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A Virtual Lab As A Vehicle For Active Learning Through Distance Education

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Abstract

Through a distance education system, the teacher education program meets its challenges in the pedagogy of practical courses. Correspondingly, student-teachers face challenges in completing their practical courses due to professional and geographical constraints. The survey research results revealed the effectiveness of a virtual lab application in connecting the pedagogical approach to the student teacher's needs for practicum through implementing the Scalable Practicum. The results showed that the virtual lab promotes excellent facilitation for student-teachers conducting science Scalable Practicum in their limited circumstances. This study recommends further research on wider scopes and samples to receive more comprehensive pictures regarding the effectiveness of the virtual lab.

Keywords: *Virtual lab (Virlab); scalable practicum; distance education; online learning; 10-point Likert scale*

INTRODUCTION

Although the world is continually dealing with the impact of the COVID-19 pandemic, most educational activities have gradually adapted to a new normal with innovative pedagogy, which is more than just encompassing the available resources through engaging pedagogy and technology together (Morgado et al., 2021; Nuere & de Miguel, 2021). Nonetheless, various limitations are still imposed by the government of the Republic of Indonesia, and those of other countries (UNICEF-Indonesia, 2021), including the limitation in geographical constraints, technological infrastructure, people's access to appropriate communication technologies, etc. Meanwhile, the pandemic, which is gradually changing into an endemic in Indonesia (Supanji, 2021), has changed lots of the conventional education system into a distance learning and education system better known as online learning. The learning emphasizes delivery processes through various communication and information technologies. The design of the learning system integrates content and technology in effective and efficient manners and is delivered asynchronously, synchronously, or both (Akimov & Malin, 2020; Bhaumik & Priyadarshini, 2020; Bordoloi et al., 2021).

Due to the limited face-to-face meetings, a distance and online learning system 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 et al., 2019; Faour & Ayoubi, 2018; Viegas et al., 2018). Distance learning requires students to meet the challenges of geographical constraints, such as remote and isolated areas. In contrast, online

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learning challenges students to comprehend their information and communication technology literacies, including access to appropriate technological tools, in particular, laptop and smartphone. At the same time, in such limited conditions, due to the pandemic, students are required to be actively involved in online learning activities. They are challenged to skillfully use various 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 the online learning process (Clark & Post, 2021; López-Meneses et al., 2020; Tamim et al., 2021; Thompson, Corrin, & Lodge, 2021).

Constraints in online learning arise when a course must be delivered practically and conducted in a laboratory. Implementing these practical learning and laboratory-based activities often fail, especially in COVID-19 times, due to restricted access to laboratories and other facilities (Koşar, 2021). We strongly understand why such practicum activities must be conducted in a laboratory or natural environment. A practical course is designed to provide students with real-world learning experiences that encourage a natural and active learning process (Domínguez et al., 2018; Potkonjak et al., 2016; Tatli, 2012) to strengthen critical and creative thinking skills (Firmansyah & Suhandi, 2021; Miguel-Revilla et al., 2020; Papanikolaou et al., 2017). This indicates a challenge that critical and creative learning skills can promote active learning in students. This learning constitutes necessarily skills that students create knowledge and understanding simultaneously throughout their learning (Howard-Jones, 2021).

Based on preliminary research, we found that Universitas Terbuka (UT), as an open and distance education university, has reconstructed face-to-face learning services to online delivery modes for the “Praktikum IPA di SD” (translated: Elementary Science Practicum—ESP) during the COVID-19 pandemic through Microsoft Teams (UT Team 2020). However, several issues arose related to supervisory processes during the implementation. A supervisor had limited access to providing intensive or frequent directions (discussion) and issuing assessment results of the student's practical work. At the same time, the students also experienced problems performing the practicum independently and were uneasy writing (uploading) online reports through the platform. These constraints degraded the quality of course implementation. We assumed that the platform was not prepared for online practicum communication interactions.

The UT Elementary Education Study Program has equipped its students with “KIT Praktikum IPA” (translated: Basic Science Practicum KIT) to facilitate the science practicum (Faqih et al., 2015). A KIT is a set of tools, instruments, and materials prepared for students to address all topics of the science practicum based on UT Standard Guidelines. Several universities in Indonesia developed the Student Science Practicum KIT, as exampled in Figure 1, following their instructional design (Faqih et al., 2015; Listyalina et al., 2020). All materials required for the science practicum were included in the Science Practicum KIT. However, in the case of UT, the accessibility to the KIT for the students conducting practicum has been frequently limited. These limitations are often caused by the distance and time constraints between students and UT as KIT providers.

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Based on these preliminary research results, we strongly agree that innovation must be directed to facilitate students with open opportunities to conduct the science practicum independently and provide intensive communication and individual supervision from the lecturers (Kusmawan & Handayani, 2021). For this reason, we argue that a platform needs to be explicitly designed to facilitate and monitor students' independent practicum activities. In addition, it must also help lecturers efficiently work on monitoring and evaluation processes. We believe that a virtual lab application or Virlab application can be designed to meet such needs.

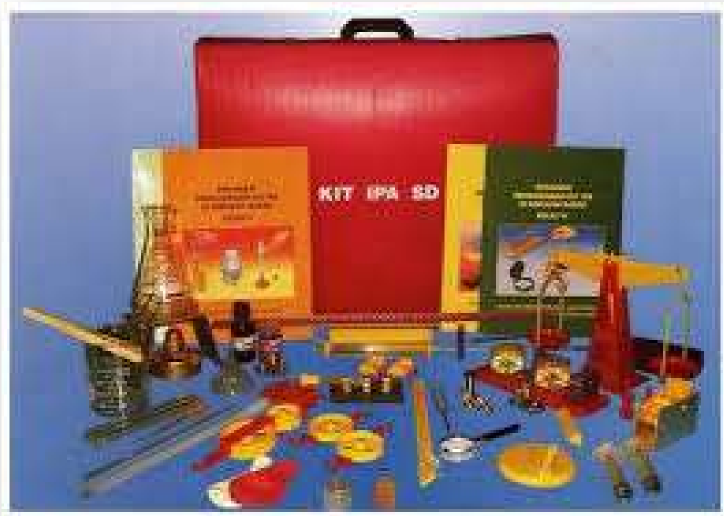

Figure 1. An example of Science is KIT (Listyalina et al., 2020).

As for the open and distance education system, their students' domiciles are spread across various locations in Indonesia. A new issue arose: equal access by all students to the KIT science practicum. Frequently, the practicum tools/instruments and materials have not been in good condition. Some instruments or materials may physically be damaged on the way to the student's location. The damaged condition may also be due to the frequent use by the students. As a result, for example, the students have limited access to 'pulleys' for the energy practicum in physics, feel unsafe working on 'flies' in the biology practicum, or do not have an 'Erlenmeyer flask' to measure the volume of practicum materials in the chemistry practicum. Thus, when students cannot access these instruments and materials, they cannot do the practicum. Alternatively, these students only receive lectures about the practicum from their lecturer but do not do the actual practicum individually. Above all, we argue that the virtual lab can become a platform that ensures intensive communication between lecturers acting as practicum supervisors and students according to the instructional principles and practical learning characteristics to facilitate virtual interactions, regardless of geographical and time constraints.

With the above explanation regarding the virtual lab, the researcher believes that in addition to direct, sustained, and intensive communication, this virtual lab can facilitate the performance of the student practicums independently. In this case, the students are permitted and even challenged to creatively and innovatively look for alternative tools or instruments and materials available in their local environment to conduct their practicums after completely and critically understanding the objectives set in the science practicum standards. Thus, the questions are as follows: What kind of practicum can provide students with creative, critical, and innovative challenges? How can these practicum activities be accommodated so that the students' creative, critical, and innovative skills

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can be well nurtured? This study aims to find out whether such a practicum conducted through virtual labs with scalable practicum methods can increase the potential for creative, critical, and hence innovative learning skills.

LITERATURE REVIEW

Scalable Practicum

Kusmawan & Handayani (2021) defines a scalable practicum (SP) or local-scale practicum as a practicum designed for students to independently perform practicum using tools or instruments, and materials existing in their surrounding environment. It provides students with the accessibility to independently apply the standard practicum prepared by UT. They can still conduct practicums without going to the laboratory under the direction of the supervisors in their local practicum areas. In the principle of procedural diversity, this circumstantial is conceived as decontextualized versus contextualized interventions of the science practicum (Cofré et al., 2019; García-Carmona & Acevedo-Díaz, 2018; Kruse et al., 2021). Students acquire real-world scientific skills through the SP practicum, such as creative, critical, and innovative skills (Commager, 1992; Owen, 2019). During preliminary research in 2021, based on testimonial statements from both the experts and students who actively participated in the study, we understand that the SP is appropriate for developing students' practical competencies with accessibility limitations to the standard practicum (Kusmawan & Handayani, 2021). This promotes active learning in essence that the students must learn the calibrations skills of the instruments and materials for their practicum under guidance from their supervisors to ensure their clear understanding of the standard practicum procedures (Davis et al., 2018; Kusmawan & Handayani, 2021; Listyarini et al., 2019). The SP allows student-teachers (science practitioners) to conduct practicum programs independently using the tools and materials obtained from the surrounding environment (Kusmawan & Handayani, 2021). Furthermore, Kusmawan highlights that this practicum must be under the expertise of supervisors to validate the calibration processes (Kusmawan & Handayani, 2021).

In several studies, SP programs have similar principles to the micro-scale practicum (MP) model. The MP experiments are conducted on a small scale using tools and materials with simplified sizes but with the same working procedures as those used in the laboratory experiments (Listyarini et al., 2019; Suchyadi & Karmila, 2019). The similarity between SP and MP practicums lies in their aim to encourage students to practice and train themselves to become more alert to the real problems involved and build solutions from the natural, social, and cultural environment around them. The two practicums have a similar implementation principle: preparing students by skillfully converting standard scale references into a new scale for the newly validated practicum procedures.

In another learning strategy, Larsen has revised and expanded Gregory Bateson's learning theory to demonstrate how scaffolding content and context occurred in computer games. Larsen suggested that the presented revision rest on a micro-level analysis of how learning occurs in the computer game, demonstrating how scaffolding content and incremental construction of contexts work in and outside the computer games' realm (Larsen, 2020). These two learning contexts of learning strategy lead us to understand that the students are encouraged to think creatively, critically, and innovatively. The students are invited to creatively find alternative tools and materials, critically develop new scales, and innovatively develop new practicum procedures under

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the supervision of lecturers. Meanwhile, the essential difference between the two lies in the notion of micro and scalable. The 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 taken or what reality can be trusted (Commager, 1992; Firmansyah & Suhandi, 2021; Ocak & Eğmir, 2016). Owen (2019) & Thompson et al. (2021) provide clues about the character of critical thinkers, including (1) understanding the relationship between logic and ideas; (2) identifying, constructing, and evaluating arguments; (3) solving problems systematically; (4) identifying the relevance and importance of ideas; and (5) sympathizing with the meaning and justification of values in a person. The accumulation of these characters can foster creative and innovative personalities. Suchyadi & Karmila (2019) state that creative thinkers are proficient in broad—and even out-of-the-ordinary—thinking. Individuals who have these thoughts possess 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 spirit is closely related to an innovative personality. They are enthusiastic about producing works/products that have never existed before or creating something completely new and inimitable.

The Virtual Lab

Several experts generally define virtual labs as online practicum simulation activities (Alexiou et al., 2004; Dalgarno et al., 2009; Domínguez et al., 2018; Dyrberg et al., 2016; Kfir, 2005; Kusmawan, 2017; Ligoxygakis, 2001; Potkonjak et al., 2016). More specifically, Purnamasari et al. (2021) explain that computers could be used to modify practicums and display complete practicums in virtual form, especially for abstract science concepts. It is in line with Nurhayati and Suryani (2021), who explained that conducting practical activities can not only be done in the laboratory but also in a virtual laboratory—a series of tools, materials, and laboratories in the form of computer software by a computer that can simulate activities in the laboratory as if the user were in a natural laboratory (Kusumaningsih, Y.R, Iswahyudi, C., & Susanti, 2014; Wijayanto et al., 2018).

However, in this study, the meaning of virtual lab is not limited to the concept of a simulative representation of scientific activities through computer application programs but also to direct, sustained, and interactive communication activities between lecturers and students conducted online. Thus, the virtual lab concept in this study is defined as practicum activities that are managed online—either through simulation application activities or actual, independent practice by students in the field, who are guided directly through intensive communication in an application. As previously described, the second part of the virtual lab concept embodies the SP principle. As a result, this study characterizes the virtual lab in three functions. The first function is to provide access to simulation-based laboratories in various disciplines of the science practicum. The second function is to stimulate students to conduct experiments by arousing their curiosity to 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 the virtual labs where the students and lecturers can avail themselves of the various tools for learning, including additional web resources, video lectures, animated demonstrations, and self-evaluation

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(Kusmawan & Handayani, 2021). Given the third function, Guillén-Gámez et al. have concluded their research that the level of digital competence and the motivation to use ICT were two variables that correlate positively and together will improve future learning skills (Guillén-Gámez et al., 2020).

Having the technological pedagogical content knowledge (TPACK) learning method introduced by Shulman in 1986 in Koehler (2012), a virtual lab functioning as an SP can reinforce the development of technology-based student learning. An SP helps apply TPACK principles in synergizing technology-based student learning activities with the learning content, which functions as a vehicle to improve critical, creative, and innovative thinking skills. A lecturer devises learning approaches to integrate technologies into content and pedagogy. The content is not the target for learning outcomes; instead, it triggers constructive interactions between students' learning process and their thinking process development through appropriate technology. Furthermore, various technologies devise learning innovations to strengthen the efforts to achieve the students' learning objectives.

Even though the current conditions have improved the integration of technologies into learning due to the COVID-19 pandemic, practicum implementation is still experiencing some access barriers. UT manages an average of more than 300,000 students per semester from all provinces of Indonesia, including remote and isolated areas (Universitas Terbuka, 2022). Some other similar online universities are also serving a large number of students. With many students, including to student teachers, the universities have implemented some strategies for practicums, including in-class face-to-face, laboratory, and remote practiciums (Mesci et al., 2020; Wan et al., 2013). Regarding the strategies, the experts explained that scientific experiments in certain subjects were conducted by students independently in virtual labs (Qiang, Zhe Qiang, Alejandro Guillen Obando, Yuwei Chen, 2020) in a remote laboratory in collaboration with partners (Nesenbergs et al., 2021), and even in their homes with tutors' guidance (Davis et al., 2018). Distance education institutions commonly provide students with printed and/or non-printed modules as teaching materials (Martin et al., 2020). In addition, UT provides students with a science practicum at KIT (UT Mobile Lab) for scientific experiments. As a result, a virtual lab is an essential application when the practicum allows students to conduct scientific experimentation independently. Integrating various technologies into learning through the application can allow students and lecturers to interact actively and sustainably to build a proper and comprehensive understanding of the practicum.

RESEARCH METHOD

The research and development (R&D) study focused on virtual lab development was addressed under the research umbrella, entitled "Penerapan model scalable practicum via virtual lab dalam meningkatkan kualitas bimbingan mahasiswa pada praktikum IPA SD" (translated: The implementation of virtual lab-based scalable practicum to improve the quality of student engagement in science practicums (Kusmawan & Handayani, 2021). Universitas Terbuka funded the research in compliance with the statement of Research Order No. 15974/UN31.LPPM/PT.01.03/2020, signed by the Head of Research UT Institute on April 20, 2020. The design of the R&D research, which refers to (Gall et al., 2007), is shown in Figure 2. The research, which began in 2021, focused on developing a virtual lab-based scalable practicum model based on students' local wisdom called "scalable practicum (SP)," where the virtual lab application

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functions as a vehicle for student-teachers implementing the SP. The research population included students actively studying at the Elementary School Teacher Education Study Program (read: PGSD) of Universitas Terbuka, Indonesia.

In a preliminary study in 2021, the quality of the SP itself model was assessed qualitatively using interviews with experts and student research participants. We invited the students participating in the SP to convey their testimonials about the SP model. Apart from the literature reviews, the concept of the SP was discussed in depth in the focus group discussion (FGD) activities with lecturers (expert research participants) whose expertise was in elementary science practicums and the student-teachers (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 to the Understanding of Scalable Practicum and available at https://sl.ut.ac.id/ScalablePracticum2021.

Meanwhile, the virtual lab application (Virlab) was assessed quantitatively using a survey instrument to obtain information regarding the ease of use and usability of the application (UX Survey). The survey was administered to students participating in the SP practicum and others who passed the science practicum course. The instrument was developed using a 10-point Likert scale. The study developed a 21-item Likert scale survey, as shown in Table 1. In addition to the reliability and validity of the instrument, we conducted statistical processing using the scale measurement

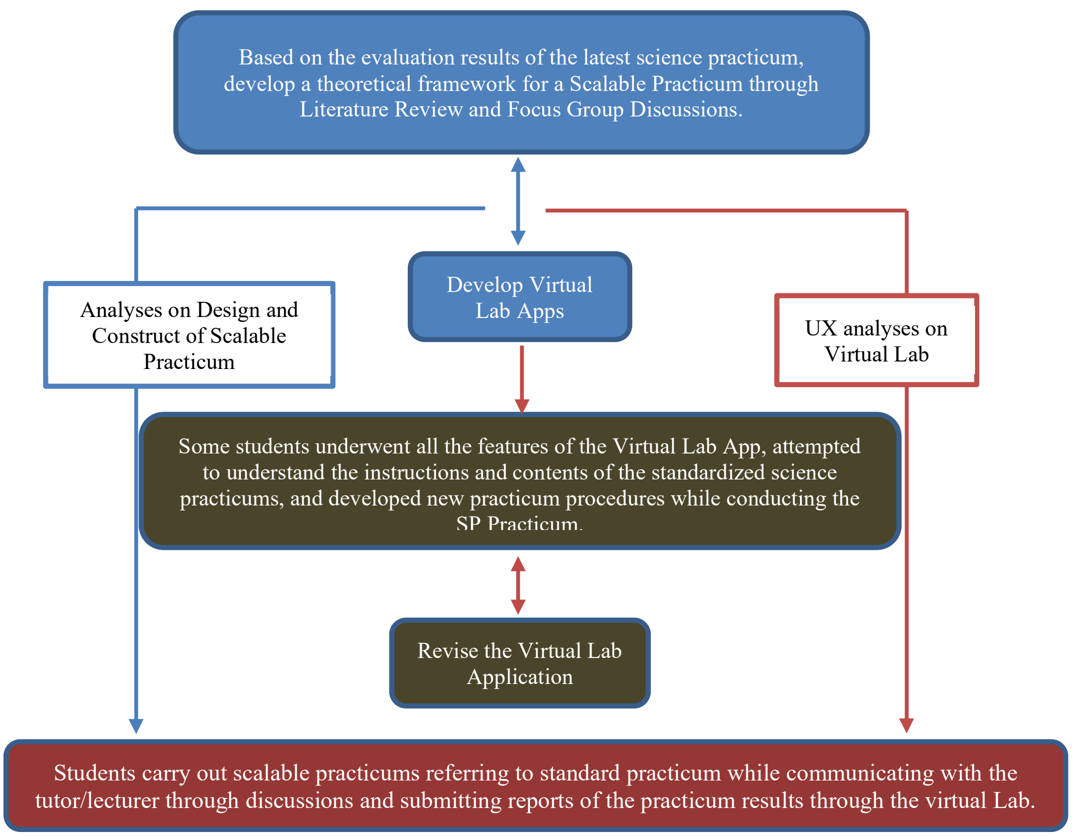

Figure 2. R&D Design for implementing Scalable Practicum through Virtual Lab

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testing of the SPSS to obtain information related to the categories of the respondents' answers about web-based virtual lab quality. A total of 201 UT students registered in the elementary teacher education study program participated in the UX survey.

Table 1. Instrumen survey UX Virtual Lab

Scale No.	UX-` Scale Theme
1	Front-site looks of the Website
2	Ease of understanding the content of the information available on the Website
3	Level of creativity of the Website
4	Information of content is easy to predict
5	The novelty of the information on the Website
6	Practically of illustrations and information on the Website
7	Level of complexity of searching for information on a website
8	The website is fun
9	The inventiveness of the technological concept on the website?
10	The website contains essential information to be known
11	Level of security interacting on the Website
12	The website brings up your motivation in improving digital and online skills.
13	The website meets your expectations
14	The website works efficiently in delivering information.
15	Clarity of commands, appearance, and menus
16	Comfort level during searching information on the Website
17	The website increases motivation to do your practicum
18	Responsiveness the Website
19	Information structured on the Website
20	The website shares the usefulness of the information
21	You will recommend this Virtual lab website to other students.

FINDINGS AND DISCUSSION

Explanation of the research results begins with elaborating on the results of scalable practicum (SP) implementation testing through testimonial data from student-teachers involved as practical students (student research participants). The testimonial results should give insights into the understanding of the virtual lab to improve the quality of student practicum.

Qualitative Approach

Scalable Practicum

In the digital book at https://sl.ut.ac.id/ScalablePracticum2021, all testimonies were expressed by the expert and student participants. During the focus group discussions at the preliminary study stage, the experts affirmed that the concept of the SP should improve the existing weaknesses of the elementary science course's practicum. They agreed that the level of undergraduate learning outcomes for science education should be devoted to equipping students with learning competencies that encourage critical, creative, and innovative thinking skills.

In the video testimonial recording presented in the digital book on page 21, one of the experts restated his exceptional understanding of the "scalable practicum," including the strengths and weaknesses of the concept in its effort to improve the quality of science learning through distance

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and online systems. His positive view of the SP has allowed him a clear and even practical understanding of the SP. The following are testimonial statements regarding the concept and implementation of SP.

Quote #1; Experts 1; Page 21: Scalable Practicum Concepts:

"… 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 scalable praktikum, mahasiswa mempelajari 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 penuntun scalable praktikum tersebut…

Praktikum scalable juga sangat sesuai untuk siswa yang mempelajari program pendidikan non-sains. Dengan kegaitan praktikum SP, sampai batas tertentu, mereka dilatih untuk secara kreatif dan kritis memahami 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 statements above, it appears that the experts can directly understand the concept of scalable practicum after they were directly involved as practicum supervisors in the SP practicum activities. It is because they immediately saw how the students underwent it. The experts emphasized that if clear standard procedures can be accessed anytime by the students and intensive guidance from practicum supervisors is available anytime, they will eventually be capable of building their creativity and criticality through their local-based practicum. These statements correspond with Michael Scriven in Commager (1992: 159), suggesting 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) the habit, based on intellectual commitment, to use these skills to guide behavior. We understand this situation as an excellent opportunity to further

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implement scalable practicum concepts to improve student access to practicum without geographical and professional constraints.

Having completed guiding student practicums, the experts found that the SP was also suitable for other educational practical activities, including teaching practice and other social-content practical courses. This statement corresponds to Alice Laquinta in Commager (1992: 116), suggesting that when students exhibit the 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 the classroom. We understand this situation as another opportunity to expand the SP practicum for non-science teacher students.

From the student-teachers points of view, this study found that most of the students stated that the SP met their need for better access to practicums by utilizing materials available in their surroundings. They also admitted that they received intensive and prolonged communication with the supervisor through the virtual lab during their practicum. Below is the quotation from one of the student SP-participant testimonies.

Quote #1; Experts 1; Page 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.…"

It is apparent from the student statements that the SP should be simple and easy to implement by the student as instruments and materials are reachable from their local environment. In general, likewise, the students stated that the SP made it easier for them to practice science despite the COVID-19 pandemic. Besides, they live in a small area far from the city, where face-to-face science practicum activities are usually managed. With the SP, the students do not need to leave their residences to do a practicum. The reason for stating their convenience for the students participating in the SP is related to their conditions as active teaching teachers. Leaving to perform their practicum out of town means leaving their duty to teach students at the school where they were teaching. In addition, some students said that the SP did not make it difficult for them to develop reports. They emphasized that they gradually filled out the practicum report and submitted it through the virtual lab application while conducting the SP. In addition to reducing the cost of photocopying and spending money on administrative matters, they also felt that they had benefited from the practicum because the data were well managed and directly reported via the application, which immediately received responses from the lecturer (supervisor).

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Connections between Scalable Practicum and Virtual lab

Science is a subject that naturally requires laboratory activities. In an educational context, hands-on 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). The laboratory activities facilitate the students to experience experimental activities to link their conceptual understanding with their abstractive thinking skills so that meaningful and long-term memory will be cultivated (Demircioğlu & YADiGAROĞLU, 2011; Tüysüz, 2010).

Even though a virtual lab cannot replace a conventional laboratory, students' interactiveness with practicums can be represented in this digital era. The virtual lab is considered a learning medium that can provide direct experimental visualization, an interactive virtual environment, and simulative-practical experimentation (Tatli, Z., & Ayas, 2013; Zare Bidaki, 2018). A virtual lab allows the students to work independently and collaboratively online regardless of the school laboratories, chemicals, and equipment available (Herga et al., 2016; Widowati et al., 2017). As a result, Meaningful learning requires real-world experiences. Therefore, a virtual lab as an educational strategy offers a conducive environment for teaching and learning which further gives room for students to learn at their own pace (Commager, 1992; Kirikcilar & Yildiz, 2019; Ndukwe & Daniel, 2020; Rohim, 2020).

The literature-based discussions above mostly deal with campus-based practicum activities. In this case, a virtual lab is defined as an alternative to physical laboratory activities. Most of the analysis results have represented the issues of this study, except for the context of distance education. It requires a unique challenge in that the students face difficulty in access to working in the physical laboratory and lack of opportunity and time to work on the practicum itself due to time and geographical constraints.

This study is oriented toward the population of academic services for UT students domiciled spread out in about 6000 islands in Indonesia, where some are isolated and remote. With such unique issues, then this study promotes the scalable practicum. In addition to providing alternative access to a physical laboratory through digital and online technologies, this study promotes a virtual lab for students to reach standardized academic competencies of the practical courses. As a result, as explained earlier, the scalable practicum or local-scale practicum is promoted as a practicum designed for students to independently perform practicum using tools or instruments and materials existing in their surrounding environment. The virtual lab in this study functions as an interactive communication medium for scalable practicum programs carried out by students from various regions, regardless of professional and geographical constraints (Kusmawan & Handayani, 2021). The following discussion deals with the quantitative analysis results regarding the virtual lab.

Quantitative Approach

Virtual Lab: Validity and Reliability of the UX Instrument

The validity of the survey instrument was tested using Pearson's product-moment statistics, and reliability was tested using Cronbach's α (Glen, 2022; Raharjo, 2021; Research, 2018). The Pearson product-moment correlation validity test uses the principle of correlating each item score

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with the total score obtained from all the respondents through SPSS v. 25 (Raharjo, 2021). The data processing results are presented in Tables 2 and 3.

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

Table 2. Case processing summary

Cases	N	%
Valid	201	100.0
Excluded	0	0.0
Total	201	100.0

Table 3. Reliability Statistics

Cronbach's Alpha	N of Items
0.948	21

Table 4. Items-total statistics

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-Tabel* 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

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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-Tabel* N=201 (df=199)
20.	309.3184	1476.068	.423**	0.422	0.752	0.139
21.	309.3184	1476.068	.423**	0.422	0.752	0.139

Note: *: Significance level of 0.05%
**: Taken from Inter-Item Correlation Matrix results
(Source: https://sl.ut.ac.id/Virlab-PublishData-2022)

Virtual Lab: Students' view on the virtual lab application

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

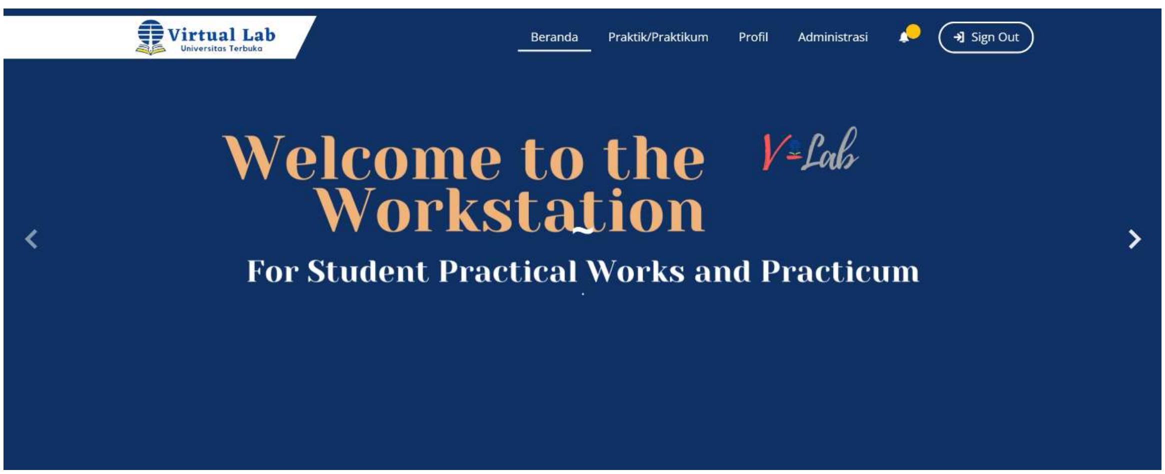

Figure 3. Front-side of the Virlab Application

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

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Table 5. Data Interval on student respondents.

Interval Category	**% Interval Limits**	
	Bottom	**Top**
Very Poor	0	19.99%
Poor	20.00%	39.99%
Acceptable	40.00%	59.99%
Good	60.00%	79.99%
Excellent	80.00%	100%
(I = 20; N = 201; Skor Total = 1005)		

Based on tables 5 and 6, it is apparent that the respondents agreed that the Virlab was "good" based on the aspects represented by items 3, 4, 5, 7, 11, 12, 16, 17, and 18 and "excellent" based on the rest of the survey aspects of the Virlab's quality. These results indicate that the Virlab application is ready for further improvement in the larger population to gain more general views regarding its quality. A higher level of user appreciation for Virlab is essential because it involves user satisfaction while interacting with all the information on the application. The main goal 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. Category of students' response on the Virtual Lab Apps

No. of UX Statements	**Very Poor**	**Poor**	**Acceptable**	**Good**	**Excellent**	**Total**	**% Total**	**Category**
1.	3	4	66	508	235	816	81.19%	Excellent
2.	1	8	78	472	260	819	81.49%	Excellent
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%	Excellent
7.	6	14	84	556	105	765	76.12%	Good
8.	4	8	69	488	240	809	80.50%	Excellent
9.	2	10	45	528	235	820	81.59%	Excellent
10.	3	9	60	527	209	808	80.37%	Excellent
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%	Excellent
14.	1	4	66	532	215	818	81.39%	Excellent
15.	2	4	27	628	155	816	81.19%	Excellent
16.	3	8	60	640	70	781	77.71%	Good
17.	1	10	66	640	65	782	77.81%	Good

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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%	Excellent
20.	1	6	69	552	180	808	80.40%	Excellent
21.	1	6	33	528	270	838	83.38%	Excellent

CONCLUSION

Firstly, as described in this paper, science learning requires actual activities in the environment, laboratory, or both. This fundamental principle becomes an issue in open and distance universities such as UT, where student domiciles are distributed in various geographical areas in Indonesia. In addition, the teachers studying at UT were active teaching teachers. Professionally, they are obliged to fulfill their professional obligations as a teacher. Therefore, these student-teachers have very limited time to leave some of their teaching schedules with their students. In this case, providing massive student services can be assisted by virtual services, such as the virtual lab, which allows individual 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 agree that science practicum activities facilitated by the virtual lab significantly encourage the effectiveness and efficiency of learning and teaching programs.

Secondly, the research has successfully built a virtual lab application that accommodates an individual practicum's management system. This application is also designed to consistently maintain the nature of the science practicum as a real-world activity. As for the scalable practicum, a supervisor controls and validates the quality of the student calibration processes of all practicum tools, instruments, and materials. Based on the statistical analysis results, it is evident that the virtual lab application has an excellent level of user-friendliness and usability.

LIMITATION & FURTHER RESEARCH

For further improvement, this study recommends further research with a broader range of respondents to get a more thorough level of trust from potential users when using virtual lab applications.

In addition to a broader range of respondents, further research should be carried out involving several study programs at the Universitas Terbuka so that variations in issues caused by differences in course characteristics can be identified. These findings will be so beneficial that improvement in the existing Virlab application can be applied clearly.

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