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An Offline Practicum Workshop As an Aid For Students' Chemistry Laboratory Practical Skills: A Case Study

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Abstract

The COVID-19 pandemic has disrupted various sectors, including education. Since it was announced for the first time in mid-March 2020 in Indonesia, teaching and learning activities have been carried out online, synchronously or asynchronously. Suppose ordinary lecture activities still allow material delivery by changing forms and media. In that case, practicum activities in the chemistry laboratory are impossible to carry out and replaced with various forms of virtual learning. This study evaluates the perceptions of student's practical skills in various basic skills after returning to offline activities and implementing practicum workshop activities as a corrective effort to improve students' skills. Based on the results obtained, students have a low perception of skills in the range of 2.56 ± 1.02 to 3.42 ± 1.16 on a scale of 6.00. It can be seen that the effectiveness of virtual practicum is low in terms of skills, and there is a need for corrective action so that students can catch up on the basic skills of practice in the chemistry laboratory. After the workshop activities, there was a significant increase ($p < 0.05$) in students' perceptions of skills, with a range of 4.87 ± 0.66 to 5.26 ± 0.73 on a scale of 6.00. Based on the results of this study, it is suggested that other study programs map and evaluate students' practical skills after the COVID-19 pandemic and take corrective measures to ensure the attainment of practical skills learning outcomes.

1. INTRODUCTION

The 2019 Coronavirus disease (COVID-19) outbreak has brought so many changes in every aspect of life. The most impact came from the social distancing and activity limitation, which became a temporary solution to minimize the spread of the disease and the number of deaths. Since the first COVID-19 case in Indonesia was announced in March 2020, all activities have been switched to online mode, including learning from home (Djalante et al., 2020). All schools and universities worldwide switched to online learning as the only possible option. Various teaching-learning activities were employed that combined synchronous and asynchronous modes (Persada et al., 2022) with several methods such as flipped classroom (Campillo-Ferrer & Miralles-Martínez, 2021), problem-based learning (Kristianto & Gandajaya, 2023), project-based learning (Miller, Reigh, Berland, & Krajcik, 2021), etc. However, the sudden change in the learning mode could bring challenges and learning loss to the students due to various technical and non-technical problems (Hidayat, Anisti, Purwadhi, & Wibawa, 2020). Several recent research papers have reported the negative impacts of school and university lockdowns on students' achievement and ability (Betthäuser, Bach-Mortensen, & Engzell, 2023; König & Frey, 2022).

In addition to lecture activities in class, there are also learning methods in the form of practical activities in the laboratory, especially in engineering and science programs. Laboratory work has several purposes, namely establishing the connection between the knowledge learned in the class and the practical setting and developing students' practical, scientific, and general skills (Reid & Shah, 2007). To fulfill these purposes, lecturers worldwide try various learning activities to substitute regular practicum. In a recent review paper by Subekti et al. (2022), they reported three classifications of the online practicum approaches: video, web, and remote-based laboratory. A positive result is reported by Wang and Ren (2020) when they use a video-based laboratory. It was found that the video-based laboratory helps the students understand how the experiment is conducted in the general chemistry laboratory. Using the online platform and learning management system to accommodate practicum learning has also provided a solution for practicum learning during the pandemic (Mahaffey, 2020a, 2020b). In addition to the previously mentioned approaches, some lecturers use home kits and appliances to make students experiment with home (Andrews et al., 2020; Kelley, 2021). These approaches also give many learning opportunities with hands-on experience. However, there is also a concern that the online – virtual laboratory cannot replace the real laboratory experience (Harefa, Silalahi, Purba, & Sianipar, 2021). Thus, a possibility of learning loss occurs.

In the curriculum design of the Bachelor of Chemical Engineering program, Department of Chemical Engineering, Parahyangan Catholic University, three practicum courses cover introductory chemistry laboratory courses, namely Basic Science Practicum Introduction to Chemical Engineering Practicum I and II. These practicums cover essential fundamental techniques and relate to several courses, namely, general, organic, physical, and analytical chemistry. Students with intake year 2020 have been unable to do lab work since the first semester due to the pandemic. The first offline activity was possible in the Spring semester of 2022 when the regulation and policy for offline activities were relaxed after the COVID-19 vaccination. During the online learning, video-based learning accompanied by a set of data was used to replace regular practicum activity. Thus, the purposes of this study are:

1. To evaluate students' perception regarding their practical skills after online practicum courses
2. To compare students' perceptions of practical skills before and after the practicum workshop.

2. METHOD

This study used a quantitative descriptive weak experiment approach that observed the changes in parameters before and after the workshop (pre-test and post-test). The subject of the study is all the students who participated in the workshop, with a total of 19 students. The workshop was done at the Basic Chemistry Laboratory, Department of Chemical Engineering, Parahyangan Catholic University, from 18th to 22nd July 2022.

Before and after the practicum workshop, the students completed a questionnaire to measure their perception of accomplishment of various basic chemistry laboratory skills using a Likert scale from 1 (strongly disagree) to 6 (strongly agree). The summary of the skills is presented in Table 1. The data obtained was analyzed using the Wilcoxon test with the aid of SPSS software (ver. 20.0). A confidence level of 95% was used for the test. The hypotheses used for the comparative test are:

H_0: There is no significant difference between students' practical skills (M1 till M6) before and after the practicum workshop
H_1: There is significant difference between students’ practical skills (M1 till M6) before and after practicum workshop

Table 1. Summary of the skills measured before and after the workshop

Code	Skills accomplishment
M1	Basic laboratory skills related to the use of analytical balance and glassware to make a solution
M2	Volumetric analysis (acid-base, complexometric titration)
M3	Gravimetric analysis
M4	Skillsets related to separation and purification of samples: filtration, vacuum filtration, centrifugation, crystallization, distillation, and Soxhlet extraction
M5	Qualitative analysis of various functional groups (primary, secondary, and tertiary alcohol, ketone, aldehyde) and macromolecules (carbohydrate, fat, and protein)
M6	The use of various analysis instruments: spectrophotometer visible, surface tension analysis, refractometer, moisture analyzer, Karl Fischer titrator, thin layer chromatography, high-pressure liquid chromatography, and Fourier transform infrared spectroscopy

3. RESULTS AND DISCUSSION

Results

The result of student perception of their practical skill before and after the workshop is presented in Table 2. It can be observed that the student's perception of their practical skills was relatively low before the workshop, which is after the online learning, with values ranging from 2.56±1.02 to 3.42±1.16. After the workshop, the value increased from 4.87±0.66 to 5.26±0.73. The result of the Wilcoxon test is presented in Table 3. It can be gathered that there is a significant difference for all skills (M1 to M6) with a p-value < 0.005.

Table 2. Students' perception before and after the workshop

Skill	Pre-test		Post-test	
	Mean	Std. Deviation	Mean	Std. Deviation
M1	3.42	1.16	5.26	0.73
M2	3.37	1.21	5.16	0.50
M3	2.89	1.15	4.89	0.57
M4	2.74	1.07	4.87	0.66
M5	3.28	1.29	5.18	0.70
M6	2.56	1.02	5.03	0.54

Table 3. Result of the Wilcoxon test

	M1	M2	M3	M4	M5	M6	M7
Z	-3.590	-3.550	-3.654	-3.833	-3.634	-3.824	-3.837
Asymp. Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.000

Discussion

Based on the results presented in Table 2, most of the students' perception regarding their practical ability is relatively low, especially for skills related to gravimetric analysis (M3), separation techniques (M4), and instrumental analysis (M6). On the other hand, the skills related to basic laboratory skills of weighting and using glassware, volumetric titration, and qualitative analysis gave higher results, although still far from the highest mark. We hypothesize that these higher values came from students' previous experience in the laboratory during high school. Many high schools in Indonesia are expected to introduce chemistry practicum to the curriculum (Nuswowati, Sumarni, & Taufiq, 2020; Rahman et al., 2020). However, the results show that the online virtual practicum did not satisfy the student's skills.

This result is validated by the students' comments from the end-of-year feedback as follows:

> "The (online) practicum course is already excellent, and the video illustration of the methods is obvious. However, because the COVID-19 pandemic is hitting Indonesia, it is miserable that we cannot do the practicum offline."

> "I am not blaming/criticizing anyone here, just deploring the situation. Due to the COVID-19 pandemic, we cannot do practical work in the laboratory, one of the most essential parts of the Chemical Engineering program.

Similar results have also been reported in the literature. Jones, Evans, and Shepler (2023) reported a negative effect of online virtual laboratories, especially on the students' effectiveness. The students are reported to be more intimidated, frustrated, and overwhelmed in the lab after returning to regular offline activity. Lee, Kang, Kim, Hong, and Martin (2023a) shared the instructors' perceptions of student learning outcomes from the remote laboratory, with more negative results for students' skills related to data processing, lab reports, and hands-on experience. In another study, Lee, Kang, Kim, Hong, and Martin (2023b) reported students' dissatisfaction with the minimum hands-on experience.

Based on the results, it can be seen that the urgency of a practicum workshop is an aid to the lack of compliance with basic chemistry laboratory skills. After the workshop, the student's perception has increased significantly (Table 3). The significance of the perception proves the importance of hands-on experience in the student perspective for their fulfillment in practical competency. The presence of laboratory assistants who give tutoring during the workshop (1 assistant per 3 or 4 students) can significantly help the students if there is confusion during the activity. There are some positive comments from the questionnaire, such as:

> "The workshop is very accommodating for introducing the use and operation of instruments and techniques in the laboratory."

> "(I suggest) longer workshop time (is needed) so we can use all the instruments until the result is obtained."

The comments show student appreciation of the workshop, even requesting for longer workshop time. A previous study by Grugnetti, Bagnasco, Rosa, and Sasso (2014) reported a significant improvement in students' skills and the development of students' technical and psychomotor abilities after a workshop.

Based on the results of this study, we encourage other study programs to map and evaluate their students' practical skills after online learning during the COVID-19 pandemic and take corrective measures if needed. It is very critical to do so to ensure the attainment of student learning outcomes. Especially in science and engineering-related programs, students' exemplary practical research performance is one of the students' learning outcomes.

Study limitation

The limitation of this study lies in the fact that the participants came from one department with a small sample population, which might hinder the universal interpretation of this study. Further studies in other programs and a more significant population might be needed to validate the findings regarding the effectiveness of virtual laboratories on students' practical skills.

4. CONCLUSION

In this study, we have measured the students' perception regarding their chemical laboratory practical skills after online learning during the COVID-19 pandemic. It can be seen that the virtual laboratory sessions during the online learning are not enough to ensure students' completion in their practical skills, as indicated in the perception that ranging from 2.56±1.02 to 3.42±1.16 (on a scale of 6.00). An offline practicum workshop session is needed to rectify this problem. After the workshop session, it can be seen that the student's perception of practical skills significantly increased, with values ranging from 4.87±0.66 to 5.26±0.73 (on a scale of 6.00). Based on these results, we suggest that other science and engineering programs map and evaluate the practical skills of their students and take corrective measures to ensure the attainment of the student's learning outcomes.

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