Scalable Practicum for Active and Creative Learning in Science Education

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February 22, 2023

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Abstract

The Covid-19 pandemic has been becoming a challenge for educators in enriching their teaching with distance learning strategies. Science teachers face their challenges in the pedagogy of teaching practical science. On the other hand, students face challenges in completing their practical courses due to pandemic warnings and geographical constraints that reduce their access to learn authentic sciences. This paper presents the results of research on student experiences in working on virtual lab applications that function as a medium for students to carry out *scalable practicum*. The application is basically designed to enrich student-teachers to have more access to science practicums in Universitas Terbuka. The results show that the virtual lab does necessarily proper in implementing the *scalable practicum*. Analysis of qualitative and quantitative research data reveals the effectiveness of virtual lab in linking pedagogical approaches with students' needs for practicum through the application of *Scalable Practicum*. The research suggested that the virtual lab provides excellent convenience for the students who do science practicum through *Scalable Practicum*. The study recommends further research with a wider scope and sample to get a more comprehensive picture of the effectiveness of virtual labs.

Keywords:

Scalable Practicum, Virtual Lab, distance education, online education, online learning, Likert scale at 10-poin

1. Introduction

Although the world continues to face the impact of the COVID-19 pandemic, most educational activities are gradually adapting to the new normal with more innovative pedagogy, which more than includes the resources available through the engagement of pedagogy and technology together (Morgado et al. , 2021; Nuere & de Miguel, 2021) . Meskipun demikian, berbagai batasan tetap diberlakukan oleh pemerintah Republik Indonesia dan negara lain (UNICEF-Indonesia, 2021) . Meanwhile, the pandemic is gradually becoming endemic in Indonesia (Supanji, 2021) telah banyak mengubah sistem pendidikan konvensional menjadi pembelajaran jarak jauh dan sistem pendidikan yang lebih dikenal dengan pembelajaran online. Pembelajaran lebih menekankan pada proses penyampaian melalui berbagai teknologi komunikasi dan informasi. Desain sistem pembelajaran mengintegrasikan konten dan teknologi secara efektif dan efisien dan disampaikan secara asynchronous, synchronous, atau keduanya (Akimov & Malin, 2020; Bhaumik & Priyadarshini, 2020; Bordoloi et al., 2021) .

Due to the limitations of face-to-face meetings, distance and online learning systems require teachers and lecturers to create a virtual learning atmosphere to facilitate practical and efficient online learning (Brinson, 2015; Dalgarno et al., 2009; Domínguez et al. , 2018; Estriegana dkk., 2019; Faour & Ayoubi, 2018; Viegas dkk., 2018). At the same time, under such limited conditions, due to the pandemic, students are required to be actively involved in online learning activities. They are challenged to be skilled at using a variety of digital and online technologies (Atmojo et al., 2021; Tamim et al., 2021; Thompson, Corrin, & Lodge, 2021; Wajdi et al., 2020) to support their access to online learning processes (Clark & Post, 2021; López-Meneses et al., 2020; Tamim et al., 2021; Thompson, Corrin, & Lodge, 2021) .

Obstacles in online learning arise when courses must be delivered practically and carried out in the laboratory. The implementation of practical learning and laboratory-based activities often fails, especially during the COVID-19 period, due to limited access to laboratories and other facilities (Ko ar, 2021) . We fully understand why practicum activities should be carried out in the laboratory or natural environment. Naturally practical courses are designed to provide students with a real-world learning experience that encourages natural, active, and authentic learning (Domínguez et al., 2018; Potkonjak et al., 2016; Tatli, 2012) to reinforce critical and creative thinking skills (Firmansyah & Suhandi, 2021; Miguel-Revilla et al., 2020; Papanikolaou et al., 2017) .

Based on preliminary research, we found that the Universitas Terbuka (UT), as an open and distance education university, has reconstructed face-to-face learning services to an online delivery mode for "Praktium IPA di SD" (translated: Basic Science

Practicum - BSP) during the COVID-19 pandemic through Microsoft Teams (UT Team 2020) . However, some problems arise related to the supervisory process during implementation. A supervisor has limited access to provide direction (discussion) intensively or frequently and issue the results of student practical work assessments. At the same time, students also experience problems in conducting practicums independently and have difficulty writing (uploading) online reports through the platform. This constraint degrades the quality of course execution. We assume that the platform is not set up for online practicum communication interactions.

The UT Basic Education Study Program equips its students with "KIT Praktikum IPA" (translated: Science Practicum Apparatus - SPA) (Faqih dkk., 2015). The SPA is a set of tools, instruments, and materials prepared for students to cover all science practicum topics based on the UT Standard Guidelines. Several universities in Indonesia have developed a Student SPA, as shown in Figure 1, following the learning design (Faqih et al., 2015; Listyalina et al., 2020) . All materials needed for science practicum are included in the Science Practicum KIT. However, in the case of UT, accessibility to SPAfor students doing practicum is also often limited. These limitations are often caused by distance and time constraints between students and UT as the organizer of the SPA.

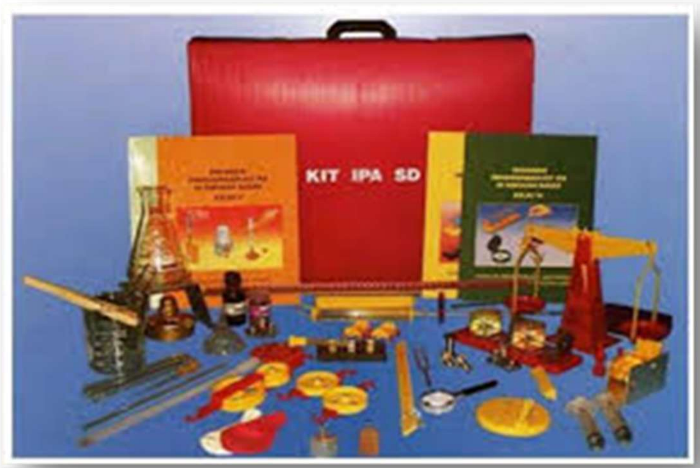

Figure 1. An example of Science SPA (Listyalina, et.al., 2020)

Based on the results of this preliminary research, we strongly agree that innovation should be directed to facilitate students by opening up opportunities to conduct science practicums independently, and providing intensive communication and individual supervision from lecturers. (Kusmawan & Handayani, 2021). For this reason, we argue that the platform needs to be explicitly designed to facilitate and monitor students' independent practicum activities. In addition, it must also help lecturers work efficiently in the monitoring and evaluation process. We believe that virtual lab applications can be designed to meet those needs.

As for the open and distance education system, most of the students' domiciles are spread across various locations in Indonesia. A new issue arose regarding the equitable access of all students to the apparatus science practicum. Often the tools/instruments and practicum materials are not in good condition. Some instruments or materials may be physically damaged on the way to the student's location . Damaged conditions can also be caused due to frequent use by students. As a result, for example, students have limited access to 'pulleys' for physical energy practicums, feel insecure working on 'flies' in biological practicums, or do not have 'Erlenmeyer flasks' to measure the volume of practicum material on chemical practicums. If the student cannot access these tools and materials, the student cannot do the practicum, or the student only receives lectures about the practicum from the lecturer without doing the actual practicum. On the other hand, as mentioned earlier, some teachers believe that a virtual laboratory can be a platform that ensures intensive communication between lecturers who act as practicum supervisors and students according to instructional principles and practical learning characteristics to facilitate virtual interaction , regardless of geographical and geographical and time constraints .

Thus, the question is, "Can students do practicum without science practicum apparatus (SPA) or laboratory? Is there a way for students to meet individual science practicum competencies without science PA or laboratory? With the explanation of the virtual lab above, researchers believe that in addition to direct, continuous, and intensive communication, this virtual lab can facilitate the performance of practicum students independently. In this case, students are allowed to even be challenged to creatively and innovatively look for alternative tools or instruments and materials in the surrounding environment to carry out the practicum after fully and critically understanding the objectives that have been set in the science practicum standards. Thus, the question is as follows: What kind of practicum can equip students with creative, critical, and innovative challenges? How can this practicum activity be accommodated so that students' creative, critical, and innovative abilities can be well cultivated?laboratory kits? Is there a way for students to meet individual science practicum competencies without science or laboratory kits? With the explanation of the virtual lab above, researchers believe that in addition to direct, continuous, and intensive communication, this virtual lab can facilitate the performance of practicum students independently. In this case, students are allowed to even be challenged to creatively and innovatively look for alternative tools or instruments and materials in the surrounding environment to carry out the practicum after fully and critically understanding the objectives that have been set in the science practicum standards. Thus, the question is as follows: What kind of practicum can equip students with creative, critical, and innovative challenges? How can this practicum activity be accommodated so that students' creative, critical, and innovative abilities can be well cultivated?

1. *Scalale practicum* for authentic science learning

Ordinary science learning often gives students a misleading view of how science works in the real world. Students will understand that the skills of the scientific process are more complex and interesting than is usually indicated in school if they have the opportunity to observe the scientist at work (McComas, 2014). Despite the pandemic above, there are two important challenges in science education, namely how to engage students in science practice and how to develop and maintain interest (Habig & Gupta, 2021; McComas, 2014). More specifically, science literacy is defined as the ability of an individual to deal with problems that arise into the real world (Permanasari et al., 2021) . Permanasari further stated that, "Scientific literacy leads ones to deepen knowledge and understand to the scientific concepts as well as to the process which is needed make a personal decision, to participate in social, cultural, and economy productivity." (Permanasari dkk., 2021: hal.323). In the context of school science learning, it was found that the natural potential of local schools (all objects in the school grounds and the surrounding environment) represents the content of the curriculum and science learning skills (Widowati, Nurohman, & Anjarsari, 2017). Jadi jelas that the authenticity of science learning has been found to be important for individual learners and therefore must be built through real activity in integrated issues that arise in the environment; including social, cultural, even economic.

However, in science curricula in which practicum is considered a necessity for students to follow procedural activities in the laboratory , their scientific skills are bound to imitate and verify standard procedures by them. Departing from this and in connection with the concept of authentic learning above, Kusmawan & Handayani (2021) proposes the implementation of *scalable practicum* (SP) or a locally scale of practicum. This practicum is defined as a practicum designed so that students can do the practicum independently by using tools or instruments and materials in the surrounding environment. It provides students with the accessibility to independently implement standard practices prepared by UT. They can still do practicum without having to go to the laboratory under the direction of the supervisors in the local practicum area. In the principle of procedural diversity, this state is understood as a decontextualized versus contextualized intervention from a science practicum. (Cofré et al., 2019; García-Carmona & Acevedo-Díaz, 2018; Kruse et al., 2021). Students acquire real-world scientific skills through SP practicum, such as creative, critical, and innovative skills (Commager, 1992; Owen, 2019) . During the preliminary research in 2021, based on testimonial statements from both experts and students who actively participated in the research, we understood that this SP is appropriate to develop student practical competencies with limited accessibility to standard practicums (Kusmawan & Handayani, 2021). Students should learn practicum tool and material calibration skills under the guidance of a supervisor to ensure a clear understanding of the standard practicum procedures (Davis et al., 2018; Kusmawan & Handayani, 2021; Listyarini et al., 2019). SP allows student-teachers (science practitioners) to conduct practicum programs independently using tools and materials obtained from the environment. (Kusmawan & Handayani, 2021). Kusmawan further highlighted that this practicum must be under the expertise of the supervisor to validate the calibration process (Kusmawan & Handayani, 2021) .

In some studies, the SP program has a principle similar to the microscale practicum (MP) model. MP experiments are carried out on a small scale using tools and materials of simplified size but with the same working procedures as those used in laboratory experiments (Listyarini et al., 2019; Suchyadi & Karmila, 2019). The similarity between SP and MP practicums lies in its goal of encouraging students to practice and train themselves to be more aware of real problems that exist and build solutions from the natural, social, and cultural environment around them. The two practicums have almost the same implementation principle, which is to prepare students to skillfully change the standard scale reference to a new scale for newly validated practicum procedures.

In other learning strategies, Larsen has revised and expanded Gregory Bateson's theory of learning to show how the content and context of scaffolding occurs in computer programs. Larsen suggests that the proposed revision rests on a micro-level analysis of how learning occurs in computer programs, showing how scaffolding content and context additional constructions work within and outside the realm of computer programs (Larsen, 2020). Both of these learning strategy learning contexts lead us to the understanding that students are encouraged to think creatively, critically, and innovatively. Students are invited to creatively discover alternative tools and materials, critically develop new scales, and innovatively develop new practicum procedures under the guidance of lecturers. Meanwhile, the essential difference between the two lies in the micro and measurable senses. MP emphasizes simplifying the scale of tools and materials, while SP emphasizes the availability of tools and materials in the surrounding environment.

The SP encourages students to develop critical, creative, and innovative thinking skills through their demands to respond to natural phenomena in education. Critical thinking is the ability to think clearly and rationally about what actions can be performed or what reality can be trusted (Commager, 1992; Firmansyah & Suhandi, 2021; Ocak & E mir , 2016) . Owen (2019) & Thompson dkk. (2021) provides clues about the character of critical thinkers, including (1) understanding the relationship between logic and ideas; (2) identify, construct, and evaluate arguments; (3) solve problems systematically; (4) identify the relevance and importance of ideas; and (5) sympathize with the meaning and justification of value in a person. The accumulation of these characters can foster a creative and innovative personality Suchyadi & Karmila (2019) suggests that creative thinkers are adept at thinking broadly—even outside the box—. Individuals who have these thoughts have characteristics that often trigger the creation of innovation and are good at handling various situations, are optimistic, and always spread enthusiasm. As a result, their creative psyche is closely related to innovative personalities. They are enthusiastic about producing works / products that have never existed before or creating something completely new and unmatched.

2. Virtual Lab mediates Scalable Practicum

Some experts generally define a virtual lab as an online practicum simulation activity (Alexiou et al., 2004; Dalgarno et al., 2009; Domínguez et al., 2018; Dyrberg et al., 2016; Kfir, 2005; Kusmawan, 2017; Ligoxygakis, 2001; Potkonjak dkk., 2016). More specifically, Purnamasari et al. (2021) explains that computers can be used to modify practicums and display complete practicums in virtual form, especially for abstract science concepts. In line with Nurhayati dan Suryani (2021) , which explains that conducting practicum activities can not only be done in laboratories but also virtual laboratories—a series of tools, materials, and laboratories in the form of computer software which can simulate activities in the laboratory as if the user were in a natural laboratory (Kusumaningsih, YR, Iswahyudi, C., & Susanti, 2014; Wijayanto et al., 2018) .

However, in this study, the definition of a virtual laboratory is not limited to the concept of simpulative representation of scientific activities through computer application programs but also to direct, continuous, and interactive communication activities between lecturers and students carried out online. Thus, the concept of a virtual lab in this study is defined as a practicum activity that is managed online both through simulation application activities and real independent practice by students in the field who are guided directly through intensive communication in an application. As explained earlier, the second part of the virtual lab concept embodies the principle of SP. As a result, the study characterized the virtual lab in three functions. The first function is to provide access to simulation-based laboratories in various practicum disciplines. The second function is to stimulate students to conduct experiments by arousing their curiosity to put into practice critical, creative and innovative scientific actions to help them learn basic and advanced concepts. The third function is to provide a complete learning management system around a virtual laboratory where students and lecturers can utilize for themselves a variety of tools for learning, including additional web resources, video lectures, animated demonstrations, and self-evaluation (Kusmawan & Handayani, 2021). Given the third function, Guillén-Gámez et al. have concluded their research that the level of digital competence and motivation to use ICT are two positively correlated variables and together will improve future learning skills (Guillén-Gámez et al., 2020) .

With the technology pedagogical content knowledge (TPACK) learning method introduced by Shulman in 1986, a virtual laboratory that functions as an SP can strengthen the development of technology-based student learning. SP helps apply the TPACK principle in synergizing technology-based student learning activities with learning content, which serves as a vehicle to improve critical, creative, and innovative thinking skills. A lecturer designs a learning approach to integrate technology into content and pedagogy. The content is not the target of learning outcomes; Instead, it triggers constructive interactions between students' learning processes and the development of their thought processes through appropriate technology. Furthermore, various technologies are designing learning innovations to strengthen efforts to achieve student learning goals.

Although current conditions have increased the integration of technology into learning due to the COVID-19 pandemic, the implementation of practicum still experiences some access barriers. UT on its average manages more than 300,000 students per semester from all provinces in Indonesia, including remote and isolated areas. Several other similar online universities with UT manage a large number of students. With so many students, including student-teachers, the university has implemented several strategies for practicum (Mesci et al., 2020; Wan et al., 2013). Regarding the strategy, experts explain that scientific experiments in certain subjects are carried out by students independently in virtual laboratories (Qiang, Zhe Qiang, Alejandro Guillen Obando, Yuwei Chen, 2020) in remote laboratories in collaboration with partners (Nesenbergs et al., 2021) , and even in their homes with the guidance of tutors (Davis et al., 2018). Distance education institutions typically provide printed and/or non-printed modules as teaching materials (Martin et al., 2020) . In addition, UT equips students with a science practicum kit (UT Mobile Lab) for scientific experiments. Therefore, virtual laboratories become an important application when practicum allows students to conduct scientific experiments independently. Integrating various technologies into learning through the application can enable students and lecturers to interact actively and sustainably to build a good and comprehensive understanding of the practicum.

3. METHOD

The research and development (R&D) study that focuses on the development of virtual labs is raised in a research umbrella entitled "Application of the scalable practicum model via virtual lab in improving the quality of student guidance in elementary science practicum" (Translation: Implementation of scalable lab-based virtual practicum to improve the quality of student involvement in science practicum (Kusmawan & Handayani, 2021). Universitas Terbuka funds the research pursuant to a Research order No 15974/UN31.LPPM/PT.01.03/2020, signed by the Head of the UT Research Institute on April 20, 2020. R&D research design that refers to (Gall et al., 2007), shown in Figure 2. The research, which began in 2021, focuses on developing a virtual lab-based scalable practicum model based on students' local wisdom called "scalable practicum (SP)", where the virtual lab application functions as a vehicle for students to carry out the SP. The population of this research is students who are actively learning in the Elementary School Teacher Education Study Program Universitas Terbuka, Indonesia.

In the preliminary study in 2020, the quality of the SP model itself was qualitatively assessed using interviews with experts and students participating in the study. We invited students participating in the SP to share their testimonials about the SP model. In addition to the literature review, the concept of SP is discussed in depth in a Focus Group Discussion (FGD) activities with lecturers (expert research participants) whose expertise was in elementary science practicum and student-teachers study program (student research participants). The results of interviews, testimonials, and FGDs related to the SP have been published in a digital book entitled "Memahami Scalable Practicum" (translated: Understanding a Scalable Practicum), available at https://sl.ut.ac.id/ScalablePracticum2021 .

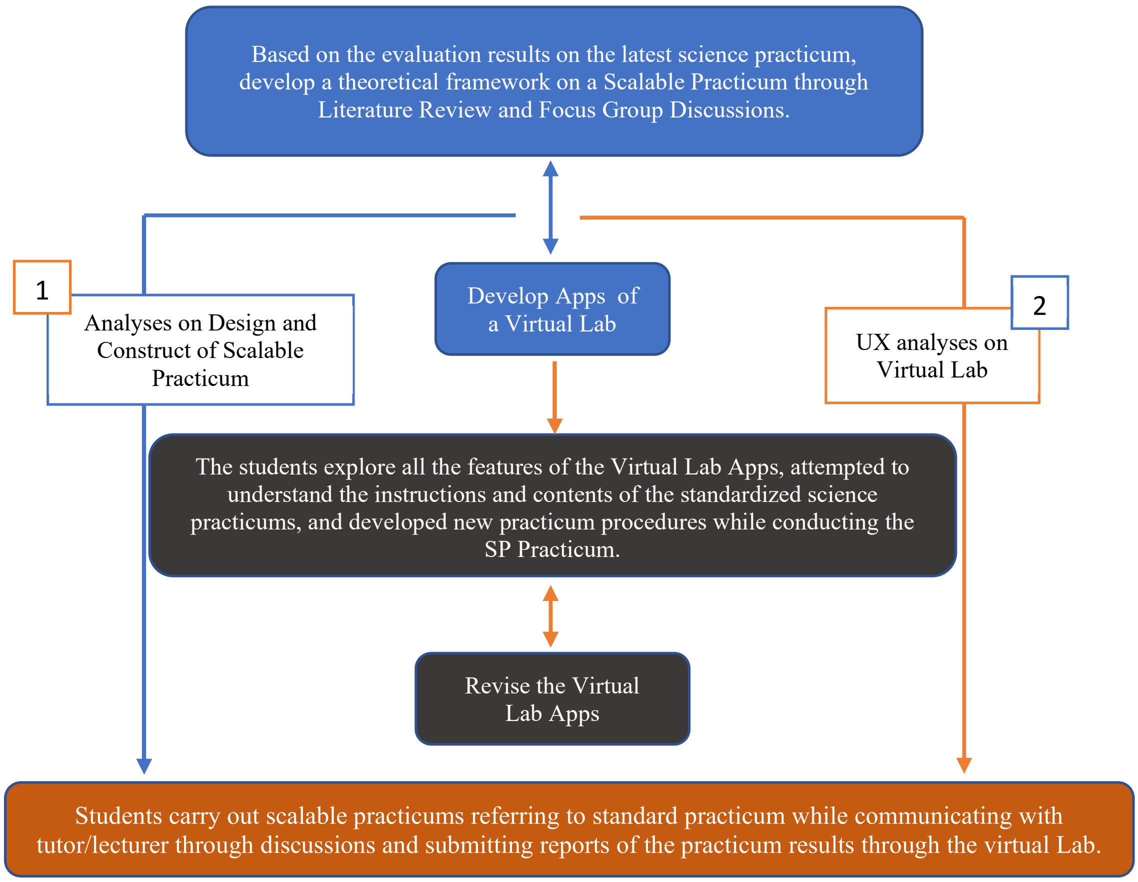

Figure 2. R&D Design for implementing Scalable Practicum through Virtual Lab

Meanwhile, the virtual lab application (Virlab) is quantitatively assessed using survey instruments to obtain information about the user friendliness and usability of the application (UX Survey). The survey was conducted to students participating in the SP practicum and students who passed the science practicum course. The instrument was developed using a 10-point Likert scale. This study developed a 21-item Likert scale survey, as shown in Table 1. In addition to the reliability and validity of the instrument, we perform statistical processing using SPSS scale measurement testing to obtain information related to respondents' categories of answers about the quality of web-based virtual labs. A total of 201 UT students enrolled in the elementary teacher education study program participated in the UX survey.

Table 1. Virtual Lab UX Instrument Survey

Scale No.	UX- Virlab Scale Theme
1	Front site view of the Website
2	Ease of understanding of the informational content available on the Website
3	Website creativity level
4	Content information is easy to predict
5	Novelty of information on the Website
6	Practical illustrations and information on the Website
7	The degree of complexity of searching for information on the website
8	The website is fun

Scale No.	UX- Virlab Scale Theme
9	Discovery of technological concepts on the website?
10	Website contains important information to know
11	The level of security of interacting on the Website
12	The website brings out your motivation in improving your digital and online skills.
13	The website meets your expectations
14	Websites work efficiently in conveying information.
15	Clarity of commands, displays, and menus
16	Level of comfort during searching for information on the Website
17	Website increases motivation to do practicum
18	Website Responsiveness
19	Structured information on the Website
20	Informational benefit sharing websites
21	You will recommend this virtual lab website to other students.

4. Results and Discussion

The explanation of the research results begins with the elaboration of the results of the measurable practicum implementation (SP) testing through testimonial data from students involved as practical students (students participating in the study). The results of the testimonials are expected to provide insight into understanding of virtual labs to improve the quality of student practicums.

a. Scalable practicum

In the digital book published in https://sl.ut.ac.id/ScalablePracticum2021, all testimonies were expressed by experts and student participants. While attending a focus group discussion at the preliminary study stage, the experts emphasized that the concept of SP should correct the existing weaknesses of the elementary science course practicum. They agreed that the level of learning outcomes of science education undergraduates should be aimed at equipping students with learning competencies that encourage critical, creative, and innovative thinking skills.

In a video recording of the testimonial presented in the digital book on page 21, one of the experts reiterated his remarkable understanding of "*scalable practicum*", including the advantages and disadvantages of the concept in his efforts to improve the quality of science learning through distance and distance. online system. His positive view of SP has allowed his clear and even practical understanding of SP. The following is a testimonial statement related to the concept and implementation of SP.

Kutipan #1; Ahli 1; Halaman 21: Konsep Praktikum yang Dapat Diukur:

"… Praktikum Scalable merupakan suatu model pembelajaran IPA dengan fokus praktikum IPA berdasarkan kekuatan lingkungan sekitar yang bertujuan untuk mendorong mahasiswa dalam melatih berfikir kreatif dan kritis ….

Dalam proses penyusunan praktikum scalable , mahasiswa belajar prosedur praktikum standar dari lembaga dan video pelaksanaan praktikum standar , selanjutnya mahasiswa mengembangkan sendiri penuntun scalable praktikum yang divalidasi oleh pembimbing praktikum dan membuat video pelaksanaan *scalable practicum* tersebut …

Praktikum scalable juga sangat sesuai untuk siswa yang mempelajari program pendidikan non - sains . Dengan kegaitan praktikum SP, sampai batas tertentu , mereka ingin untuk secara kreatif dan kritis mengerti makna praktikum bagi diri mereka sendiri "

Translated into:

"… Scalable practicum is a model of learning science focusing on science actions in the real-word and the self-environment. It aims to encourage students to think creatively and critically while preparing for implementing the scalable practicum….

> The students must first learn the standard practicum procedures from the institutions. Then, the students think of the possibility of finding alternative instruments and materials for practicum and then develop new scalable procedures validated by their practicum supervisor, followed by making videos of the implementation of the scalable practicum…
>
> A scalable practicum is also appropriate for students studying non-natural science educational programs. To some extent, with the scalable practicum, they are trained to, and hence accustomed to being, creatively and critically understand the meaning of the practicum for themselves."

From the above statements, it appears that experts can immediately understand the concept of *scalable* practicum after they are directly involved as practicum supervisors in SP practicum activities. Because they immediately saw how the students lived it. Experts stress that if clear standard procedures are accessible at any time to students and intensive guidance from practicum supervisors is available at any time, they will eventually be able to build their creativity and criticality through their locally based practices. The statement corresponds to Michael Scriven in Commager (1992:159) It is argued that the ability to think critically can be seen from two aspects of ownership, namely 1) a set of skills that generate and process information and beliefs, and 2) habits. , based on intellectual commitment, to use these skills to guide behavior. We understand this situation as an excellent opportunity to further apply the practicum concept to improve students' access to the practicum without geographical and professional constraints.

Upon completion of guiding the student practicum, the experts found that SP is also suitable for other educational practice activities, including teaching practice and other social content practice courses. This statement corresponds to Alice Laquinta in Commager (1992: 116), It is stated that when students show an attitude of creative thinking, they will be able to encourage others to think creatively. This similar attitude increases the self-esteem of others and themselves. They may apply these behaviors and attitudes in every area of their lives, including in the classroom. We understand this situation as another opportunity to expand SP practice for non-science teacher students.

From a student-teacher point of view, the study found that most students stated that SP met their need for better access to the practicum by utilizing the materials available around them. They also claimed to have intensive and prolonged communication with supervisors through virtual labs during the practicum. The following is an excerpt of one of the testimonies of students participating in SP.

> ***Kutipan #1; Ahli 1; halaman 23:***
> "…Jika praktikum SP dilakukan sendiri menurut saya sangat menarik dan menantang untuk siswa , karena siswa akan menemukan percobaan yang bisa dilakukan dengan alat dan bahan yang sederhana …"
>
> ***Translated into***:
> "…If the SP practicum is done individually, I think it is exciting and challenging for us as students because we will find experiments that can be done with simple tools and materials.…"

From the student's statement, it can be seen that SP should be simple and easy to implement by students because the instruments and materials can be reached from the surrounding environment. In general, students also stated that SP makes it easier for them to practice science even in the midst of the COVID-19 pandemic. In addition, they live in small areas far from the city, where face-to-face science practicum activities are usually carried out. With the existence of SP, students do not need to leave the house to do practicum. The reason they expressed comfort for the students participating in the SP is related to their condition as teachers actively teaching. Leaving to do practicum out of town means abandoning the task of teaching students in the school where they teach. In addition, some students say that the SP does not make it difficult for them to develop a report. They confirmed gradually filling out the practicum report and submitting it through the virtual lab application while conducting SP. In addition to reducing photocopying costs and spending money on administrative matters, they also feel the benefits of practicum because the data is well managed and directly reported through an application that immediately gets a response from the lecturer (supervisor).

b. Connection between Scalable Practicum and virtual Lab

Science is a subject that naturally requires laboratory activities. In an educational context, direct and experimental actions in the laboratory require guidance from supervisors in order for students to acquire comprehensive knowledge and science through inquiry and discovery learning (Copriady, 2014). Laboratory activities facilitate students to experience experimental activities to relate their conceptual understanding with their abstract thinking skills so that meaningful and long-term memories will be cultivated (Demi rci o ğ lu & YADiGARO LU , 2011; T ü ys ü z, 2010) .

Although virtual laboratories cannot replace conventional laboratories, the familiarity of student practicums can be represented in this digital era. Virtual labs are considered learning media that can provide hands-on experimental visualizations, interactive virtual environments, simulative-practical experiments (Tatli, Z., & Ayas, 2013; Zare Bidaki, 2018). Virtual labs allow students to work independently and collaboratively online regardless of school labs, chemicals, and equipment available (Herga et al., 2016; Widowati, Nurohman, & Setyowarno, 2017). As a result, meaningful learning requires real-world experience. Therefore, virtual laboratories as an educational strategy offer an environment conducive to teaching and learning that further gives students space to learn at their own pace (Commager, 1992; Kirikcilar & Yildiz, 2019; Ndukwe & Daniel, 2020; Rohim, 2020) .

The literature-based discussions above mostly discuss campus-based practicum activities. In this case, a virtual laboratory is interpreted as an alternative to physical laboratory activities. Most of the results of the analysis have represented the problems of this study, except for the context of distance education. This requires its own challenges, namely students face difficulties in access to work in physical laboratories and lack of opportunities and time to do the practicum itself due to time and geographical limitations.

This study is oriented towards the population of academic services for UT students who live spread across around 6000 islands in Indonesia, where some are isolated and remote. With this unique problem, this study prioritizes *scalable practicum*. In addition to providing alternative access to physical laboratories through digital and online technologies, the study promotes virtual labs for students to achieve standard academic competencies from practical courses. Therefore, as previously explained, scalable practicum or local-scale practicum is promoted as a practicum designed for students to perform the practicum independently using tools or instruments and materials that are in the surrounding environment. The virtual laboratory in this study serves as an interactive communication medium for *scalable practicum* programs carried out by students from various regions regardless of professional and geographical boundaries (Kusmawan & Handayani, 2021). The following discussion is related to the results of quantitative analysis of the virtual lab.

c. Virtual Lab: Validity and Reliability of UX Instruments

The validity of the survey instrument was tested using Pearson's product-moment statistics, and reliability was tested with Cronbach (Glen, 2022; Raharjo, 2021; Penelitian, 2018). Pearson's product-moment correlation validity test uses the principle of correlating the score of each item with the total score obtained from all respondents through SPSS v. 25 (Raharjo, 2021) . The results of data processing are presented in Tables 2 and 3.

Table 2 shows that 100% of the data (N = 201) is valid. The reliability results of the instrument using Cronbach showed a score of 0.948 (Table 3). This score indicates a high level of internal consistency for UX scale instruments with 201 respondents (Glen, 2022). In addition, based on the item-total correlation, the data show that all statistical scores are higher than the r-table (0.138, df = 199; Table 4); These data show a high degree of validity for each survey item used in the study. This indication is supported by a high score for the statistical data "Cronbach's Alpha if Items are Deleted ", which shows that overall, the survey results show a high coefficient of reliability.

Table 2. Case processing summary

Cases	N	%
Valid	201	100.0
Excluded[a]	0	0.0
Total	201	100.0

Table 3. Reliability Statistics

Cronbach's Alpha	N of Items
0.948	21

Table 4. Item-statistik total

No. of UX Statements	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Correlation values of Item Score with Total Score**	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted	r-Table* N=201 (df=199)
1.	309.5771	1473.185	.447**	0,414	0,752	0.139
2.	310.0846	1453.958	.667**	0,642	0,748	0.139
3.	310.1095	1432.848	.768**	0,747	0,743	0.139
4.	310.0846	1447.278	.706**	0,685	0,746	0.139
5.	309.3532	1460.270	.676**	0,667	0,749	0.139
6.	310.0100	1422.510	.742**	0,729	0,742	0.139
7.	309.6169	1434.528	.709**	0,691	0,744	0.139
8.	309.6468	1426.400	.854**	0,842	0,742	0.139
9.	309.2736	1445.440	.695**	0,675	0,746	0.139
10.	309.6667	1431.693	.870**	0,863	0,743	0.139
11.	309.6617	1431.415	.873**	0,866	0,743	0.139
12.	309.4328	1426.977	.738**	0,717	0,743	0.139
13.	309.4279	1454.546	.621**	0,594	0,748	0.139
14.	309.4677	1456.630	.676**	0,657	0,748	0.139
15.	309.7214	1437.762	.817**	0,806	0,744	0.139
16.	309.8507	1446.428	.781**	0,771	0,746	0.139
17.	309.7910	1450.706	.737**	0,728	0,747	0.139
18.	309.2139	1446.649	.682**	0,665	0,746	0.139
19.	309.4378	1437.057	.750**	0,732	0,744	0.139
20.	309.3184	1476.068	.423**	0.422	0,752	0.139
21.	309.3184	1476.068	.423**	0.422	0,752	0.139

Keterangan : * : Tingkat signifikansi 0,05%
* * : Diambil dari hasil Inter-Item Correlation Matrix
(Source: https://sl.ut.ac.id/Virlab-PublishData-2022)

d. Virtual Lab: Student view on the virtual lab application

Further investigation aims to obtain information from application users regarding the user-friendly level and usability of the virtual application lab (Virlab), which can be contacted at https://virlab.ut.ac.id/. In simplifying the analysis, the study recategorized the 10-point Likert scale of UX instruments into a 5-point scale ranging from "Very Bad" to "Excellent." Furthermore, this study paired respondents' answers into five categories after first calculating the interval range. The formula for calculating the interval range is 100:5 (interval), and the interval range obtained is 20 (Hidayat, 2021) .

Table 5 presents the respondents' UX category data intervals. Their total score of answers for each survey item is converted into a percentage by dividing the total score of each survey item by the respondent's maximum score of answers; So the total score of respondents is 201×5 = 1005. The results of the percentage calculation of each survey item are presented in Table 6.

Table 5. Student Respondent Data Intervals.

INTERVAL CATEGORIES	% INTERVALS	
	Bawah	Atas
Very Low	0	19,99%
Low	20,00%	39,99%
Acceptable	40,00%	59,99%
Baik	60,00%	79,99%
Baik once	80,00%	100%
(I = 20; N = 201; Skor Total = 1005)		

Based on Tables 5 and 6, it is seen that respondents agree that Virlab is "good" based on the aspects represented by items 3, 4, 5, 7, 11, 12, 16, 17, and 18 and is "excellent" based on other aspects of the Virlab quality survey . These results suggest that Virlab's application is poised for further improvement in the larger population to gain a more general view of its quality. A higher level of user appreciation for Virlab is essential because it involves user satisfaction when interacting with all the information on the app. The main purpose of any application is to be easy to use and efficient when users interact with it (Cooper, James M., 1971; Ed-Era., 2021; Islam et al., 2017) .

Table 6. Categories of student responses on the Virtual Lab Application

No. of UX Statements	Very Poor	Poor	Acceptable	Good	Excellent	TOTAL	% Total	Category
1.	3	4	66	508	235	816	81,19%	Very Good
2.	1	8	78	472	260	819	81,49%	Very Good
3.	1	10	135	556	55	757	75,32%	Good
4.	5	8	120	556	65	754	75,02%	Good
5.	3	8	100	523	154	787	78,26%	Good
6.	0	4	42	536	255	837	83,28%	Very Good
7.	6	14	84	556	105	765	76,12%	Good
8.	4	8	69	488	240	809	80.50%	Very Good
9.	2	10	45	528	235	820	81,59%	Very Good
10.	3	9	60	527	209	808	80,37%	Very Good
11.	1	10	60	616	105	792	78,81%	Good
12.	1	10	60	616	105	792	78,81%	Good
13.	4	8	42	544	215	813	80,90%	Very Good
14.	1	4	66	532	215	818	81,39%	Very Good
15.	2	4	27	628	155	816	81,19%	Very Good
16.	3	8	60	640	70	781	77,71%	Good
17.	1	10	66	640	65	782	77,81%	Good

No. of UX Statements	Very Poor	Poor	Acceptable	Good	Excellent	TOTAL	% Total	Category
18.	1	2	75	616	100	794	79,00%	Good
19.	1	6	45	432	370	854	84,98%	Very Good
20.	1	6	69	552	180	808	80,40%	Very Good
21.	1	6	33	528	270	838	83,38%	Very Good

5. Conclusion

As explained in this paper, science learning requires real activities in the environment, laboratory, or both. This fundamental principle is a problem in open and long-distance universities such as UT, where student domiciles are spread across various geographical areas in Indonesia. In addition, teachers who study at UT are active teachers teaching. Professionally, they are obliged to fulfill their professional obligations as teachers. Therefore, these teachers have very limited time to leave part of their teaching schedule with their students. In this case, massive student service delivery can be helped by virtual services, such as virtual labs, which allow individualized services to be provided equally and fairly to all students, both in urban areas and in remote and geographically isolated areas. All SP research participants agreed that science practicum activities facilitated by virtual labs greatly encourage the effectiveness and efficiency of teaching and learning programs.

In addition, this research has succeeded in building a virtual lab application that accommodates individual practicum management systems. This application is also designed to consistently maintain the nature of science practicum as a real-world activity. As for scalable practicum, a supervisor controls and validates the quality of the student calibration process of all practicum tools, instruments, and materials. Based on the results of statistical analysis, it is evident that the virtual lab application has an excellent level of friendliness and usability. For further improvement, the study recommends continued research with a wider range of respondents to receive a more thorough level of trust from potential users when using a virtual lab application.

6. Disclosure Statement

This is to acknowledge that this article is written based on research funded by Universitas Terbuka (UT) pursuant to a Research order No 15974/UN31.LPPM/PT.01.03/2020, signed by the Head of the UT Research Institute on April 20, 2020.

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