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Research Article

Developing media of virtual laboratory of science: To support as a pioneer of cyber-university

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ABSTRACT

The Open University is a university that has been around for a long time, so that it is able to develop a learning process that demands the development of science and technology, both online and offline independently. Therefore, this study aims to describe and analyze the process and results of the development of a virtual science laboratory to support UT's role as a pioneer of cyber-university in Indonesia. This research is a development-research that uses the ADDIE model. The instruments used were validation sheets filled in by 64 validators, practicality sheets and effectiveness sheets filled out by 237 respondents. The data analysis used to answer the research objectives was descriptive and inferential statistical tests using the IBM SPSS 23.00 program. The results showed that product development in the form of textbooks based on the virtual laboratory of science met the valid, practical and effective criteria for use in the process learning. The results of this study have implications for stakeholders and teachers to be able to implement this media in a more appropriate and interesting learning process and can be a source of inspiration for conducting current research.

Keywords: developing media, virtual laboratory, science, ADDIE model

INTRODUCTION

The flow of globalization is unstoppable. Changes in the order of thinking and performance can change conventional systems towards modernization to increase competent human resources. The world of education is an important example to support human ability for the better, such as the ability to insight into and care for social and environmental concerns; this is (the idea of) the Era of Industry 4.0. The development of technology in the Era of Industry 4.0 changes the order of thinking and performance of humans to be faster, more efficient, and more effective in various fields of life, including in the field of education. According to Ghobakhloo (2020), that there are sophisticated priority relationships among various sustainability functions in Era of Industry 4.0, so that it can provide many innovative ideas and solutions for global (Javaid et al., 2020).

The ability to create intelligent human beings requires encouragement starting from the moment the thought was formed, such as formal schools that can help to improve quality human resources. However, currently based on preliminary information from the United Nations (UN) in the field of World Health

Organization (WHO) (Jamrozik et al., 2021), there has been an extraordinary pandemic case throughout the world, namely the coronavirus disease 2019 or known as COVID-19. As a result of this situation, it is necessary to use technology that is faster and more widespread in order to maintain human capabilities in the future (Ting et al., 2020; Whitelaw et al., 2020).

Schools and universities, especially in Indonesia, are greatly affected by the COVID-19 pandemic, resulting in the temporary closure of learning activities for an indefinite time. Utilization of e-learning tools and platforms for effective student engagement may have limited accessibility and affordability for many students. The pandemic has exposed the deficiencies of the current higher education system and the need 3for more training for educators in digital technologies to adapt to the rapidly changing world education climate (Rashid & Yadav, 2020). As a result of this event, it becomes difficult for teachers and lecturers to teach theories that are implemented in practice or practicum, so it is necessary to make efforts to use appropriate technology. Chick et al. (2020), He et al. (2021), and Rahmatullah and Syamsu (2021) explain that to deal with the problem of the pandemic, extracurricular regarding the COVID-19 pandemic and social distancing are needed.

Maintaining social distancing while delivering learning materials is difficult to implement properly, so other efforts are needed. The field of learning in higher education, especially in the faculty of teacher training and education, one of which is the natural sciences education has laboratory practicum courses that are very difficult to conduct if the materials taught are only in the form of theories. Various subjects in natural science studies cover practical aspects that are needed to strengthen theoretical certainty in the materials, so new techniques or strategies are needed to support performance learning. However, there are still many problems in the management of laboratories in schools and universities as described by Nur'aisah et al. (2020) that problems still occur in science laboratory. Problems in the management of laboratories need improvement efforts, Nahdiyaturrahmah et al. (2020) summarize several problems in the management of laboratories, namely planning, management, and performance, as well as lack in terms of tools and materials.

In the management of laboratories that are good and integrated with technology, various laboratory management program planning must have been formed including laboratory staff and administrative needs–such as the standard operating procedures, budget plans, and procurement of tools and materials. Laboratory administration must be carried out by good laboratory staff but based on the identification by Sutapa et al. (2020), the reality in the field shows that practicum implementation sometimes only uses an ordinary classroom, even–if a laboratory does exist, it is still a combined laboratory namely physics, chemistry and biology laboratory. The results of the identification study also reveal that the number of laboratory learning facilities in schools sometimes is not in accordance with the ratio of students. Aimah and Rohmah (2020) and Gustini and Wulandari (2020) reveal another problem in the management of laboratories, namely the placement of laboratories is less strategic. Also, Harefa et al. (2021) and Laeli and Maryani (2020) reveal that the lack of procurement of tools and materials in the laboratory made it less effective. These problems in the management of laboratories need solutions by utilizing technology. Technological innovation can be used as the biggest tool in all fields so as to enable a higher level of efficiency (Bai et al., 2020; Birkel & Müller, 2021; Frank et al., 2019), one of which is in the teaching and learning process through the implementation of laboratory use interactive virtual environment (Roman-Sanchez et al., 2018).

The use of technology is very helpful in supporting laboratory performance, including during this COVID-19 pandemic, so that adequate technology is needed for schools and universities. In addition, Indonesia is currently facing the ASEAN economic community (Plummer, 2006), so the education curriculum in 2020 has established an independent learning campus program. The term independent learning campus, which was coined by the Minister of Education and Culture, Mr. Nadiem Makarim (Siregar et al., 2020) is an effort to improve the competence of university graduates who have high competitiveness in the Era of Industry 4.0 and Society 5.0. This is in accordance with the RIP-UT 2020-2024, which contains excellent research institutions (related to the role of UT as a distance teaching university and a pioneer of cyber-university in Indonesia) to support the development milestones of UT for the 2020- 2024 period, namely "UT leading the PTJJ innovation" (LPPM UT, 2020).

The problem that many schools experience is the lack of equipment and materials in laboratories and due to the limited budget available for schools and the high cost of maintaining laboratories (Bogusevschi et al.,

2020). The development of internet technology is therefore a new way of sharing information and has facilitated the emergence of various e-learning scenarios. Recent technological advancements provide a great opportunity for schools to overcome budgetary and cost issues by using virtual 3D learning environments that support simulation and observation of various experiments (Estriegana, 2019; Sprenger & Schwaninger, 2021), this is because education today requires the development of new educational platforms to assist instructors in using the technology in the teaching process (Ahmed & Hasegawa, 2021). Virtual laboratory technology can have positive effects both on objective network knowledge, as well as subjective self-assessment of self-efficacy with respect to implementing the technology (Efstathiou et al., 2018; Luse & Rursch, 2021).

Dealing with problems such as the COVID-19 pandemic, the lack of infrastructure, tools, and materials–as well as the challenges of the independent learning campus program has encouraged the need for new innovations such as the use of environmental materials and the use of technology. Lasia et al. (2020) explain that the use of environmentally sound materials can minimize work accidents, and it can make it easier to identify safe materials during practicum. Also, the use of technology in practicum is very useful as a means of making it easier to deal with tool difficulties, as described by Wardono (2020) that the use of a homemade digital microscope can help teachers or instructors convey concepts.

Based on this description, it is necessary to use distance learning technology such as virtual. Remote laboratory learning has been carried out by Post et al. (2019) showing results that there is a positive response to distance laboratory learning. Sun et al. (2008) reveals that virtual laboratory learning can improve knowledge and learning styles and is most favored by students. Virtual laboratory learning can be carried out at various levels of education as expressed by Alfarizi K et al. (2020) that networked learning can be used at the primary school (SD), junior high school (SMP), senior high school (SMA), and university (PT) levels. Virtual learning is not just about material delivery but also the need for features in answer analysis and practical reports such as suggested by Rokhim et al. (2020) that there needs to be an online feature to send a practicum report.

Based on the studies that have been described, the purpose of this research is to develop a media science virtual laboratory to support UT's role as a valid, practical, and effective to be pioneer of cyber-university in Indonesia. This also aims to increase UT's efforts to become a benchmark as a cyber university in 2035.

METHOD

This research is an R&D research. The development of the science virtual laboratory was carried out using the ADDIE development model (analysis, design, development, implementation, evaluation) by Dick et al. (2005). The research was conducted in Pekanbaru in 2021 with the object of study being tutors and UPBJJ UT Pekanbaru students. The instruments used to collect data were the need analysis, validation sheet and small-group test for the development of the virtual science laboratory. At this stage of needs analysis, the subjects involved were 240 people consisting of 127 teachers and 113. And The textbook was validated by 64 validators consisting of 36 teachers and 28 lecturers. Then a small-group test was carried out by distributing questionnaires on the practicality and effectiveness of the product to 180 students (student teachers) and 56 teachers (tutors). This study aimed to describe and analyze the process and results of the development of the science virtual laboratory to support the role of UT as a pioneer of cyber-university in Indonesia that is valid, practical, and effective. The results of this study are for the stabilization and improvement of the tutorial system, especially in laboratory practice in teaching and learning processes at the Open University.

Development of research instruments used to collect data were the validation sheet for the development of the virtual science laboratory and the questionnaire sheet from experts. The validation sheet aims to determine the validity of the science virtual laboratory product development. The questionnaire sheet aims to obtain data on the usefulness of the virtual science laboratory by students teachers and teachers.

This study also conducted the simulation of needs analysis was carried out design and small-group a field simulation test planning was carried out using the analyses of document, structural, procedural, and technology processing related to the development of the science virtual laboratory. In the development of research instruments, validation questionnaire analysis was carried out using Cronbach's alpha with SPSS 22 and SEM. The results of data analysis were used as the basis for the development of the science virtual

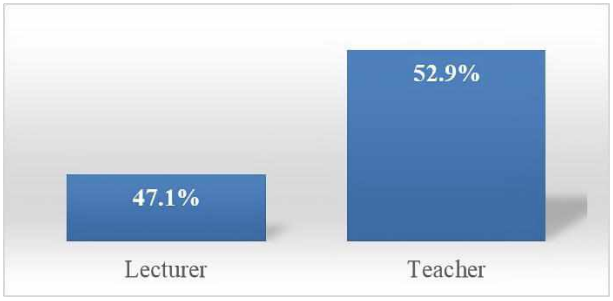

Figure 1. Diagram of respondents needs analysis (Source: Authors)

laboratory design. Assessment of product development was carried out with assessments by experts, students, and teachers. Data was obtained using a google form and sent to research subjects including lecturers, teachers and students. Before answering the questions in the questionnaire that was sent, of course the researcher did it with the consent of the participants and without coercion so that the data obtained could be useful in accordance with the objectives of the research being carried out. The results of the analysis were used as the basis for the revision of the resulting prototype (product prototype), which was evaluated based on effectiveness and practicality through field simulations. An attitude questionnaire was distributed to determine changes in the use of the science virtual laboratory program development.

RESULTS AND DISCUSSION

The results of this study are a description of the results of the development with the stages of the ADDIE model; used to stages process were the need analysis, validation sheet and small-group test for the development of the virtual science laboratory with questionnaire sheet. A description of the results of the development of the virtual science laboratory to support the role of UT as a pioneer of cyber-university in Indonesia that is valid, practical, and effective.

Description of Research Results

Analysis

At this stage, several activities were carried out, namely analyses of experience in the development and knowledge of the virtual science laboratory to support the role of UT as a pioneer of cyber-university in Indonesia that is valid, practical, and effective. At this stage of needs analysis, the subjects involved were 240 people consisting of 127 teachers and 113 lecturers as presented in **Figure 1**.

The researchers carried out an investigation regarding experience in the development of teachers and lecturers based on an aspect of experience in participating in training in the development of the virtual science laboratory. Based on the results of the analysis, it was found that teachers and lecturers on average have had experience in participating in training in the development of the virtual science laboratory so that it is easier for them to develop and overcome difficulties in the development of the science virtual laboratory. However, the results of the analysis and discussion with several respondents revealed that there is still a need for teachers and lecturers to be given training on the product development process, in particular for the virtual science laboratory, so they can minimize the difficulties encountered in the development of learning products. According to Ma et al. (2022), virtual laboratories are easily accessible and become a versatile tool for advanced students. Then in testing the research by Sriadhi et al. (2019) shows high feasibility in design, representation of user needs, reliability, system security, and ease of use. Virtual laboratories are also able to increase student learning motivation and have an impact on improving student learning outcomes (Altalbe, 2019; Maksimenko et al., 2021). While efficiency can be increased in terms of time flexibility, learning places, facilities and cost savings because learning is virtual.

The results of this study showed that teachers and lecturers on average have had experience in participating in training in the development of the virtual science laboratory, so it supports them to develop and minimize difficulties in the development of textbooks based on the virtual science laboratory. Therefore, teacher and lecturer respondents in this study expressed that they need to participate in training in training

in the development of teaching materials based on the science virtual laboratory. Today, many people have used training to assist them in carrying out various tasks in life. Basically, training gives someone experience to develop behaviors, in this case, knowledge, skills, and attitudes to achieve something desired (Efendi, 2017). Training provides opportunities for teachers to conduct self-evaluations (Baharun, 2018). Training must be in accordance with the needs of teachers. Therefore, professional training must carefully plan each training program, starting from the selection of material, time, place, and method to the quality of the instructor–most importantly, it must be planned in accordance with the needs of teachers and be carried out at the right time in the midst of teachers' busy schedule (Juniantari, 2017).

Such training will make it easier for teachers and students to implement the results of the training and make an impact on other teachers and students. Of course, the expected output of the training is that the results of the training can be applied on campus/school and have an impact on teachers and students. Such training will make it easier for teachers and students to carry out the results of the training and make an impact on other teachers and students. Of course, the expected output of the training is that the results of the training can be implemented in universities/schools and have an impact on other teachers and students. The results of this study further showed that, first, the media or applications used in the learning process include Google Classroom, PPT, Smartphone, Zoom, YouTube, E-Poster, Canvas, Google Meet, Mendeley, Zotero, laptops, and other media. This is in accordance with the opinion of Salamah (2020) that one way that can be done in learning is by utilizing the existence of Google for Education. Google for Education is an interesting innovation from Google for learning activities. There are various services provided in Google for Education, including Google Classroom, Google Calendar, Google Mail, Google Drive, and Google Docs. Google Classroom is highly recommended to be applied in learning activities in Indonesia because it is in accordance with the current learning conditions. According to Rosdiana et al. (2020), Google Classroom is a mixed-learning platform dedicated to every scope of education with the aim of finding solutions to difficulties in creating, sharing, and classifying paperless assignments.

Many educational institutions carry out synchronous online learning by utilizing video conferencing technology. Video conferencing is a meeting where participants who are in different locations can communicate with each other through audio and visual (Sidpra et al., 2020). Some video conferencing platforms that are widely used for learning include Zoom (Singhal, 2020), Google Meet (Al-Maroof et al., 2020), and Cisco Webex (Brady & Pradhan, 2020). The use of video conferencing applications allows synchronous learning to occur even though teachers and students are in different locations. Teachers can present teaching materials and provide explanations that can be directly accessed and listened to by students at the same time. Nevertheless, learning in this form has several limitations that cause teachers to not be able to carefully observe the activities of students during the learning process. Teachers cannot be sure whether students really follow and pay attention to learning, or whether they carry out other activities that have nothing to do with the learning process.

In addition to researching the media used in learning, this study also explored information related to the difficulties encountered in learning, including designing PPT, lack of understanding of the use of learning media, lack of clarity about the materials being taught due to network constraints, inadequate devices, and so on. A slow internet network connection can hinder the success of the learning process (Nurmukhametov al., 2015). The use of the Internet media has considerable obstacles; slow network connection and technical errors, such as server-down and errors can hinder the success of the learning process (Nurmukhametov et al., 2015). According to Moore et al. (2011), online learning is a type of learning process that relies on an internet connection to conduct the learning process, so a stable network connection is needed. The technical weakness is that not all students can take advantage of internet facilities because of the unavailability or lack of computers connected to the internet. This is in accordance with the results of a study by Rondonuwu et al. (2021), revealing that some students who were temporarily directly involved in the online learning process became the main problem found, namely the problem with an inadequate internet network connection–in this case, students did not have psychological readiness to overcome the problem, they only felt frustrated when their internet network connection was bad, so it was difficult for them to focus in learning. Also, the devices owned by students did not have large enough capacity and memory, so it affects the existing learning process, especially during exams.

Figure 2. Virtual science laboratory cover design (Source: Authors)

Furthermore, the researchers carried out an investigation regarding media and sources that are often used in the learning process, which include books, the internet, e-journals, and others. This is in accordance with the opinion of Antiwi and Nasution (2021) and Us and Mahdayeni (2019) that online information sources are types of information sources that are available online, and to access them, an internet network connection is needed. Usually, students look for sources of information through libraries, which provide various types of information sources such as books, journals, magazines, newspapers, and others.

The results of this study indicate that the learning media used are in accordance with the technology produced by Industry 4.0 and Society 5.0. The use of these learning media can improve the ability of Entrepreneurship, are creative, innovative, and oriented, in accordance with the values of Pancasila and the expectations of the vision and mission of Indonesian education, can improve the skills of the 21st century, and can improve the quality of education. This is in accordance with the opinion of Ria and Wahidy (2020) that Indonesia has now begun to maximize the movement in the Era of Industry 4.0, which is based on modern technology and artificial intelligence, but with the Era of Society 5.0, people must also prepare themselves for quality and continue to adapt innovations that will continue to develop.

In addition to being in accordance with Industry 4.0 and Society 5.0, the use of entrepreneurship-based learning media can improve learning outcomes in the form of learning achievement, activeness, learning motivation, and creativity (At'haya & Abidin, 2022). The use of entrepreneurship-based learning media is effective in developing interest in entrepreneurship (Hayati & Fitriyah, 2021). Studies on the development of entrepreneurship-based learning media continue to be carried out, such as a study by (Gatti et al., 2020) on the development of the pedagogy-based game in entrepreneurship learning. Utilization of technology as a medium of learning is an implementation of learning in the 21st Century where students are trained to master media literacy and ICT literacy (Anggraeni & Sole, 2018).

Design and Development

The following section will describe the characteristics of the virtual science laboratory developed by the researchers. The initial page design (cover design) and textbook usage guidelines for the development of a textbook based on the virtual science laboratory are presented in **Figure 2** and **Figure 3**.

The results of the development of a textbook based on the virtual science laboratory were submitted to experts for assessment. The textbook was validated by 64 validators consisting of 36 teachers and 28 lecturers as shown in **Figure 4**.

The experts who became validators in this study come from three areas of expertise, namely education, educational technology, and language (linguistics). Next, validation of the science virtual laboratory by experts was carried out. Aspects observed in the virtual science laboratory were aspects of substance component, learning design, visual communication display, and software utilization. The results of the analysis showed that the average score for the validation of the textbook as a whole is 4.39, with the criteria of "very valid". It can be concluded that a textbook based on the virtual science laboratory is valid according to experts, so the process can be continued to the implementation and evaluation stages.

Figure 3. Textbook usage guidelines (Source: Authors)

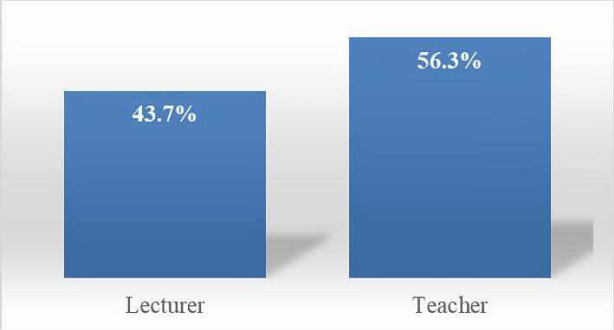

Figure 4. Validator team diagram (Source: Authors)

Based on the criteria obtained in each of these components, overall, a textbook based on the virtual science laboratory obtained a validity value of 4.39 with the criteria of "very valid". This shows that according to experts, product development in the form of a textbook based on the virtual science laboratory is valid and can be used in the learning process. Thus, this textbook based on the virtual science laboratory is appropriate and can be said to be feasible to use. This textbook based on the virtual science laboratory is said to be valid. According to Thahir et al. (2018), the criteria assessed by experts include the components of content feasibility, linguistics, presentation, and graphics. This is supported by Soewondo and Yuliani (2019), that a textbook is said to be valid if the four development requirements obtain a validity score >2.50 with the criteria of "valid".

The first aspect is the substance component, which includes the materials. One of the purposes of validating teaching materials is to see the suitability of the content or substance of teaching materials with the expected learning outcomes (Ariani, 2017). In this study, the teaching material developed and validated was a textbook. The textbook referred to in this study is a textbook that following the Decree of the Minister of National Education Number 36/D/O/2001 concerning technical guidelines for the implementation of assessment of lecturer position credit scores article 5 paragraph 9 letter a, which explains that a textbook is a handbook for a course that is written and compiled by experts in related fields and meets the rules of textbooks and is officially published and disseminated (Ratmelia, 2018). Textbooks are arranged according to the needs of students (Danaye Tous & Haghighi, 2014). First is the need for knowledge, such as natural knowledge, at the primary school level, the student's needs are only to know but at senior high school level, the student's needs are not only to know (understand) but also to apply. At this level, training and mentoring are needed. Second is the need for feedback on what is conveyed to students (Yusria, 2020).

The second aspect is the learning design, which includes the suitability of the media title with the material, KI & KD with content standards, indicators with KD, and sample questions and exercises with achievement indicators, as well as the availability of a list of references in the media presented. This is supported by Alkadri et al. (2017), that the nine indicators of the aspects of learning design include

(1) the title is in accordance with the material (Batubara, 2018),

(2) KI, KD, and indicators (Triyandana et.al, 2016),

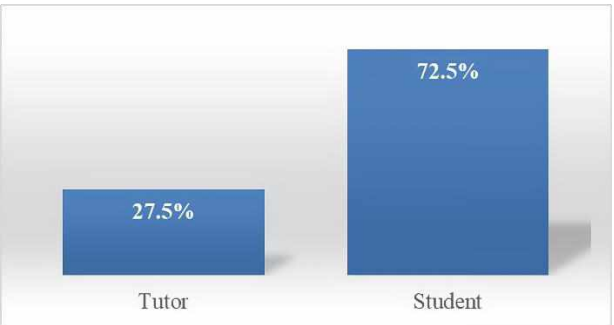

Figure 5. Results of respondents' practicality and effectiveness test (Source: Authors)

Table 1. Teachers' profiles by gender

		Frequency	Percent	Valid percent	Cumulative percent
Valid	Male	56	24.4	24.4	24.4
	Female	175	75.6	75.6	100.0
Total		231	100.0	100.0	

(3) KI and KD are in accordance with content standards (Rachmawati, 2018),

(4) indicators as a marker of the achievement of student competencies (Indaryanti et al., 2019),

(5) the materials are in accordance with KI and KD (Purwanto & Rizki, 2015),

(6) sample questions are in accordance with indicators (Zaleha & Nugraha, 2017),

(7) exercises are in accordance with indicators (Astuti et al., 2017),

(8) include the identity of the compiler (Pentury et al., 2019), and

(9) include a reference list (Ramaniyar & Hariyadi, 2019).

The third aspect is the visual communication display. The results of the study are in accordance with the validity standards of the learning media used referring to the criteria presented by Wahono (Inayah, 2017), which include aspects of instructional media design, software engineering, and visual communication. The data analysis was carried out by referring to Riduwan and Akbar (Aththibby, 2015). Furthermore, the determination of the validity of interactive learning media was based on the percentage range and qualitative criteria of the media (Wahyuni et al., 2017).

The fourth aspect is the utilization of software. The utilization of software is one of the components of ICT-based teaching materials assessment (Ramadhan & Linda, 2020). The results of this study are supported by Oktavia et al. (2021) that the development of the e-module using a professional 3D page flip application on the topic of acids and bases for class XI at the senior high school level, which was developed using the stages of the ADDIE model, has been declared valid by the material expert and media expert validators based on aspects of substance component, learning design, visual communication display, and software utilization. The aspect of software utilization is in accordance with the Ministry of National Education (Alberida & Fitri Arsih, 2015) regarding the component of software utilization, which includes aspects of feedback from the system to users, the use of supporting software other than the main software, and the authenticity of the teaching material work.

Implementation and Evaluation

After the assessment from the validators, then a small-group test was carried out by distributing questionnaires on the practicality and effectiveness of the product to 180 students (student) and 56 teachers (tutors), the results are shown in **Figure 5**.

The following is a description of research results by gender and occupation. This study involved as many as 231 people. Data from the results of descriptive analysis give a description regarding the profiles of the respondents. The detailed description is presented in **Table 1**.

Table 1 shows that the majority of the respondents are females with 175 (75.6%) people and then males with 56 (24.4%) people. This means that more female respondents answered the research questions than

Table 2. Teachers' profiles by occupation

		Frequency	Percent	Valid percent	Cumulative percent
Valid	Teacher (tutor)	56	23.7	23.7	23.7
	Student (student teachers)	180	76.3	76.3	100.0
Total		236	100.0	100.0	

male respondents, it was shown that the number of male respondents who chose the teaching profession is fewer than female respondents. This textbook based on the virtual science laboratory was assessed through a questionnaire filled out by teachers and students as users. The components assessed for the practicality of this textbook based on the virtual science laboratory are effectiveness, creativity, efficiency, interactivity, and interesting components. Overall, the average scored obtained for the practicality is 85.50% in the criteria of "practical".

Based on the questionnaire that has been filled out by teachers and students, in terms of ease of use, the textbook based on the virtual science laboratory is easy to use and carry. This is because lecturers and teachers advise their students to leave their heavy printed textbook and bring their textbook based on the virtual science laboratory instead to reduce the physical burden in their bag because the textbook based on the virtual science laboratory is considered complete by teachers and lecturers. Besides, the questions contained in the textbook based science virtual laboratory can also be solved by both by teachers and students. In terms of presenting the LKPD material, the textbook based on the science virtual laboratory is already interesting because it consists of colors that attract the attention of students as well as pictures and illustrations to help students understand the teaching materials. In terms of efficiency and effectiveness, according to students, this textbook based on the virtual science laboratory is already very efficient and effective to read. This means that the textbook based on the virtual science laboratory is practical according to students as users.

The usefulness of the textbook based on the virtual science laboratory depends on the results of user evaluation. This is in accordance with the opinion of Farida et al. (2019), that the use of the textbook based on the virtual science laboratory is expected to facilitate the transmission of problems used in learning for teachers. Teachers only need to look for questions that will be asked on the topic and then input them into the science virtual laboratory, so students can get information easily and quickly. This shows that the textbook product development present the materials clearly and concisely–the contents of the textbook is generally easy to understand, the font size and type are easy to read, the size is comfortable, and the textbook is equipped with clear general instructions. This is in accordance with Mirza et al. (2019), whose point of views is similar to the researchers, that language or readability standards of a textbook include correct use of Bahasa Indonesia, clarity, and readability. This practical standards show that the textbook product development is efficient and effective for use in learning. This textbook product development make study time more efficient and make students able to learn according to their own abilities.

This shows that the textbook based on the virtual science laboratories that have been developed can make learning time more efficient and make students able to learn according to their own abilities. According to Lestari et al. (2018), one of the practical considerations that must be considered in the development of learning media is that the time required for the process of using it should be short, fast, and precise. As Setiawan and Saputri (2020) said, using textbooks for learning can increase study time. Textbooks can be used to speed up learning time and complement the topics in other textbooks. Therefore, teachers and students should consider the practicality and convenience of the textbooks prepared, namely the ease of use and practicality of the textbooks to be used in the actual situation. Next, to see the respondents' occupation, the results are presented in **Table 2**.

Table 2 shows the respondents' profiles by occupation. It is known that the majority of the respondents' occupations are students with 180 (76.3%) people and then teachers with 56 (23.7%) people. This means that more students answered the research questions, which shows positive enthusiasm from them, so it provides motivation to improve quality. The questionnaire in this study contained objective questions of 8 items. The final test showed that the respondents who passed (the subject) reached 84.43%. The number of respondents who passed was more than the classical passing (mastery) of 70%. This means that the textbook based on the virtual science laboratory that has been developed is effective.

Effectiveness is related to the impact of the textbooks based on the virtual science laboratory towards the final test of learning outcomes, namely the suitability to independent learning. The final test was given in the form of a questionnaire with eight questions. Product development in the form of a textbook based on the virtual science laboratory has met the criteria of effectiveness in terms of the suitability to independent learning of 84.43%, with the criteria of "effective". The final test scores obtained are then compared with the KKM (minimum mastery criteria/passing grade) that has been set by the school, which is 70. Based on the learning outcomes, the attitude of caring for the environment of teachers and students shows that the level of classical mastery exceeds the predetermined classical mastery of 70%. The results of this study are supported by the opinion of Damopolii et al. (2019), that the effectiveness criteria are met if students reach the specified KKM limit, which is 70. This indicates that students are able to absorb lessons and increase their knowledge by using textbook product development. According to Subagia and Wiratma (2016), learning outcomes will reflect students' ability to perform and will serve as a guide for students to achieve behavioral changes related to learning activities. This is in accordance with the views of Khamidah et al. (2019) that if teachers use teaching materials that are very effective in the learning process, it will have a good impact on students' performance.

From the results of the analysis, it is also found that the attitude of caring for the environment of teachers is in the criteria of "very good" with a percentage of 100% while the attitude of caring for the environment of students is in the criteria of "good" with a percentage of 94.4%. The formation of attitudes is basically the result of a person's socialization and interaction with his environment. The environment is the embodiment of one's thoughts, feelings, and assessments of objects based on knowledge, understanding, opinions, and beliefs–that give rise to behavioral tendencies (Suharyat, 2009). According to Soekarjo and Ukim (2009), if teachers want to change their student's behavior, they must first try to change their beliefs or opinions. The student's point of view is closely related to attitude because attitude is a person's behavior or response to stimuli or objects that are still closed (Azhar et al., 2015, p. 467).

According to Suharyat (2009), students' attitudes toward certain objects continue to develop throughout the development process. In learning, attitudes are closely related to the knowledge and skills possessed by students. This is very important because the environmental knowledge information obtained from learning will be processed in the brain through a series of analysis, synthesis, and evaluation activities to produce values contained in the form of attitudes. Bradley et al. (1999), state that in addition to life experience, socioeconomic status, and culture–attitudes are highly dependent on what the teacher teaches in the classroom. When implementing the Adiwiyata school project, the role of the teacher needs to be strengthened, especially if the courses taught are related to environmental issues. Teachers must be able to integrate environmental problems that occur in everyday life by providing simple examples so that students can easily understand them. Teachers must also receive training to improve their skills, so they do not experience difficulties in integrating environmental issues into the learning process.

To form attitudes, teachers must apply various learning models. Landriany (2014) suggests that if students' attitudes towards environmental care are still low, it may be caused by a misunderstanding of the concept of environmental protection. Meanwhile, according to Costel (2015) and Guo et al. (2017), the basic concept of caring for the environment includes institutional and school management factors, students' conceptual knowledge, environmental factors, and educational strategies. Meanwhile, to maximize the caring attitude, it is recommended that teachers adopt a constructive approach in the curriculum. Because to convince students of the importance of a value, teachers need to gradually build an understanding of the value itself and natural phenomena (Istiqomah, 2019). In turn, Summaryat (2014) shows that to change students' attitudes through the learning process, the transmission of knowledge and information must be persuasive, namely gaining trust through the process of analysis, synthesis, and evaluation.

According to the researchers, besides the ODHA course, another way to increase environmental awareness is to incorporate religious and spiritual values into all aspects of school activities. This is in accordance with the goals of national education, and it is indeed important to instill spiritual values to achieve a complete character. Instilling spiritual values helps encourage people to obey God's commandments and learn to be responsible for themselves and society. Besides functioning as an educator, the teacher can also act as a role model and instill habits. This is supported by the opinion of Suharyat (2014) that to cultivate students' attitudes, teachers must be role models, namely be able to create situations and conditions that

make students care about the environment, especially in the learning process–habits and reinforcement must continue to be developed.

A study by Tri (2014) shows that teachers can use simple examples, such as cleaning the board after class, picking up trash, participating in community service activities, and always encouraging students to cultivate positive values. Dagiliute and Andrius (2014) show that attitude changes will be influenced by various factors, such as age, gender, culture, motivation, existing school infrastructure, and social pressure. Making the environment a part of life can also increase emotional attitudes. Baartman and De Bruijn (2011) and Loughland et al. (2003) found that some teenagers only make environmental problems as independent objects, and consider some things that are not important outside their lives. According to Nuzulia et al. (2019) and Roswita (2016), the Adiwiyata school project can be used to develop programs that aim to foster the attitude of caring for the environment in students. In addition to their study of ODHA, they also included ODHA in all subjects, environmental management, and environmental protection facilities. In addition, students who violate school regulations should be punished by cleaning up the campus/school environment and developing environmental protection slogans to cultivate habits.

CONCLUSION

Based on the analysis of the results that have been carried out, it is concluded that

(1) the process of the development of a textbook based on the virtual science laboratory consists of the stages of analysis, design, development, implementation, and evaluation. This product development provides teaching material facilities based on the virtual science laboratory with a combination of video, text, and images. Product development in the form of a textbook based on the virtual science laboratory has met the validity criteria of 4.41, with the criteria of “very valid”;

(2) product development in the form of a textbook based on the virtual science laboratory has met the practicality criteria of 85.50% with the criteria of “practical”; and

(3) product development in the form of a textbook based on the virtual science laboratory has met the effectiveness criteria in terms of environmental care attitude of 84.43% with the criteria of “effective”.

The conclusion of this research is that the developed science virtual laboratory media is valid, practical and effective to be used in the learning process. so that this research has implications for stakeholders and teachers to be able to implement this media in future learning processes that are more precise and interesting and can be a source of inspiration for conducting current research.

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