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TeamViewer Technology's Effectiveness as an Alternative Tool to Facilitate Online Laboratory Practices for Chemical Engineering Courses Learned during Pandemic

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Abstract
As the accreditation guidelines of various accreditation bodies emphasize, acquiring psychomotor skills is a very important part of learning outcomes in a chemical engineering degree. Thus, it is crucial to ensure the effective achievement of these skills, even with limited physical delivery during this pandemic period. This challenge can be overcome by adopting virtual lab experiments and simulations, which enable the students to understand the concepts, important relationships between the variables, and the potential impact of manipulating the variables on the process operation. However, many simulation software programs cannot be purchased by students individually as the license is quite expensive. Hence, using TeamViewer software as a remote learning tool has significantly benefited students accessing license simulation software in the university from wherever they are with an internet connection, a valid ID, and a password. This paper highlighted the effectiveness of employing TeamViewer as a remote learning tool to facilitate online laboratory practices in two chemical engineering courses of CHE263 (Material and Energy Balance) and CHE249 (Separation Processes). The experimentation and data analysis showed that the proposal significantly increased students' psychomotor skills while enhancing their understanding. The learning that was attained in the face-to-face classroom format and the learning that was attained using the suggested remote laboratory were found to have similar outcomes. This study will benefit other educators who need an alternative tool to do an online laboratory that uses system software and needs remote access.
Keywords: Remote Learning, TeamViewer, Simulation, Laboratory Practices, Psychomotor

Introduction

Background of Study

When the COVID-19 pandemic struck, university programmes transformed their teaching and learning delivery methods into open-distance or online-based approaches. For example, in engineering, science, technology, medicine, and hospitality, to name a few, the psychomotor element is an important part of the requirements set by the accreditation body apart from cognitive and affective skills. Psychomotor is a practical skill that can be assessed by observing the technique of experimental execution. In engineering, students' psychomotor skills are normally developed in a laboratory setting. However, since students are not allowed to be in the lab during the pandemic, the Higher Institutions need to think of other ways to assess them to ensure they can still do all the important things that a 21st-century graduate should be able to do.

The Engineering Technology Accreditation Council (ETAC) established guiding principles in June 2021, and courses can use three psychomotor assessment methodologies with considerable laboratory work. Laboratory experiments based on simulations are one of the ways. This is appropriate for courses that allow for software simulation. The higher education institution typically has licenced software that is only accessible within the higher education institution's network. Therefore, it is necessary to adopt a proper remote learning tool so that students can still use the licenced software even when they are at their own premises and the programme won't merely sit idle within the higher institution network (Board of Engineers Malaysia, 2021).

A software named TeamViewer is used to manage a personal computer remotely. It can also be used for desktop sharing, online conferences, and file transfers across PCs. The software is compatible with a variety of operating systems, including Windows, Mac OS, Linux, iOS, Android, and Windows Phone. The primary purpose of Team Viewer, which operates as a browser, is the remote control. Remote technical assistance is also possible using Team Viewer. By using this software, students can ask a friend or a lecturer for help, resolving problems without having to visit each person in person (Drugarin et al., 2016). The instructor can also evaluate the experiment online without being present in the lab. The efficiency of TeamViewer software in an online evaluation for experiment assignments in Chemical Engineering courses at UiTM Pasir Gudang is highlighted in this research. Since students cannot access experiment equipment on campus, this approach will address the question of how experiment assessment will be assessed

Statement of Problem

The subject of engineering studies requires all students to complete laboratory experiments, which takes several credit hours. A single practical course or a combined theory and practical course must be completed to satisfy this requirement. The global education system has changed as a result of the pandemic outbreak in the first half of 2020. The lecturers must implement an online learning strategy if they want students to continue and complete their studies on time (graduate on time, GOT). A study by Santhosh Kurukunda highlighted the use of a software platform to connect students to the actual lab to construct a remote laboratory. The students can carry out remote routines, programme for conditioning circuits, and remotely observe the impact of the "virtual" lab done at home using the TeamViewer software, LabVIEW, MATLAB, and Arduino. The hardware component is set up in the university's "actual" research laboratory, and researchers can remotely carry out measurements, characterise objects, and conduct experiments to validate the hypothesis. This study applied the usage of the TeamViewer software in a DC motor study that included an examination of vibrations and transients and dynamic simulations performed in MATLAB. The students have been virtually connected to the actual lab using TeamViewer software, LabVIEW for the characterisation, and Arduino for the acquisition and driving. The DC motor and accelerometer connected to the computer using LabVIEW and Arduino. Using TeamViewer software, the students can remotely access this computer from their homes. The lab computer is now easily accessible to students at home, who may use TeamViewer software to remotely control the computer and use the webcam to see the hardware setup. (Kurukunda et al., 2020).

Another study by Muhammad Abdul Jalil illustrated how to perform the online practical assignment for the Malaysia Polytechnic's Embedded System Application Course. Along with the well-known computer remote access programme TeamViewer, the PTK40A PIC trainer is utilised as control hardware. For purposes of pre-programming and control, the PTK40A is connected to a computer. A student can remotely control the PTK40A from home using the internet and TeamViewer software. The outcome demonstrates that without touching the hardware, the learner can use embedded software and complete the practical task. They demonstrate the viability of this online practical task implementation with this technique (Jalil & Kamar, 2020).

The lack of hands-on experience with devices and equipment is one drawback of virtual and remote laboratories. As a result, manual skills, such as dexterity, which are required to produce the same experiment results when working with real-life equipment, are not improved in a virtual or remote laboratory. Since the virtual environment is similar to video games, this is another drawback. Because they frequently treat the virtual experiment as a game, students lose the sense of seriousness. As all controlled components have predefined limitations that are checked by the environment in remote laboratories, students are unable to harm the environment by making mistakes. These labs don't require the same level of restraint and caution needed to conduct the same experiment in a conventional laboratory safely (Budai & Kuczmann, 2018).

Hence, this study presents the TeamViewer software application in virtual laboratories for the Chemical Engineering Embedded System Application Courses. The objective of this study is:

- To provide a solution to the subjects of how TeamViewer Technology assists students in completing online labs for Embedded System Application courses.
- To compare the students’ performance with and without using TeamViewer in their laboratory practices.

Literature Review

Past studies on the usage of TeamViewer

When direct physical access to a computer is neither feasible nor convenient, remote viewing or software enables an individual to have access to a computer. Instead, users can access their computers from wherever they are using remote viewing software. Instead of storing or transferring data to a flash drive for later use, as is the case with standard File Transfer Protocols (FTP), you may edit, alter, and see everything on the hosting computer. Remote access software is one choice for users who need to share their desktop or move data across computers. Because of its many features and low user cost, TeamViewer software is widely used. For Windows, Mac, Linux, Android, and iOS, TeamViewer is available in various versions that can be purchased or downloaded for free (Lahaie & Leberfinger, 2013).

TeamViewer software has been used in various applications including plantation, medication, education and many more. In Green House Automation, TeamViewer software has been used in Zigbee-based wireless greenhouse monitoring and control system to address issues with slow real-time data collection, a high labour need, and the drawbacks of wired systems, including complicated cabling. A custom Visual Basic Web Server is created to interact with other devices, like an Android smartphone, utilising synchronisation software of TeamViewer. Thanks to this program, all the devices will remain in sync with the server. A wireless camera is connected to a real-time monitor. Additionally, since the gadgets are connected to the Internet, the owner can check and control them in real-time from anywhere in the world. The user can also receive updates to the information via SMS service. The proof-of-concept architecture combines traditional data recording devices with commodity computing, ensuring cost-effectiveness and easy integration (Kumar, 2017).

TeamViewer software also has been embedded in an education project for disabled students in Ukraine. One of the most important current challenges in Ukraine is the education of people with disabilities. Without education, a disabled person is unable to contribute to society or find fulfilment in their work. One of the choices for a certain category of disabled persons is a profession in the IT industry, but they need training both in-person and online. The TeamViewer software experience is applied in information technologies for teaching of disabled students. Participants' computers can be accessed remotely using the TeamViewer tool. With TeamViewer, the students have the option of having complete access to a remote computer and keyboard control. Voice and video communication, video conferencing, multi-user chat, file sharing, remote printing, session recording, and computer shutdown are all supported by TeamViewer. Even PCs without TeamViewer installed can control the remote computer using a web interface, although doing so necessitates creating an account on the producer's website. A mobile device can also be used to control a computer (smartphone or tablet). This should make it easier to fulfil the main goal, which is to assist disabled persons in realising their professional potential in the modern IT industry and give them a head start for further growth and life synchronisation (Fisun et al., 2015).

Past studies on challenges of assessing laboratory skills during pandemic

During the pandemic, universities have opted to take online courses. Many laboratory activities have been cancelled to prevent student agglomeration and the danger of illnesses due to the closure of university facilities and to maintain academic and laboratory activities for students. It is important to keep in mind that, when it comes to the many engineering disciplines, measuring systems, characterisation techniques, theory, and experimentation are crucial to students and their education. A physical world signal can be calculated and interpreted using measuring system studies (real case). These systems, which comprise sensors, transducers, instruments, and other components, change the data format so the user can understand it. Comparing the unknown quantity to the known quantity is helpful. For measurement structures to perform consistently, accuracy and precision are essential, and students must learn about various systems through experimental research. It is impossible to dismiss this research or forbid students from participating in experimental activities owing to illness (Kurukunda et al., 2020).

Compared to other fields, engineering education has certain unique characteristics. Students are expected to acquire design thinking skills by learning theory and fundamental concepts in the classroom, followed by hands-on experimentation in the lab for psychomotor learning. This will prepare them to address problems in the real world. The main focus of engineering education is design, development, and practical lab exercises. Although virtual labs are useful for teaching the fundamentals of engineering, it is not easy to plan and carry out labs if a student-developed interface with the hardware is required. Apart from that, the greatest choice for supporting distant online classes and virtual labs is broadband internet. However, sufficient internet bandwidth is required, which is challenging to manage in developing countries, in order to conduct online classes. The only workable solution is to email students from distant locations the lecture slides and audio that were recorded. In these cases, it is also possible to mail lecture CDs to students who live in rural areas of the nation. But this method will require long time for the materials to reach the students and will disrupt the learning process. Last but not least, different remote virtual laboratories have different minimum needs to support an online e-learning environment. As of right now, the instructor's laptop should have a core i5 CPU and Windows 7 operating system (or higher) to conduct online classes. At the receiving end, students can even use a tablet computer, but they will also need desktop or laptop computers with strong internet connection to run simulations and complete laboratories assignments. A strong internet connection can be a huge challenge for a student who lived in rural area (Khan & Abid, 2021).

Methodology

Most students were not allowed to be physically on campus when COVID19 Pandemic struck to prevent severe virus transmission. This has caused a limitation on student accessibility to the laboratory's available facilities. The Chemical Engineering department has initially bought and installed 5-year licensed software of ASPEN Plus for two computer labs early in February 2020. It would be a waste if the students did not use the licensed software. With the aid of TeamViewer software, students can still access licensed software owned by the university from wherever they are. Generally, the remote learning concept can be illustrated in Figure 1 below:

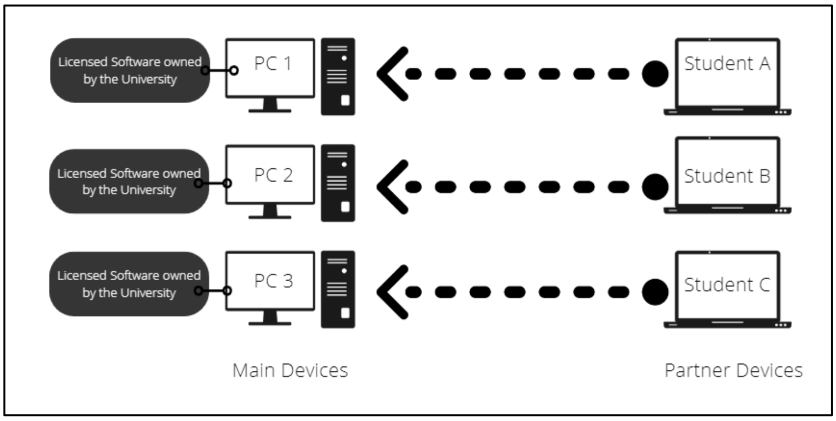

Figure 1: Illustration of remote learning concept

Part A: TeamViewer Configuration Process

Below are the steps taken to set up TeamViewer software in both devices:

1. The TeamViewer software was downloaded and installed on the main device. For educational purposes, it is sufficient to download the free version of TeamViewer software.

The software can be downloaded from this link: https://www.teamviewer.com/en/products/teamviwever. For this study, the main devices are located in the College of Engineering (Chemical) computer labs at UiTM Pasir Gudang.

2. TeamViewer was downloaded and installed on students' devices, also known as partner devices.

3. After installation is completed, each device will have a unique TeamViewer ID and password. A list of TeamViewer IDs and passwords will be given by the laboratory coordinator and shared with students.

4. Each student will receive one dedicated TeamViewer ID and password, which is dedicated to one main device at the computer lab. Figure 2 shows a screenshot of the TeamViewer apps from the view of the main device. In the red box below, the TeamViewer ID and password for this computer were shown.

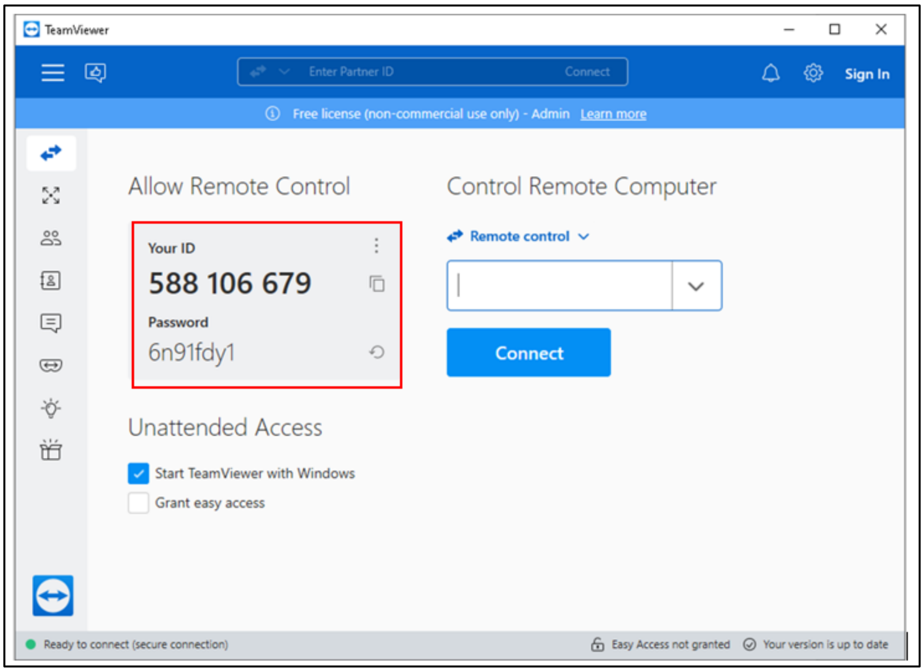

Figure 2: TeamViewer display from the main device

5. In order to connect with the main device in Figure 2, the partner device needs to key in the specific TeamViewer's ID of the main device under the Control Remote Computer column and then click on the "Connect" button, as shown in Figure 3.

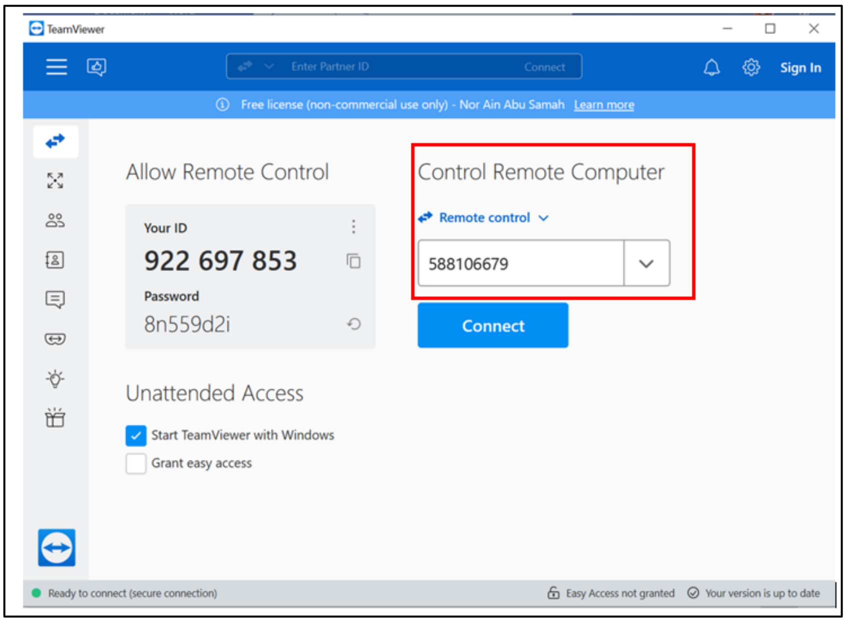

Figure 3: TeamViewer Display from the partner device

6. Then, the specific password of the main device needs to be keyed in once TeamViewer Authentication prompts up, as in Figure 4. In this example, the password would be "6n91fdy1". After that, click the "Log On" button to proceed with remote connection with the main device.

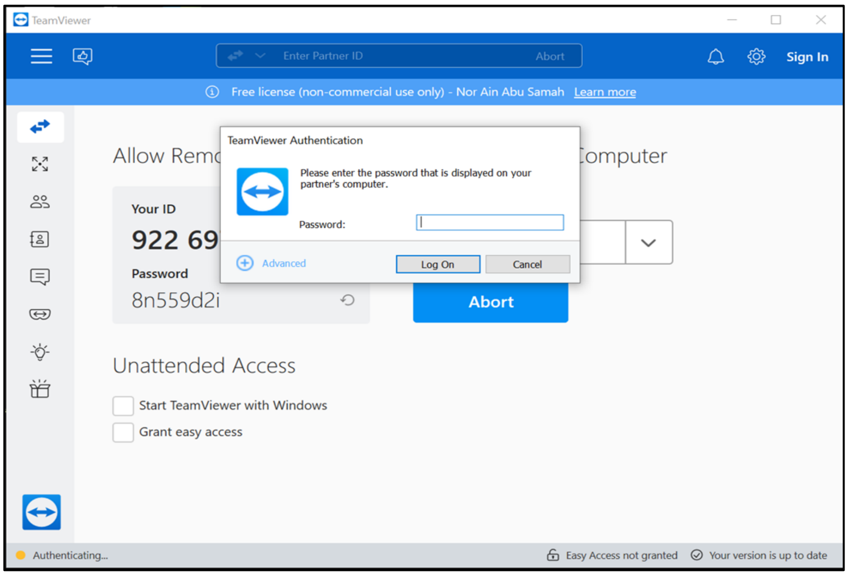

Figure 4: TeamViewer Authentication from the partner device

7. The remote connection was successful once the partner device could see the main device's content. To stop the remote connection, the user can click on the partner device's close button (X).

Part B: Online Laboratory Practices for CHE263—Material and Energy Balances

Specifically, there were five laboratory practical sessions for Course CHE263—Material and Energy Balances. One session is dedicated to software introduction and lab demonstration, and the other four sessions are for students' hands-on practical assessment. The session is done synchronously within two-hour laboratory sessions. Table 1 details expected course and program outcomes related to ASPEN Plus laboratory assessments. Each student is assigned and paired with a dedicated computer inside the laboratory. During MCO, university staff can be on campus for a certain duration. The course instructor must be physically present in the laboratory to facilitate, assist, and troubleshoot any issues during the two hours of remote laboratory sessions. The instructor's presence is important as he or she can monitor each student's progress on each dedicated computer screen. Figure 5 illustrates the flow of the laboratory sessions.

Table 1
CHE263 Course Outcome and Program Outcome related the ASPEN Plus laboratory assessments.

Course Outcome	Program Outcome	Taxonomy Domain	Assessment Output
CO3: Manipulate the variables in Material and Energy balance equations to solve non-reactive and reactive systems by using computer simulation software.	PO5: Identify and Apply appropriate techniques, resources, and modern engineering and IT tools to handle well-defined chemical engineering problems, with an awareness of the limitations.	P3	Simulation Report

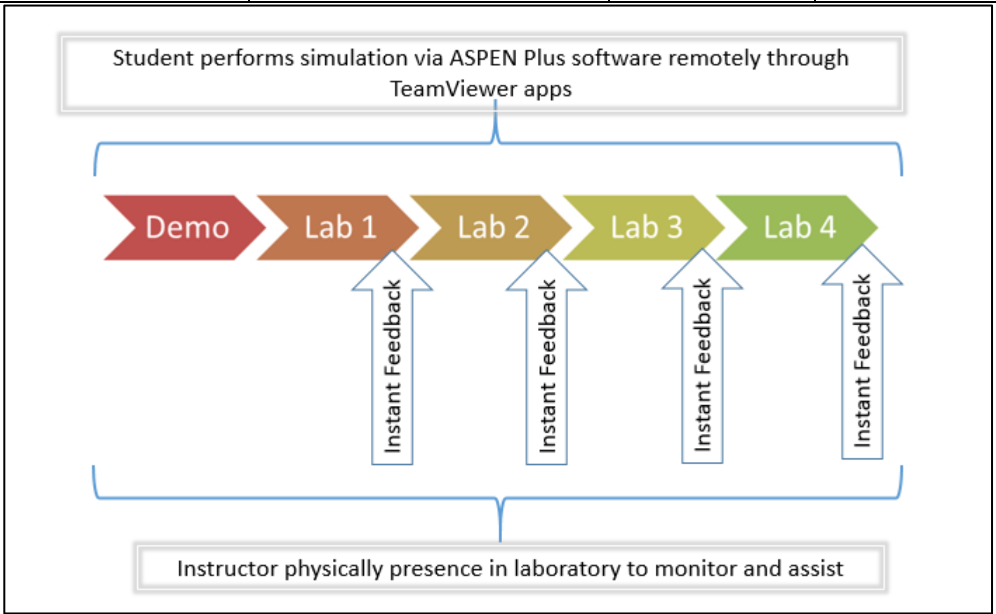

Figure 5: Flow of online laboratory sessions

During the demo session, the instructor introduced ASPEN Plus and explained the general step-by-step procedure for synchronously performing simulation in ASPEN Plus via Google Meet for the first 30 minutes. Then, for the remaining one and a half hours, the students will try out two examples from guided videos prepared by the instructor. The instructor prepared these two example videos so the students could try running the software at their own pace. From the Lab 1 session until the Lab 4 session, students must perform a simulation with well-defined and guided lab instruction. They may also need to manipulate process variables or conditions to achieve the defined target. As for report submission, the student needs to come up with:

1. A screenshot of the Process Flow Diagram was displayed on the Simulation Tab. The screenshot must include the TeamViewer PC ID (top left corner) and the date and time (bottom right corner). This is to ensure students do not plagiarize other students' work. Figure 6 shows a sample screenshot of the Process Flow Diagram for one of the lab sessions.

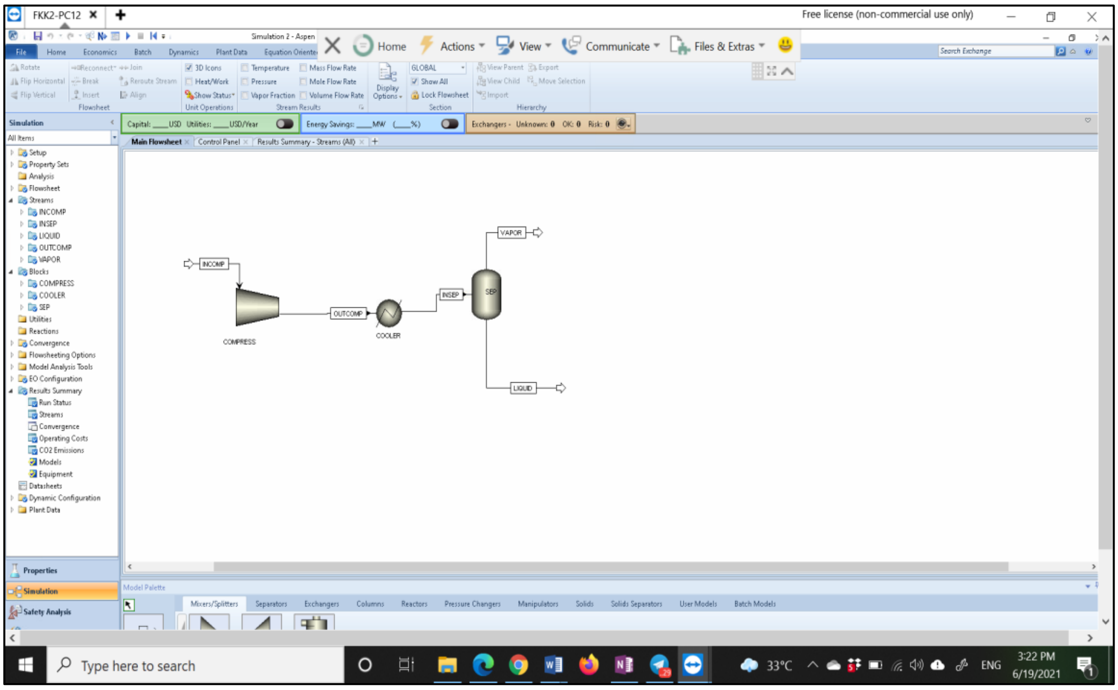

Figure 6: Sample screenshot of Process Flow Diagram

2. Screenshot of the Result Summary of all streams, with highlighted details of the mole fraction of each stream. This screenshot also must include the TeamViewer PC ID (top left corner) and date and time (bottom right corner). Figure 7 shows a sample screenshot of the result summary for all streams.

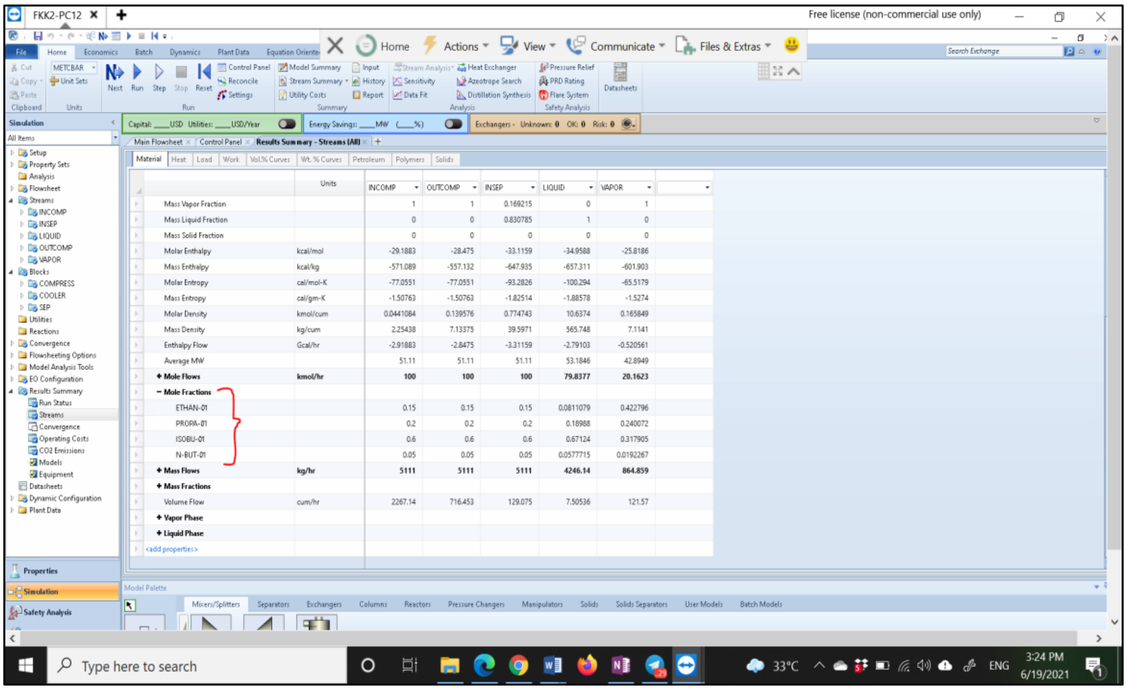

Figure 7: Sample screenshot for Result Summary of all streams

3. Apart from that, the student must also provide answers to questions in the laboratory guidelines. The questions were prepared according to the topic in the course lesson plan.

Part C: Online Laboratory Practices for CHE249—Separation processes

For the CHE249-Separation processes course, students need to perform four types of process simulation on the distillation (batch and total reflux), liquid-liquid extraction, and gas absorption processes using ASPEN Plus software. Table 2 details expected course and program outcomes related to ASPEN Plus laboratory assessments in this course. Each student is assigned and paired with a dedicated computer inside the laboratory via TeamViewer software. A guideline for each simulation process was given to the students before they performed the virtual and remote laboratories. The students must respond to the experiment outcomes while learning to operate the distillation unit, gas absorption unit, and liquid-liquid extraction unit using ASPEN Plus software. They must also manipulate the variables in a unit operation by the simulation model. The instructor assessed the students' work synchronously via Google Meet. Figure 8 to 10 shows the process flow diagram of the distillation unit, gas absorption unit, and liquid-liquid extraction unit that they need to perform in the ASPEN Plus software. Figure 11 displays the outcomes from the simulation work performed by the students to assess how they manipulate the variables in a unit operation.

Table 2
CHE249 Course Outcome and Program Outcome related the ASPEN Plus laboratory assessments.

Course Outcome	Program Outcome	Taxonomy Domain	Assessment Output
CO3: Respond to the Experimental and simulation outcome of separation Process experiments.	PO4: Conduct investigations related to chemical engineering of well-defined problems; locate and search relevant codes and catalogues, conduct standard tests and measurements	P3	Simulation Report

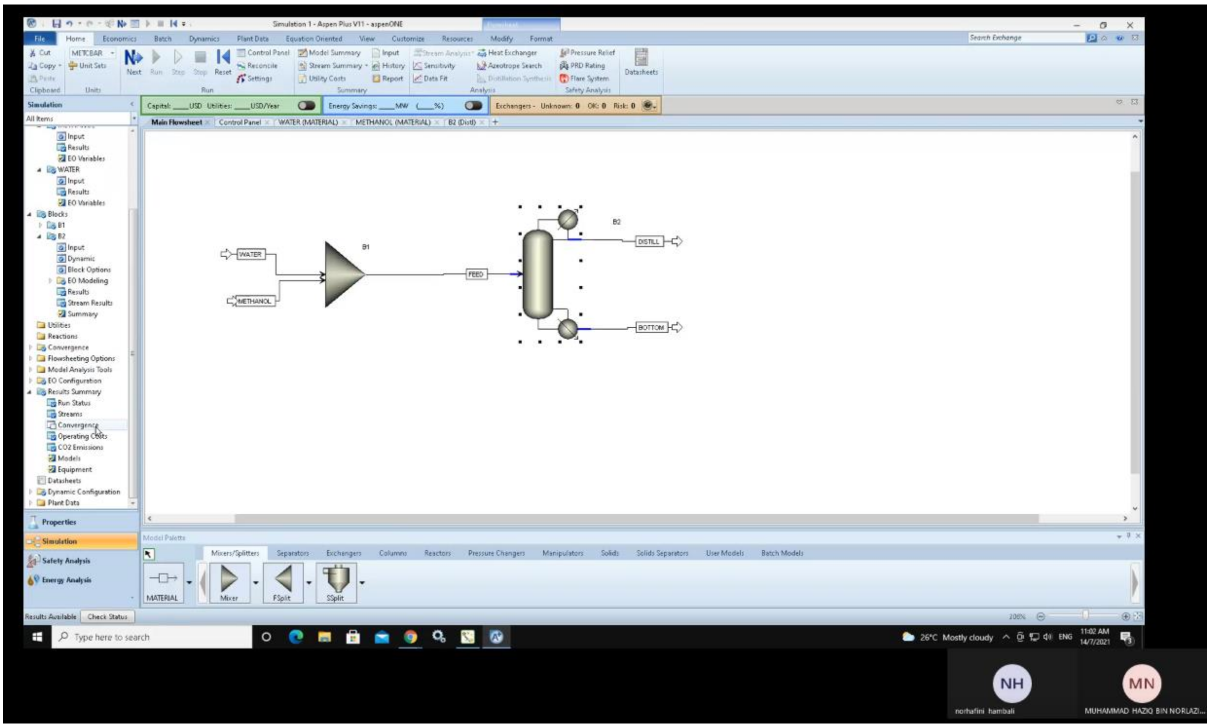

Figure 8: Distillation unit process flow

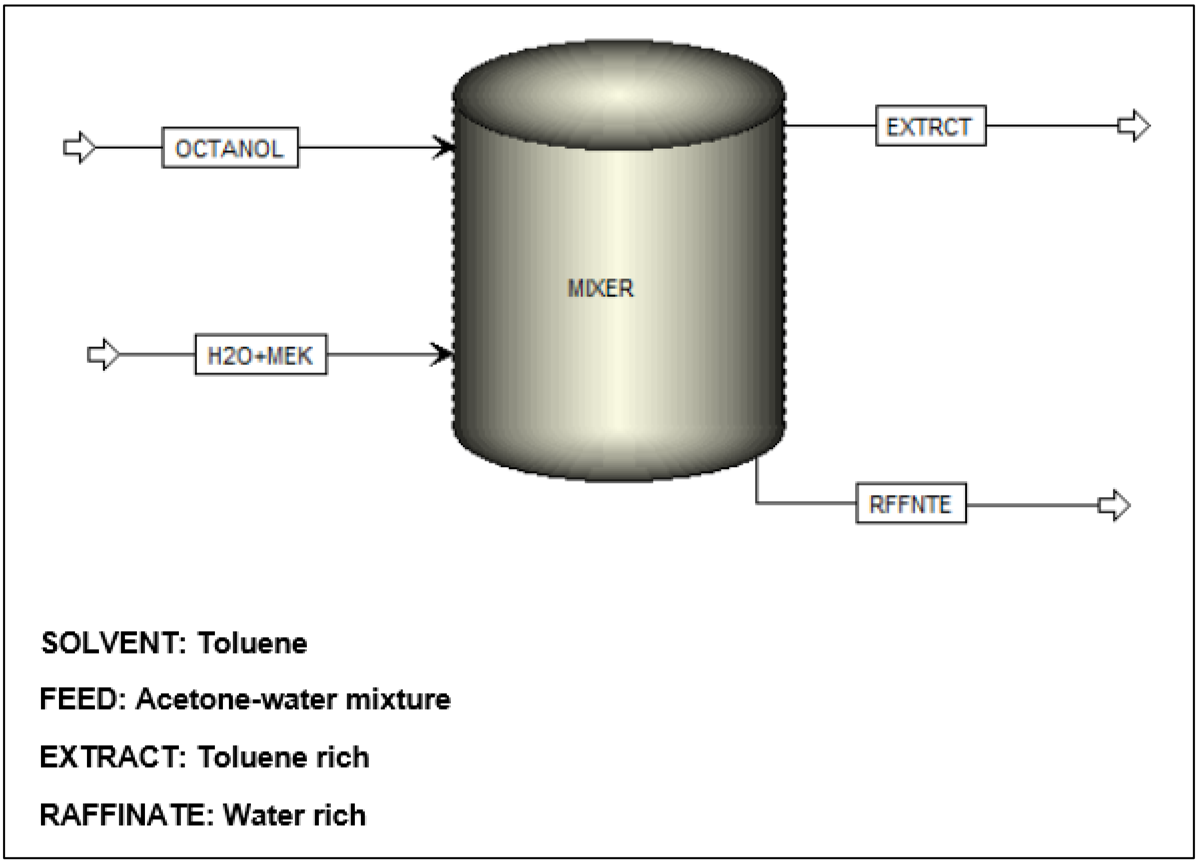

Figure 9: Liquid-liquid extraction process flow

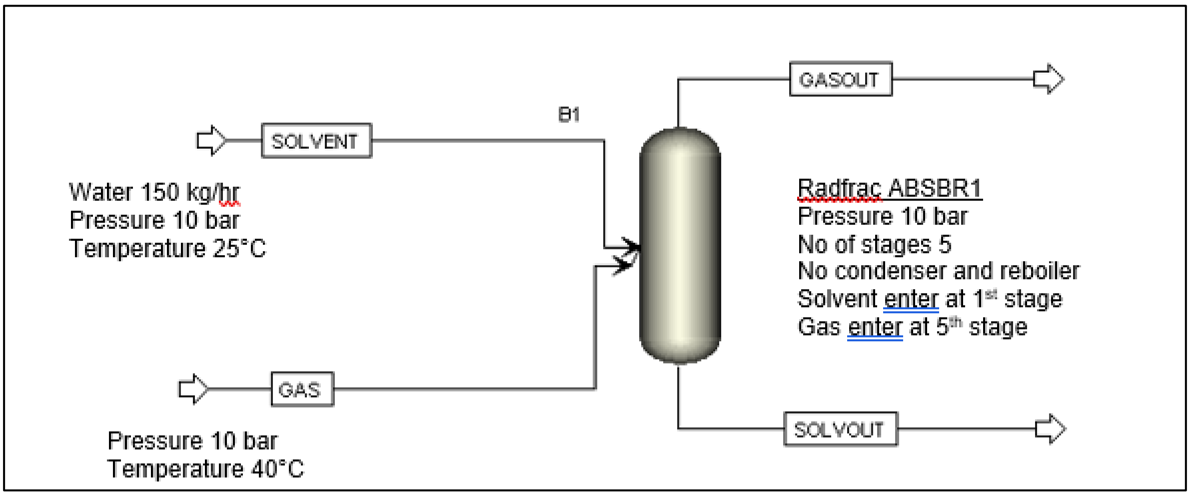

Figure 10: Gas absorption process flow

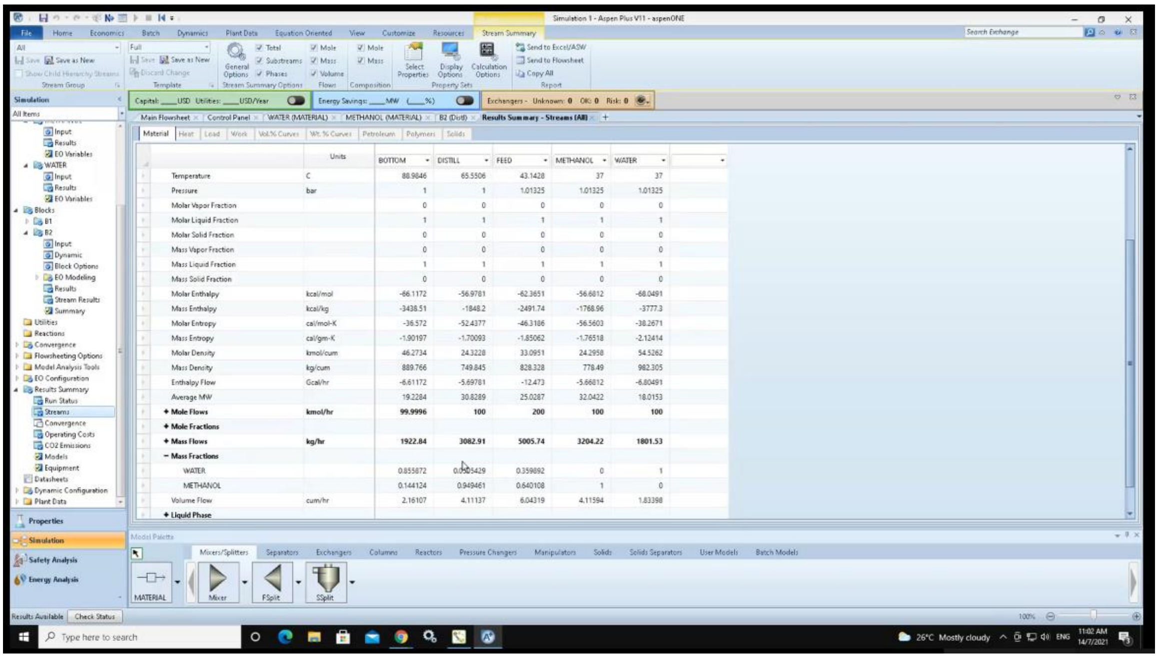

Figure 11: Example of process outcomes from the student's simulation work

Findings

In order to measure the effectiveness of employing TeamViewer as a remote learning tool, PO attainment from two different batches is compared, as shown in Table 3. The data is obtained based on the sample size of 40 students, using the same laboratory assessments and evaluated by the same lecturer. They only differed by the assessment method, where Batch A used TeamViewer to access ASPEN Plus remotely. In contrast, Batch B used ASPEN Plus software in the Computer Labs for CHE263 and face-to-face laboratory experiments for CHE249.

Table 3

The results of PO attainment from two different batch

Semester	Previous Semester Batch A	Current Semester Batch B
Assessment Method for CHE263	Perform ASPEN Plus simulation exercises synchronously via TeamViewer	Perform ASPEN Plus simulation exercises directly via Face-to-Face
PO5 Attainment for CHE263	Average: 82.9% Median: 84.3%	Average: 87.5% Median: 88.5%
Assessment Method for CHE247	Perform ASPEN Plus simulation exercises synchronously via TeamViewer	Perform hands-on practices using available equipment in the laboratory
PO4 Attainment for CHE247	Average: 81.7% Median: 82.6%	Average: 82.2% Median: 82.8%

From the comparison of the results in Table 3, it can be concluded that both periods show that the attainment percentages, specifically for PO4 and PO5, earned by students from both batches in both courses, are very similar. The above validates that with the proposed remote lab, the learning objectives are achieved, reaching a similar learning experience both in presential class and remotely.

Based on the analysis of Table 3, a quantitative experiment is created to assess the impact of the virtual and remote labs on the students of Chemical Engineering. All 34 participants were chosen from the College of Engineering (Chemical) year two students. Twelve questions on the Linkert scale of 1 (strongly disagree) to 5 (strongly agree) make up the survey. Google Forms were used to collect the information. Measurement criteria included technical, cognitive, psychomotor, and significant learning, as shown in Table 3. The survey findings are statistically analysed using SPSS version 26. The data is presented in mean scores to answer the research questions. This study's scale has a 5-point range; thus, the mean interpretation is divided into three categories; low (1.00–2.33), moderate (2.34–3.67), and high (3.68–5.00).

From the research survey, technically, the students had a good perception of the 4.56 highest mean value of the user-friendly software. This system lets you share files, print from a distance, hold online meetings and web conferences, and access the devices of people who are attending. In addition, it is supported across several operating systems, including Mac OS, Android, iOS, Windows, and Linux (Oloyede et al., 2022). Even though the software was easy to install, students were still having trouble with the connection problem. The mean value of 3.91 is the lowest score in the technical area. This challenge is mostly caused by the limitations placed on lecturers by the internet service, such as the bandwidth that is only occasionally accessible, causing access to data to be slowly related to the application of the required online practice. Overall, the score is still above moderate.

For cognitive measurement, the result shows that all questions were above 3.68, which means the student had a high perception regarding learning materials, including guidelines and manuals, where most of the information provided by the lecturer was adequate to do the virtual and remote experiments. TeamViewer was embedded in the remote laboratory model, which comprises easy-to-learn online learning instructions, simulator usage instructions, and digital practise instructions (Mulya et al., 2021). Having a high mean value score of 4.15, the subject or exercise was simple to learn as the student was able to complete the task given on time with minimal mistakes, as measured through question number 6. The results of these cognitive tests show that students think they have learned something new since the practise started. Meanwhile, the involvement of students in remote or virtual learning was rated at the lowest mean value score of 3.15. This moderate score in the psychomotor area could affect how the students and lecturer interact physically, especially for those who were physically active in face-to-face classes before the pandemic.

Significant learning components demonstrate that students have a positive perception of the freedom to explore engineering software at their own pace without the need to purchase a software license. This is at a respectable level, with a mean value of 4.53 for the flexibility aspects. The lowest mean value score is 3.91, where students slightly agree that virtual or remote practises helped them understand the course contents. This is probably due to a lack of interactive communication between their classmates and lecturer to ensure that the theoretical knowledge is aligned with the practical exercises throughout the online learning. In conclusion, the survey shows a significant positive impact on students in remote or virtual laboratories using the online pedagogical resource, i.e., TeamViewer. According to Zahid & Raza (2016), students who participate in TeamViewer sessions do better and earn higher GPAs than those who do not, although the data was not collected and discussed in this survey study.

Table 4
Mean value for each of items survey

No	Questions	Mean value
TECHNICAL		
1	The TeamViewer software is easy to install and user-friendly.	4.56
2	The necessary software e.g. ASPEN installed in faculty's PC is easy to access using TeamViewer software.	4.41
3	The virtual and remote laboratories can easily be performed using the internet connection at my home.	3.91
COGNITIVE		
4	The virtual and remote laboratory (using simulation and TeamViewer) is an effective tool for learning.	4.18
5	The information provided by the lecturer is adequate to do the virtual and remote experiment.	4.29
6	I can complete task given in time based on the information provided by the lecturer using remote/virtual laboratories in order to achieve the course objectives.	4.15
PSYCHOMOTOR		
7	Remote technology i.e., TeamViewer software was a good alternative for developing engineering practices.	4.32
8	My participation or involvement in remote laboratories is better than face-to-face laboratories.	3.15
SIGNIFICANT LEARNING		
9	The virtual and remote laboratory contributed to the course objectives.	4.18
10	The practices with the virtual and remote laboratory helped me understand the course contents.	3.91
11	I would like to have more practices with the virtual and remote laboratories using TeamViewer.	4.18
12	TeamViewer give me a flexibility to explore the engineering software at my own pace without need to purchase or download a license software in order to fulfill the course objective.	4.53

Conclusion

Summary of Findings and Discussion

This paper outlines how to create a remote lab using TeamViewer software for two chemical engineering courses, Material and Energy Balance (CHE263) and Separation Processes (CHE247), using equipment readily available in the University. This study also demonstrated how well students' cognitive and psychomotor skills were developed due to the remote laboratory activities. The students who use the TeamViewer software are then asked to complete a survey. From the analysis of this survey, one can infer that the learning outcomes are comparable to those of a classroom-based course. It shows that the suggested remote lab is a great way to teach practical skills at home, especially since the COVID-19 pandemic is unpredictable.

Pedagogical Implications and Suggestions for Future Research
The engineering-focused educational institutions in Malaysia have risen to the challenge of delivering instruction via virtual and e-learning even while face-to-face interaction is required for the execution of physical laboratories. The Universiti Teknologi MARA in Malaysia is working to meet students' demand for interactions between them and their teachers. They recently began a variety of interactive sessions, including audio-video interactive sessions employing software and technology as needed, for this goal. This study was done to assess the efficiency of using TeamViewer software to run virtual labs in terms of student satisfaction and grades earned by the students. The academic performances of the students in engineering courses are seen to benefit from TeamViewer sessions between the students and lecturers. Therefore, it is advised to promote the use of TeamViewer in engineering courses where students must access sophisticated software remotely. This study intends to spread knowledge and experiences that will benefit students' online learning from the students' point of view. The challenges, preparation and input required from the perspective of the educator in practising remote lab should also be studied, as part of the further suggested study. It might serve as a starting point for further investigation into the advantages of having a remote lab in engineering courses. Especially if the instructor is working alone, they need to figure out what will give them the best return on their time and effort spent making and teaching the course.

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