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Engineering Teaching Techniques and Experience in the Midst of Covid-19

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Abstract

The Covid-19 pandemic has imposed pressure on academic teaching and learning. Conventional teaching methods have to be adjusted in order to meet the new environment. During the last three of learning, online teaching has become one of the main methods of delivering lectures. This paper details a list of skills and methods that would improve the online teaching and learning experience and should therefore be used. The culture of teaching and learning has been modified by the pandemic, and the teaching, learning and assessment have been substantially reformed. The assessment of students and teacher feedback are important issues, and they are described in detail. The methods used in engineering teaching and the student's performances in the final grades are compared. It is found that the proposed method of engineering teaching and assessment for online teaching did not impose any major drawbacks or deteriorate the learning outcome. It seems that after three years of the pandemic, both students and instructors have adapted to the new method of online teaching, and the teaching method, computer-based engineering laboratory, assessment, and mentality have been adopted to the online system.

Keywords: Covid-19, learning from home, engineering, distance interactive learning, online teaching

1. Introduction

Covid-19 is a global issue, and all countries in the world are affected. It started in Asia around January 2020, and the classes in Asian countries started school closures, and it gradually spread to Europe and then America in March. Starting from April 2020, all countries in the world were affected. Most of the actions taken by the government and school management are school closures in order to stop the spread of the diseases. Different measures have been taken by governments and academic institutions. For government action, it can be mostly summarized as stay-home order, social distancing, mask-wearing, and school closure. Because of this action, academic institutions have to impose different teaching manners and policies. The method used includes cancellation of face-to-face teaching, no physical contact, public examination suspension, change of assessment modes, laboratory class suspension, online teaching, and online examination. Most engineering courses have laboratory classes, but the experiment cannot be conducted in the laboratory, and a new method of laboratory class has to be developed.

Online teaching has been promoted since web-based teaching was developed in the last 20 years (Cheng K.W.E., 2003). Recently the use of MOOC for open learning has been widely adopted by the public (Q. Zhou, 2018). For engineering teaching, laboratory classes are important; the virtual laboratory (Cheng, 2019) has been reported to replace the conventional computer simulation laboratory (Magistris, 2005). The method has shown useful experimentation by users, and students can experience a good environment to learn the practical training of engineering experiments. Assessment is always an issue for conventional teaching and online teaching (Okada, 2019). Plagiarism and even cheating during Coursework and examination are not easy to eliminate, and this is especially during Covid-19; most of the submissions are online, and the initial cyber security or proctored exam has not been in place yet. Peer Assessments have been reported (Antonio R. Anaya, 2019), but they may not always be applicable especially for the final examination or higher level of education assessment. The online-to-offline (O2O) (Xisan Wei, 2018) model has been considered, but it is part of the teaching mode, and it may not be useful for all cases of engineering teaching. The online materials have to be attractive, and the charming feeling is discussed (Jia-Xuan Han, 2019).

The use of Information and Communications Technologies (ICT) for online teaching to trigger reflection and constructive dialogue should be considered (Sarah Prestridge, 2015). For engineering teaching, specially designed software (Raúl Igual, 2018) can be used for online teaching. However, during Covid-19, the change of courses has to be done quickly, and a long duration of revision of the course is not feasible. The task here is to revise and update the existing in-person course to an online course and its assessment method under Covid-19 but without deterioration of the teaching and learning. The assessment should be formative so that the feedback to students can be automatic and systematic (Wood, 2018).

This paper is to discuss the issues of the teaching experience imposed by different institutions and how the response has been received from the students. The paper also discussed using online teaching; the learning outcome is analyzed.

1.1 Title Major issues after the school suspended during a course

Most schools or universities have not prepared properly for the closure before the end of the quarter in early 2020. As soon as the alarm from the government and education department were aware of the severity of the virus, most schools and universities started to suspend classroom teaching to avoid the virus spreading. It happened around February to April 2020 globally, and in the US, it is around the second half of the quarter or near the end of the spring quarter. The syllabus did not accommodate these changes. Therefore, the assignment, assessment, and laboratory class have to be altered or canceled. The overall assignment of a course was then based on the assessment already done only. This might impose unfairness as some final examinations may have higher weight, whereas it was relatively fine for courses with heavy Coursework.

The lectures were then changed to recordings or online straight away. However, as the students and instructor might not be familiar with online teaching, there were a lot of issues that came up online. This may include that presentations have to be updated for online teaching. Even the assignments have to be updated. The computing facilities have also been upgraded as well. The great demand for Webcams, online teaching software, and new licensing arrangements has to be organized instantly. Some schools have to arrange a lot of personal computers for students to take home.

1.2 Major issues for school suspension before a course starts

If the school is closed after the quarter ends, this may not impose too much hustle, and the instructor may revise the syllabus during the quarter break to meet the new requirement of the teaching and assessment in the next quarter. The changes in the courses depend on the course content and the nature of the course. In general, the presentation, lecture notes, demonstration, laboratory work, in-class exercise, tutorial class, and examination are needed to change to meet the new style of teaching. The changes to the revised syllabus can be announced to students as early as possible to allow sufficient time for students' preparation before the quarter starts. The changes may be minimal if little time is available. For example, the cancellation of the hardware laboratory and adaptation of the software laboratory instead. Of course, the detailed adaptation of the software laboratory to replace the hardware laboratory class is not simple, and a lot of consideration is needed.

Substantial changes may be imposed when sufficient time is available. The modification and adjustment to the syllabus may include the use of new software, new laboratory classes, assessment methods, and weight of contents without deterioration of the learning outcome. The instructors should introduce suitable software and revision of the Powerpoint to meet online teaching. A much more workload is expected from the instructors. They have to search for suitable software for online teaching without weakening the teaching quality. For engineering courses, a substantial revision of the laboratory class to meet the online simulation learning and teaching should be prepared.

2. The assessment

Assessment is a major issue of the courses. In the past, the assessment may include quizzes, homework, mini-projects, and examinations. Usually, the quiz is a small test and can be open-book or close–book. The mini-project requires students to present in front of the class. The assessment criteria include the content of the work, presentation skills, and the impact of the work. The final examination is conducted in the last week and usually carries a heavier weight. Because online teaching is generally adapted for the courses during Covid-19, the quiz and examinations must be online as well. However, in order to avoid security issues, the instructor can opt for open-book and open notes. However, this is still unable to eliminate cheating among students as they may source the answer through the internet or discuss the questions with their classmates using a variety of communication channels.

The conventional assessment for engineering is usually homework, mini-project, laboratory work, quiz, and examinations. Under Covid-19, because of social distancing and the closure of the school, experimental work is difficult, and learning or assessment through laboratory classes is difficult. Instructors may switch to computer simulation, but this is not as good as the hardware test. A virtual laboratory with a real and remote test is available (Cheng, 2019) but a large scale of the virtual laboratory is restricted by the online hardware facility, and it still takes time for installation.

2.1 Type of assessment

The type of assessment is vast and has been reported extensively by literature, and they all have pros and cons. Let's summarize the common assessment types.

Assessment is divided into tight/restricted time schedules and flexible time schedules. The former is similar to a limited-time examination or test/quiz. Students have to complete a task within a set time, and it is usually 30 minutes to 4 hours. The home-based computerized proctored assessment was less commonly used before because it required camera monitoring and internet software installed in students' computers for communication checks and image processing to check any unwanted supports in the candidates' location. Online proctoring is now more commonly used and promoted because of Covid-19, and students and invigilators have to compile with social distancing and physical examination cannot be used. However, the online proctored examination has its drawback because the software is expensive, and the software-controlled proctored examination still has drawbacks and faults. It cannot eliminate all aspects of cheating incidents.

Continuous assessment is usually homework, in-class exercises, laboratory work, and project. The continuous assessment can usually be supported by the peer or other channel, and the grade received may not truly reflect the ability of the student. Therefore, many instructors or senior management may not prefer continuous assessment as the only type of assessment and it must be mixed with the formal examination. However, this is not possible during the Covid-19 period.

It is of interest to develop a new type of assessment that can solve the drawbacks of the above two standard assessments, but so far, there is not any successful example. The assessment also highly depends on the course, field of study, learning outcome, rubrics, and academic level, and there is no single assessment that can fulfill all types of courses.

2.2 Continuous assessment instead of the final examination

Instead of online examinations, the assessment through the Covid-19 period has been moved to continuous assessment such that homework and mini-projects are often used. Such assessment methods usually give a long duration for students to complete the work. A few days to a couple of months are commonly used. Due to this, an accurate test for problem-solving skills is limited as this assessment only tests students' ability to solve a problem without a tight schedule, and they can always consult his/her peer or other resources. The advantage is that continuous assessment is allocated with flexible time, and students can conduct the work in his/her own chosen time and could spend a much longer time without much time restriction. Therefore, this type of assessment is not able to check the student's ability under a fixed time limit.

On the other hand, the conventional examination is usually proctored, and some of them are usually closed books and closed notes. A fixed time limit is often used. This method tests if the student's grasp holds of the learning and his/her time management with the set schedule is also inherently part of the assessment. The disadvantage is that the student will work under pressure, and in many cases, it highly depends on his/her memorization ability.

2.3 Alternative examination

Using a proctored examination may not be the best because students may not have a camera, or the instructor or the proctoring software may not 100% control the students to follow all the strict procedures. Hence large-scale implementation of proctored examination is difficult and is still early. Alternatively, a different approach can also be used.

a) Declaration of the examination conduct:

   A declaration statement is needed to sign or type by the student to fulfill the examination conduct. An example shown below has been adopted:

   By typing my name above, I confirm that I did NOT consult with anyone other than the course instructor while taking this exam, and I did not access any resources other than my notes, textbook, a calculator, and materials available on Canvas/Blackboard under Modules/Content.

   Although it is not useful for students intended to make a fault declaration, it does make the first effort to make clear to the students that the examination conduct

b) Reformat the examination style

   The conventional examinations are designed for students' physical presence in the examination venue. The questions are configured for such an environment. However, for online examinations, because the online examination is mainly open books and open notes, the question must be original, and it is not possible for students to search for similar questions and solutions online.

c) The questions can also be plentiful.

   This is to ensure that students have to answer it quickly without any additional time to search for answers elsewhere. This can also prevent students' discussions through their chat room channels or the exchange of information during the examination.

Although students may not have sufficient time to complete a lengthy paper and hence it may reduce the overall total points received by students; in fact, the actual answer script does not imply such initial thought. Experience from experienced instructors has found that a careful design of the question paper is very important so that the assessment is accurate and the time of grading I reduced.

d) Multiple choice questions.

It is being used in many public examinations such as SAT etc.

It reduces the time for the marking, and the grading can also be automatic. The numbering of questions and choices can be generated randomly so that it imposes a difficulty to cheat or exchange information during the examination. Another advantage is that many concept questions can be used, and it is a very good mechanism to test students in logical thinking, correlation, basic knowledge/components, simple calculation, simple design, and fundamental theory. However, the disadvantage of this method is that it is difficult to test the ability of students in design, description, presentation, and illustration. That can be assessed in other components such as mini-project, homework, and other coursework components.

e) Examination style

Because the assessments are all online, the conventional examinations have to be modified so that fewer drawings and fewer equations are needed during the examination as the drawing and typing equations are not feasible and time-consuming the examination; therefore, the examination questions have to consist of a higher portion of multiple-choice questions and short questions. Circuit, diagram, and waveform drawings have to be reduced.

3. Learning methods

The face to face teaching is not used during Covid-19, and most institution has switched to online. Zoom and Team are commonly used in many institutions, and the lectures can also be recorded, and the student can review the lectures anytime. These types of online teaching are synchronous, and instructors can discuss questions with the student.

There is also a chat room for students who do not like to speak out. Pre-recorded lecturing videos can be done in many methods, such as Panopto and any video recording software. The PowerPoint used in face-to-face lectures has to be modified to meet the online teaching.

The modification can be summarized as:

a. More animations should be used and less writing:

In classroom teaching, instructors can use a whiteboard for illustration, clarification, explanation, and derivation, but now all these should be done in animation in the powerpoint and avoid too much writing on the screen. Zoom and other online teachings, webinars and meeting software usually allow instructors to write directly on the screen, but it may be confusing, and the clarity would not be as good as the built-in animation in the powerpoints. Instructors should prepare all possible questions that students may ask. Prepare sample Q&A beforehand, and use animation slides to assist the teaching. The screen drawing is only reserved for students to raise questions during class.

b. Communication: Online teaching, in general, deteriorates the in-class communication between the student and instructor. It should be enhanced for online teaching. Instructors should raise more questions in the class and poll questions to students using the facility of online teaching software. The polling of questions can be done separately from the powerpoint so that an instructor does not need to modify the powerpoint significantly but use polling questions for different classes or in revision.

c. Chat room: The Chart function in most online teaching software is another useful tool for communication and engaging in the class. The instructor can chat with the whole class or individual students. Chat can also be used in the examination invigilation to discuss any issues in the examination paper when the student has questions without speaking in the microphone.

4. Mini-project and laboratory

4.1 Mini-project

Presentations are an important mechanism for checking project work. A mini-project is assigned at the beginning of a course, and they have to select a topic and conduct the project within a set time, such as a few weeks. They have to present the project in a powerpoint and then have to submit a project report. A schedule is set out for the student to present, and they can form groups for the project. For a large class, a few students may form a group. Those students who presented earlier will be given a bonus point to encourage students to present earlier and also to even out the presentation schedule.

The share function in the online teaching software is useful for the student to share their PowerPoint and present them to the whole class. The peers and the instructor can raise the question at the end of the presentation. The assessment of the mini-project includes presentation skills, technical content, and the report. The members of the mini-project group may declare their contribution to the project. Usually, the points they receive are equal unless a declaration is made of uneven contributions. The presentation skill can be assessed during the online presentation of the share screen through the online teaching software.

4.2 Laboratory work

For an engineering course, the laboratory class is important to provide practical training to students. It is different from computer simulation, which is the only computer-generated algorithm or image, and it cannot replace the experimental hardware work. During Covid-19, schools are closed, and the laboratory is also closed. The school or university staff and instructors work from home because of the stay-home order.

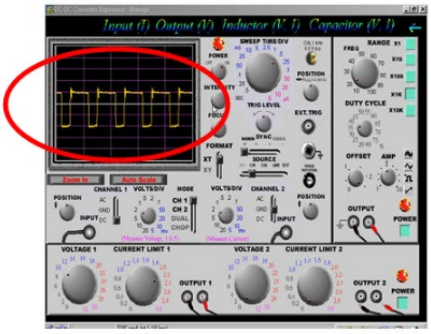
Without laboratory supervision, students are not allowed to work in the laboratory; any hardware experiment is not possible to be conducted. An alternative manner of laboratory classes should be implemented.

4.3 Virtual laboratory

The virtual laboratory has been promoted in the last few years [2] [3]. They are based on the remote-controlled hardware experiment that is located in the laboratory but allows students to remotely control their operation. Even circuit wiring, sensor connection, and data acquisition

are allowed so that students can conduct nearly the same hardware test as in the laboratory. This is not a computer simulation but a remotely controlled laboratory test. The tests can be done 24/7. The procedure is preset, and therefore, safety is not an issue as the preset procedure has taken into precaution. There is no need for technical staff or instructors to supervise the experiment. Figure 1 shows one of the displays of the virtual laboratory:

Figure 1: Oscilloscope used in Virtual Laboratory

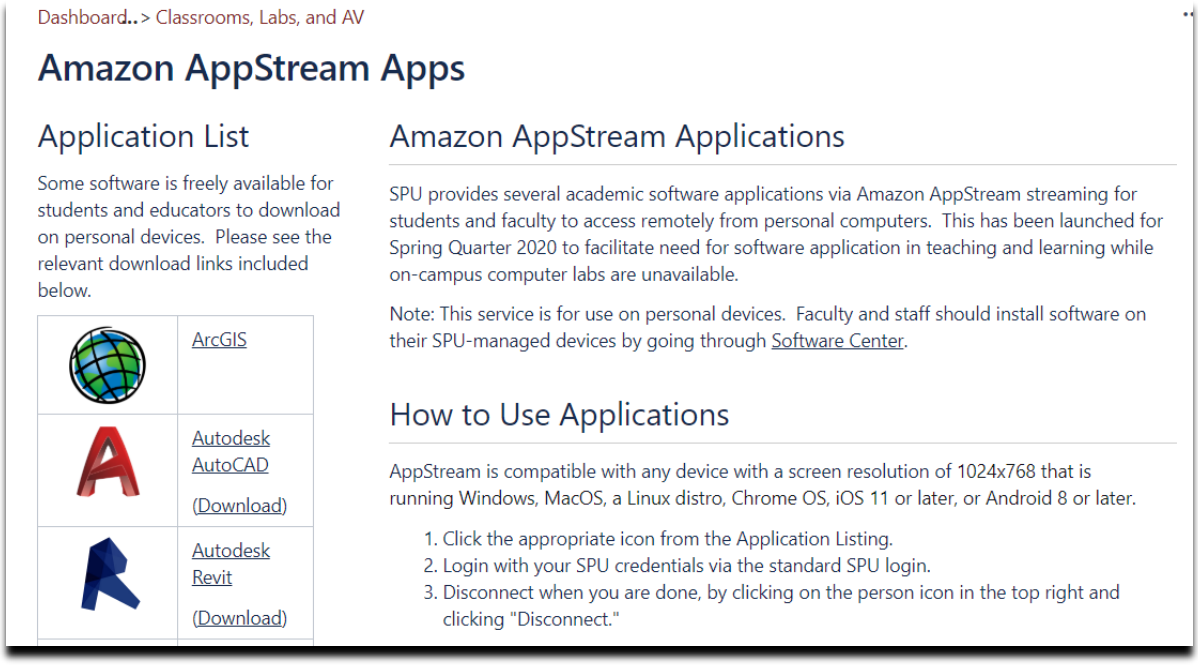


4.4 Computer simulation

It is one of the common tools for teaching, and in the past, it was usually installed on the university computer, or a site license was used for the whole campus.

Students can log in to the laboratory computer or designated computers on the campus to conduct the computer simulation of software work. A site license is usually used because the price is lower and welcome by the university or school. However, under Covid-19, students do not go to school, and they may not be able to access the software because of the restricted license agreement between the institution and the software house. Because Off-site licenses are expensive, AppStream streaming is now made available in their university or school for students and staff to access remotely from personal computers at home during the stay-home order.

Figure 2: Amazon AppStream Apps

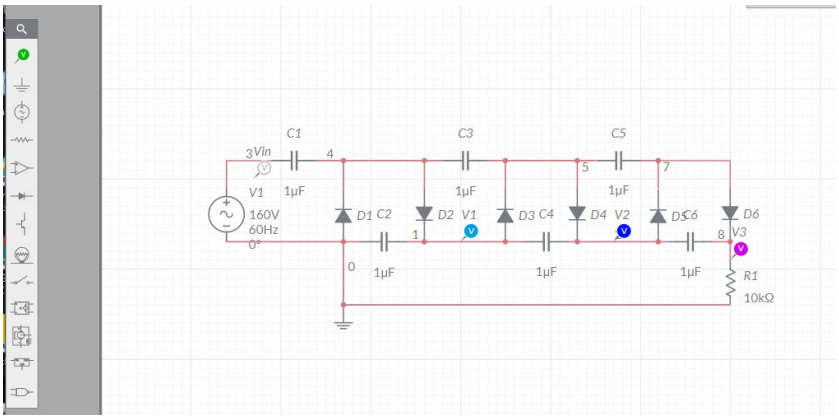


Web-based software

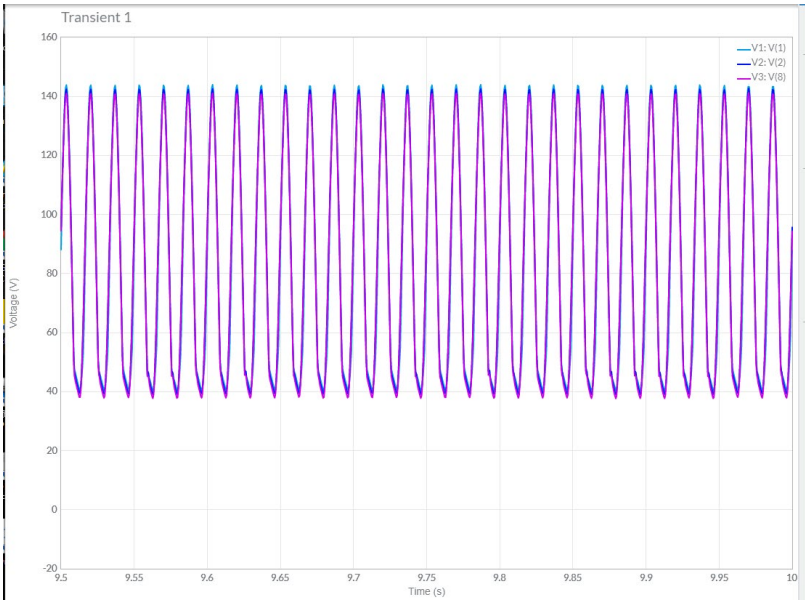
Engineering software is usually installed on a personal computer or laboratory computer. Most of the software for academic use usually has a trial period of one month; after that, the license key is needed. For software that is unavailable from the laboratory or after the trial period expires, an alternative method is needed. For electrical and electronics students, circuit simulation is necessary for most of their studies, such as power electronics, electronics, electrical circuits, and control. Common software such as Saber, PSIM, and Autocad is not available off-site unless with high fees or special arrangements; therefore, users may consider Multisim. It is also users friendly, and it also has a one-month trial period; after that, Multisim Live can be used. Anyone can access it as long as there is the internet. It is free, but the circuits developed are shared on the internet so everyone can view them. If it is intended for teaching and learning in school, the circuit you worked on will, therefore a public domain anyway. The sharing of the circuit is then not an issue. Figure 3 shows the Multisim interface [12]. Schematic capture is used for circuit development.

Figure 3: Multisim live for online circuit simulation

(a) Mutisim Live sketch



(b) Online simulated waveform of a circuit



4.5 Design software

Engineering design is one of the major components of learning outcomes. For Electronics, Electrical, and industrial engineering students, Printed Circuit Board (PCB) design is mandatory. In the past, students may design and prototype the circuit to their designed PCB, but during Covid-19, only PCB Design is taught, and the actual manufacturing of the PCB can be excused for the moment as it is only a minor task.

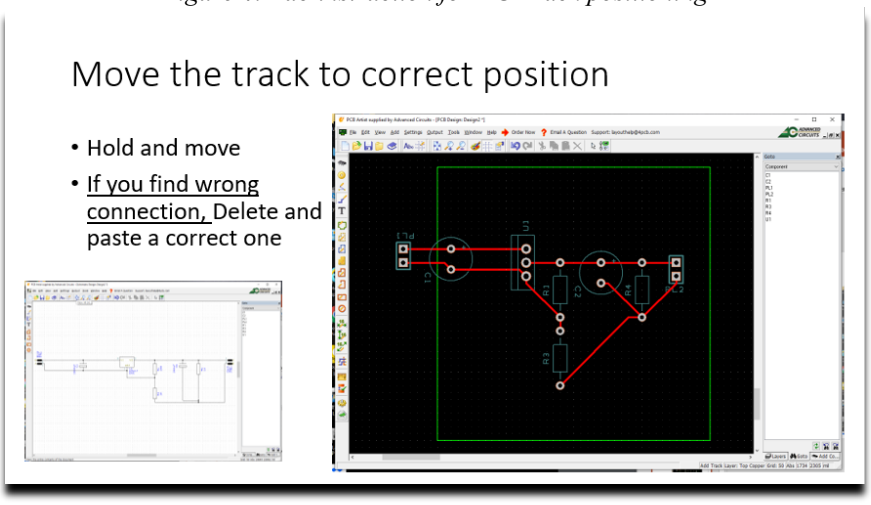
The PCB design is one of the contents of the Electronics Course. Instructors have to search for licensing that is available from the school or off-campus. PCB Artist [13] is adopted because it is free, and students and instructors may come to download it to their computers. A set of procedures are provided by the instructors in a step-by-step manner to tell the students to learn the basic PCB design techniques.

The skill and steps to be learned include:

- How to download the software?
- How to start a new schematic design?
- Propose a circuit for the PCB exercised.
- Understand the configuration of the parts.
- Annotate the necessary routes for low current and high current.
- Identify the high voltage and low voltage.
- How to search for a component?
- Additional connectors.
- Wiring techniques and their Current rating.
- Convert circuits to PCB.
- How to relocate components on PCB?
- How to move the track?

Figure 4 shows the laboratory instruction to teach students the PCB design. It preserves the PCB design techniques, and students have shown a good response to learning computer skills in PCB design even without a real circuit board to make because the teaching fulfills the learning outcome of the computer method in PCB design.

Figure 4: Lab instruction for PC Track positioning



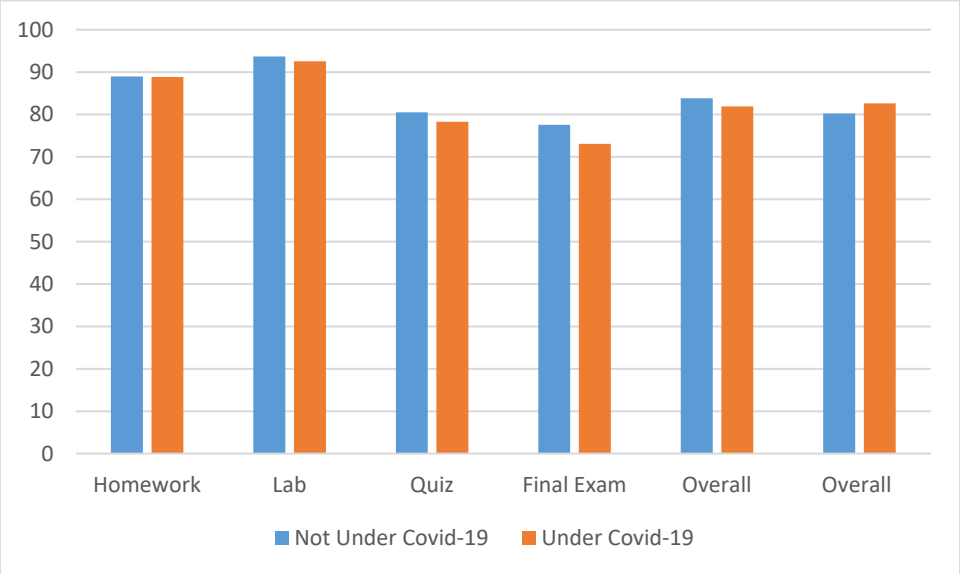
5. Analysis

With all the above implementation for teaching to combat the Covid-19 pandemic, it is now compared with the students' performance between two groups. One is the performance of the students during normal in-class teaching, and the other group is during the Covid-19 teaching. The same course but different students are used for this comparison. The course title is "Introduction to Logic System Design." Students learn the basic numbering system, logic gates, K-map, Latch, Flip-flop, Logic IC, counter, and State machine. One group was from the Fall quarter with 36 students, and the whole class attended the normal classroom teaching. The other group is from Spring Quarter with 14 students, and the whole class attended online teaching. The syllabus is the same, and the difference is the teaching method. i.e., One is classroom teaching, and the other is online teaching. The other difference is the laboratory work. Both classes have also conducted laboratory work, but the demonstration is through an online Zoom demonstration, and the experiment will be conducted by the students from home for the assessment. It also consists of the quiz, which is a rather short test of around 45min.

1. Mid-quarter examination and final examination. Both classes also have weekly homework. The quiz and examinations during Covid-19 are organized as in the procedure in Section 2, which are open-book exams, fewer drawings, fewer equations, and multiple-choice and lengthy examination adopted. The examination is prepared sufficiently long and closely monitored the progress of students during the examination, and the end time is extended when most of the students complete the examination paper. i.e., the end-time is flexible and continuously adjusted when a large portion of the students in the class complete the paper.

2. Figure 5 shows the mark between the two groups. It can be seen that the marks between the two groups do not have a significant difference. The change in percentages is very small. Each of the assessment components varies by less than 3% and but the Final examination drops by 6.1%. The overall differs by 2.3%. Therefore, it can be confirmed that the performance of the students has not changed. The use of the new method in teaching and assessment has not changed the students' output.

Figure 5: Comparison between two groups of students under and not under Covid-19



6. Discussion

The comparison between the two groups of students in the "Introduction to Logic System Design" course showed that the shift to online teaching and assessment during the Covid-19 pandemic did not significantly impact student performance. Despite the transition from in-person to remote instruction, the marks across all components—including quizzes, midterm, homework, and the final exam—were largely consistent between the Fall 2019 group (in-person) and Spring 2020 group (online). The variations in percentages for each component were within 3%, except for the final exam which dropped by 6.1% for the online group. However, the overall mark only differed by 2.3% between the two groups.

These results suggest that the adopted online teaching and assessment methods were effective in enabling students to achieve comparable learning outcomes as the in-person format. The open-book, lengthier exams with more multiple-choice questions, as well as the flexible end times, seemed to suit the at-home testing environment during this period of social distancing. Overall, the performance of students was not significantly changed by the transition to remote instruction. Despite the differences in teaching and laboratory methods, the students were still able to demonstrate a similar level of knowledge and skill attainment at the end of the course. In summary, the quick shift to online education did not appear to disadvantage students or substantially impact their abilities to fulfill the course objectives.

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