producing quality workers (Gunawan et al., 2021; Hamid et al., 2017). Vocational learning must be able to encourage students to be creative and innovative, think critically to solve problems, and have the ability to communicate and collaborate (Hidayati & Wagiran, 2020; Hima et al., 2021). So, in other words, vocational education is an education that provides human resources who are ready to work, therefore vocational education must be able to produce human resources who are

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able to compete in the era of the industrial revolution 4.0 and have 21st century capabilities (Hidayah et al., 2021; Rizaldi et al., 2020). One of the abilities that must be possessed is the ability to think creatively and innovatively. One of the levels of formal education in Indonesia is Vocational High School (SMK). The purpose of developing vocational education programs is to prepare human resources who are ready to enter the world of work, have high leadership, are disciplined, professional, reliable in their fields and productive. Ideally, SMK graduates are middle-level workers who are ready to be used, in a direct sense they can work in the business and industrial world (Estriyanto et al., 2017; Mutohhari et al., 2021; Redhana, 2019). Thus, vocational students are required to be skilled in accordance with their competence.

However, the Central Statistics Agency (BPS) noted that the open unemployment rate for Vocational High Schools (SMK) was the highest among other education levels, at 8.92%. This shows that SMK graduates have not been absorbed in the industrial world because the competence of SMK graduates expected by the industry has not been formed. The unpreparedness of SMK graduates in entering the world of work is due to limited equipment and the low budget for practicals so that students are not optimal in mastering the skills that should be possessed (Kanah et al., 2019; Made Sudana et al., 2019; Shrestha, 2016). This condition is supported by a preliminary study which found that teachers who teach Nursery and Plant Tissue Culture subjects have difficulty carrying out the practice because of the limitations of tools and materials in the laboratory. Students also think that learning is more theory than practice, even though practical is one of the important methods in learning Plant Tissue Nurseries and Culture because apart from having to know the basic concepts and supporting theories, it is also necessary to conduct experiments / trials in the laboratory to understand certain concepts or basic theories that have been learned in order to have a deeper level of understanding and skills (Fadlilah et al., 2020; Ural, 2016). This is in line with the results of research which states that one of the learning difficulties of students in tissue culture material is due to the lack of learning media that can attract and motivate students to learn. (Huda et al., 2017).

Some research and development has produced learning media with the topic of plant tissue culture. In Indonesia, the learning media that has been developed for the topic of tissue culture is interactive multimedia, learning video, and virtual laboratory (Aulia & Aina, 2016; Batubara, 2017; Hartini et al., 2019). Although there are learning media for the topic of plant tissue culture, practical activities for SMK students still play an important role because it aims to make students skilled in using tools and materials, students can also recognize and utilize the work system of tools and materials in the laboratory. As well as supporting the scientific learning of a field by enabling students to gain practical skills through experimentation and giving them the opportunity to have a deeper understanding of the content (Aljuhani et al., 2018; Solé-Llussà et al., 2020; Wibowo et al., 2016). Activities in the laboratory also allow students to observe and interact interactively to investigate phenomena, relate data to disciplinary principles, and work with others in teams (Acar Sesen & Tarhan, 2013; Malicoban & Castro, 2022; Nolen & Koretsky, 2018). Many studies have shown that practical activities in the laboratory improve student achievement and interest in understanding subject matter, especially in scientific disciplines such as science, engineering, computing and others. (Alkhaldi et al., 2016; Husnaini & Chen, 2019).

However, practicum cannot always be carried out due to limited tools and materials. While the tissue culture technique requires certain conditions that must be met in its implementation. Tissue culture laboratories must provide working tools, supporting facilities for the creation of controlled aseptic conditions and basic facilities such as water, electricity and fuel. With advances in computer technology, one thing that can be done to overcome this is that some practical activities can be simulated by using multimedia, hereinafter known as dry laboratories or virtual laboratories. A virtual laboratory is a media that is made similar and can simulate real laboratory conditions to practice before entering the real laboratory (Estriegana et al., 2019; Ibrahem et al., 2022; Karmila et al., 2019). Virtual laboratories are not considered a substitute or competitor to real laboratories, but rather as an opportunity to bridge the gaps found in real laboratories where experiments that are too expensive (either cost of instrumentation or supplies of materials), complicated or even dangerous to perform can be re-created safely in a virtual environment (Gunawan et al., 2019; Ibrahem et al., 2022). In addition, experiment time was significantly reduced and routine procedures for processing experimental results became simpler (Bortnik et al., 2017; Estriegana et al., 2019).

In the virtual laboratory, students can access and conduct experiments in a virtual room that has been programmed. It is in line with previous study that state virtual laboratory have some of the advantages of a virtual laboratory as a simulator, namely; relatively safe, relatively expansive and provide opportunities for students to explore (Heinich et al., 2002). Furthermore, virtual laboratories can be used as a low-cost alternative solution to real laboratories (Liu et al., 2015; Ndjangala et al., 2021). Several studies related to virtual laboratories include research that implements virtual laboratories for excretory system learning (Setiawan et al., 2015). Research that analyzes the effectiveness of virtual laboratories to improve the competence and character of vocational students concludes that learning outcomes using virtual labs are better, especially in the implementation of practical activities that meet the increasing need for cognitive skills of students and make students understand something abstract and complex (Jaya et al., 2016; Potkonjak et al., 2016).

Much previous research has been done for higher education, primary and secondary education as well as for Vocational High Schools in the Field of Technology and Engineering. In addition, the virtual lab for Vocational Schools produced in previous studies cannot be accessed by other SMKs with the same field of expertise. Starting from this gap, the virtual laboratory resulting from this research and development is devoted to facilitating learning on the topic of Plant Tissue Culture for Class XI Agribusiness and Agrotechnology Vocational High School students. The novelty of this research is the application of the model in which there is an assessment analysis and 10 steps of initial and front-end needs analysis. The aims of this study developing virtual laboratory for practical learning in vocational education using nine events of instruction approach.

2. METHODS

The approach taken in this research is a product-oriented learning development approach and uses a model development. This model was chosen because it is a model devoted to developing computer-based multimedia (Lee & Owens, 2004). This model arranged in four stages, namely needs assessment and analysis, learning design, development and implementation, and evaluation. The first stage will be an assessment or analysis in the form of a needs assessment. This needs assessment stage will determine whether there is a gap between the desired and current conditions. If there is a gap, the next step is to conduct a front-end analysis to then determine the type of intervention needed to close the gap. The second stage is to design a virtual laboratory. This design will refer to the learning event theory and the programming used is Adobe Flash CS 3. The design phase uses the conclusions from the assessment and analysis phase in order to build a roadmap for development. The third stage is development and implementation. In the development stage, the design stage is translated into a physical form in the form of a prototype (prototype). Meanwhile, in the implementation stage, a product review is carried out. The fourth stage is evaluation. Product evaluation is carried out by analyzing the results of expert validation and test results on students. Based on the results of expert validation and product trials, a product revision was carried out.

The selection of respondents in this study used a purposive sampling technique (purposive sampling). The technique is taken by the researcher if the researcher has special reasons or certain considerations regarding the sample to be taken (Sarnoko & Setyosari, 2016; Sugiyono, 2018). The selected sample is class XII students of SMKN 63 Jakarta with Agribusiness Crops and Horticulture Expertise Competencies. In the one-to-one test, 3 (three) students with very good, good, and moderate abilities were selected. The three students were selected based on recommendations from the teacher in charge of Plant Seedlings and Plant Tissue Culture Subjects. In a small group test, the product will be tested on 10 (ten) students of the Food Crops and Horticulture Agribusiness Expertise Competency who were randomly selected. In the field test, it involved 55 students.

Data collection techniques regarding water responses to the use of a virtual laboratory for Nurseries and Plant Tissue Culture use observations, interviews, questionnaires, and learning outcomes tests (Prawiradilaga & Chaeruman, 2018). The data that has been collected needs to be analyzed to find out whether the research objectives have been achieved or not. Those that are used in the development of a virtual laboratory for Agribusiness Seedling and Network Culture Subjects in Agribusiness and Agrotechnology Vocational Schools are qualitative analysis and quantitative analysis. One to one test and small group test using Yes and No answer techniques. The answer is scored 1 and the answer is not scored 0. The data processing of the effectiveness test was carried out by using the N-gain score or normalized gain score. The N-gain test is carried out by calculating the difference between before a method is applied (pretest) and after a method is applied (posttest).

3. RESULT AND DISCUSSION

Results

The preliminary analysis shows that first, the student analysis includes the age of students, ownership of smart phones, ownership of laptops/computers, media that are often used in the learning process, and media that are often used by teachers. Second, this analysis includes an analysis of the situation of the student learning environment. Seen from a geographical perspective, SMKN 63 Jakarta is located in a strategic place for SMK in Agribusiness and Agrotechnology Expertise. SMKN 63 Jakarta was also designated as a Vocational Center of Excellence in 2020 for the fields of Agribusiness and Agrotechnology so that SMKN

63 was considered worthy of a virtual laboratory testing place that was developed. Third, the State Vocational High School (SMKN) 63 Jakarta is included in the SMK that carries out computer-based exams and has various facilities that can support the learning process using a virtual laboratory.

The facilities provided are a computer laboratory, projector, and laptop. Fourth, the virtual laboratory that was developed was originally planned to be used for the preparation of students before entering the real laboratory. However, with the COVID-19 pandemic, virtual laboratories are needed to support the Education Policy Principles during the COVID-19 Pandemic. It is hoped that by using this virtual laboratory, students can improve their understanding of plant tissue culture material and reduce the time of face-to-face practical learning so that the risk of infection during practical learning can be reduced. Based on the previous analysis stage, the media needed is media that can support learning in an attractive and interactive way, has interesting information and animations with illustrations like in the laboratory directly according to the original, and has clear simulation exposure about tissue culture.

The next stage is design. Setting a schedule for media development activities, designing media specifications, designing material structures, and designing configuration controls that will be developed in multimedia are activities carried out at the design stage. What is done when designing the structure of the material, in addition to determining the material to be developed in the virtual laboratory, is to determine the learning steps. The steps in the developed virtual laboratory refer to the Event of Instruction which consists of getting attention, informing learning objectives, stimulating recall of previous knowledge, presenting material, providing learning guidance, performance training (practice), providing feedback, assessing performance, increasing reinforcement and knowledge transfer.

The third stage is the product development stage, which is translating product specifications into physical form. The result of the development is a program supported by macromedia flash for simulation. The results of the initial design stage are the design of learning media that will be developed in the form of flowcharts and storyboards. Based on the flowchart and storyboard, a prototype is made. Making prototypes, based on flow charts and storyboards, the process of making a virtual laboratory prototype is carried out. The elements in the virtual laboratory are the homepage, instructions for use, menus, competencies, materials, simulations, quizzes, and profiles. Home, Home is the initial display of the developed virtual laboratory. Students can press Start when they are ready to use. There is also an option if students want to turn off the background sound or close the program. The view of the homepage can be seen in Figure 1.

Figure 1 View of the Homepage of a Virtual Plant Tissue Culture Laboratory

Instructions for Use, after clicking start, students will enter the user guide display. The user manual display can be seen in Figure 2.

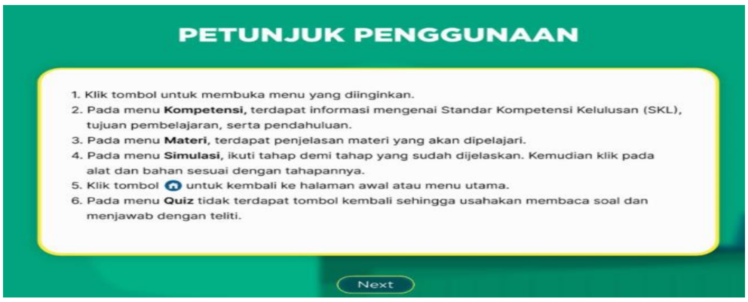

Figure 2. Display of Instructions for Use

Menu, in the menu display there are several sub-menus, namely competence, material, simulation, quiz, and profile. The menu display is shown in Figure 3.

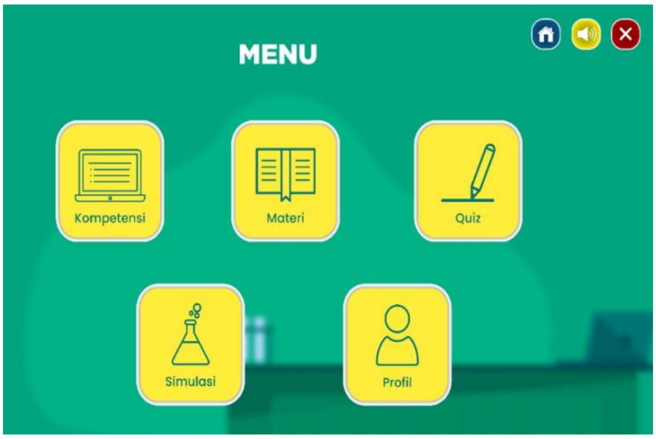

Figure 3. Menu Display

Competence contains information about competency areas, Graduate Competency Standards, Content Standards, and Basic Competencies. The competency display can be seen in Figure 4.

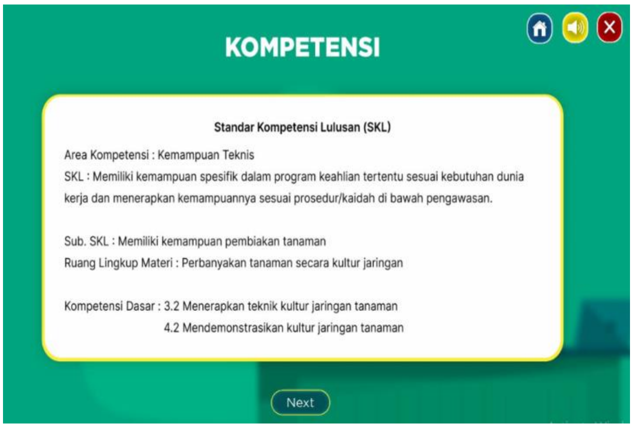

Figure 4 Competency Display

The material display consists of several sub-menus, namely tissue culture, K3, tools and materials, sterilization of tools, manufacture of culture media, sterilization of explants, inoculation of explants, and acclimatization. The display of the material can be seen in Figure 5.

Figure 5 Material Display

Simulation, the simulation display consists of several menus, namely tools and materials, sterilization of equipment, manufacture of culture media, sterilization of explants, initiation of explants, multiplication of explants, and acclimatization. Simulation display can be seen in Figure 6.

Figure 6 Simulation Display

The fourth stage is the media evaluation stage. The goal is to find out whether the developed virtual laboratory has met the product feasibility criteria. The developer divides 3 (three) outlines of the media evaluation stages. The first is evaluation planning, the second is evaluation implementation, and the third is product revision. The feasibility assessment of this virtual laboratory is carried out through expert validation. After obtaining validation from experts, the developer revises the prototype. The revised product is then taken to a one-to-one test to determine readability. Next, the product is taken to a small group test.

Expert Validation

The resulting laboratory has been validated through reviews by learning media experts, learning design experts, and material experts. The results of the validation of these experts are described as follows. Learning Media Expert, the results of the review of learning media experts are presented in Table 1.

Table 1 Results of the Learning Media Expert Review

Aspect	Total Answer	Total Idea Value	Percentage
Media Display	18	28	64,28
Program	24	32	75
Material Presentation	46	52	88,46
Average			**75,91**

Base on Table 1, based on the validation criteria, according to learning media experts, the developed virtual laboratory is in the good category (75.91%). The learning media expert stated that the virtual laboratory developed was worthy of being used with revisions.

Learning Material Expert

The results of the review from the material experts are presented in Table 2.

Table 2 Results of the Expert Review of Learning Materials

Aspect	Number Answer	Number Ideal Value	Percentage
Learning	20	20	100
Materi	31	32	98,87
Appearance	12	16	75
Languange	16	16	100
Program	19	24	79,16
Rata-Rata			90,20

Based on Table 2 show the table of validation criteria, according to the material experts, the developed virtual laboratory is in the very good category (90.20%). The materials expert stated that the virtual laboratory developed was feasible to use without revision.

Learning Design Expert

The results of the review from the learning design experts are shown in Table 3.

Table 3 Results of the Learning Design Expert

Aspect	Number Answer	Number Ideal Value	Percentage
Appearance	26	32	81,25
Learning	27	40	67,5
Languange	16	16	100
Average			**82,91**

Based on Table 3 the criteria table, according to the learning media experts, the virtual laboratory developed is in the very good category (82.91%). The learning design expert stated that the virtual laboratory developed was feasible to use in revised learning. The results of the review of learning media experts, material experts, and learning design experts are used as the basis for revising the product. The revision will then be implemented at the one-to-one test stage and small group test. Base on recapitulation of the one-to-one test results which can be seen in Table 4.

Table 4 Percentage of One-to-One Test

Respondent	Number Answer	Number Ideal Value	Percentage
1	10	10	100
2	10	10	100
3	10	10	100
Average	**10**	**10**	**100**

Based on Table 4, the average of the three respondents is 100% so it can be concluded that according to the respondents in the one to one test, the virtual laboratory developed is very feasible without any revision. The effectiveness of using a virtual laboratory as a learning medium is carried out by analyzing the increase in student learning outcomes after using the virtual laboratory. The effectiveness of learning outcomes is calculated by using the N-gain score or normalized gain score. The results of the N-gain Score from 55 students of SMKN 63 Jakarta who studied tissue culture found that the average N-gain score was 0.77 or when expressed as a percentage, it was 77%. This means that there is a 77% increase in learning outcomes after using a virtual tissue culture laboratory. Percentage of small group test results is show in Table 5.

Table 5 Percentage of Small Group Test Results

Respondent	Number Answer	Number Ideal Value	Percentage
1	10	10	100
2	10	10	100
3	10	10	100
4	10	10	100
5	10	10	100
6	10	10	100
7	10	10	100
8	10	10	100
9	10	10	100
10	10	10	100
Average	**10**	**10**	**100**

Discussion

The results of this research and development are divided into 3 (three), namely the development of a virtual laboratory for Nursery and Plant Tissue Culture Subjects, the feasibility of a virtual laboratory as a learning medium for Nurseries and Plant Tissue Culture, and the effectiveness of a virtual laboratory as a learning medium for Nurseries and Plant Network Culture in the laboratory. Students also think that learning is more theory than practice even though practicum is one of the important methods in learning Plant Tissue Nurseries and Culture because in addition to having to know the basic concepts and supporting theories, it is also necessary to conduct experiments/tests in the laboratory to understand certain concepts or basic theories that have been learned in order to have a deeper level of understanding and skills.

Based on the results of interviews with teachers and supported by the results of electronic questionnaires filled out by students, the developer designs the structure of the material to be developed and the learning steps in the virtual laboratory that will be developed. These steps refer to the Event of Instruction which consists of getting attention, informing the learning objectives, stimulating remembering prior knowledge, presenting material, providing learning guidance, performance training (practice), providing feedback, assessing performance, increasing reinforcement and knowledge transfer. This is in accordance with research conducted by previous research that state it is important to consider the principles of learning design when designing virtual reality-based learning (Merchant et al., 2014). The next stage is the development stage, namely the developer translates the specifications from the design stage into physical form. It begins with making flow charts and story boards. Based on these two things, the developer creates a prototype of the virtual laboratory. This prototype is also prepared to be brought to teach media experts, material experts, and learning design experts to be assessed for the feasibility of the product. Based on the input from the expert, the virtual laboratory was revised to be implemented at the evaluation stage.

Expert validation was carried out by reviewing a virtual plant tissue culture laboratory by teach media experts, material experts, and learning design experts. Aspects assessed by learning media experts are media display, programs, and presentation of materials. Based on the result it is known that learning media experts give an average of 64.28% for the media display aspect, 75% for the program aspect, and 88.46% for the material presentation aspect. Overall, learning media experts gave a score of 75.91%. Suggestions and inputs from learning media experts are changing the font type, improving the appearance of the material, adding instructions, and making the interface more attractive. The conclusion from the learning media experts is that it is feasible to use as a learning medium for Nurseries and Plant Tissue Culture with revisions according to the input and suggestions given. According to previous research multimedia components consist of text, graphics, sound, animation, images, video, and interactivity (Davis et al., 2018; Kljun et al., 2020; Norhayati et al., 2018). In this virtual laboratory there is a text component. The sound component is in the background sound which can be disabled if the user does not want to use the background sound. The animation component in this virtual laboratory is found in the simulation menu. The image component is contained in the material. The interactivity component is contained in the navigation buttons, simulation process, and practice questions. Based on this, this virtual laboratory has fulfilled the multimedia component.

Aspects assessed by material experts are learning, material, display, materials, and programs. Based on result it is known that the learning material experts gave a score of 100% for the learning aspect, 98.87% for the material, 75% for the display, 100% for the language, and 79.16% for the program. Overall, the material expert gave a score of 90.20%. It is known that the virtual laboratory developed is in very good qualification. The conclusion of the learning material expert is that it is feasible to use without revision. The learning material expert suggested adding additional teaching aids. During this Covid-19 pandemic, according to the material expert, virtual laboratories are effectively used for distance learning processes. This is supported by research results from which mentions that virtual laboratories can support distance learning (Potkonjak et al., 2016). Research results mentions that the use of simulations in virtual environments can engage students effectively outside the classroom environment (Makransky et al., 2019). In line with previous research that mentioned that the benefits of virtual laboratories are flexibility in terms of access so that they can be used to support distance learning (Alkhaldi et al., 2016).

Learning effectiveness can be defined as the success of students in achieving predetermined learning goals (Setyosari, 2017). Virtual laboratories can improve learning outcomes in accordance with the results of research conducted by previous research. In line with this, suggested that games, simulations and virtual worlds were effective in increasing the acquisition of learning outcomes (Hartini et al., 2019). The increase in understanding and knowledge after learning with virtual laboratories was also reported by previous research that assume that the increase in learning outcomes is because students can learn over and over again (Coleman & Smith, 2019).

The implication of this research is to provide information on the development of a virtual laboratory for practical learning in vocational education using nine events of instruction approach. This virtual laboratory is very useful to be applied to vocational school learning which can be an option from the limitations of tools, place or time that is carried out when learning practices in the Lab. This will certainly make learning more efficient and easy to access. There are many limitations of this study, including the subjects in this study which only involved one vocational school. It is hoped that further research will be able to deepen and expand the scope of research related to the development of a virtual laboratory for practical learning in vocational education.

4. CONCLUSION

This research and development resulted in a Virtual Laboratory for practical learning in vocational education using the nine events of instruction approach which in this approach is a systematic process that has a behavioral approach with a focus on outcomes or behavior during the learning process. This method can be applied in conjunction with Bloom's taxonomy. Thus, it will produce a more meaningful learning experience. Based on the initial needs assessment, it was found that the lack of tools and materials caused the students to not be able to carry out the practicum optimally. In addition, the results of the analysis of important events at the early-late analysis stage found that students were unable to carry out face-to-face learning because of the Covid-19 pandemic. Departing from this, we need learning media that can support learning in an attractive and interactive way, have interesting information and animations with illustrations like in a live laboratory, in accordance with the original, and have clear simulation exposures about network culture knowledge exchange.

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