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ABSTRACT

Using open and distance learning (ODL) for courses that included laboratory sessions was challenging to teach and learn during the COVID-19 era. SCADA (Supervisory Control and Data Acquisition), also known as ESE691, is the School of Electrical Engineering elective that requires students to be present in the lab for their mini-project group assignments. During the outbreak, students were not permitted to attend the laboratory, but they were required to complete their assignments. The rapid transition from face-to-face delivery modalities to a flipped classroom will be more difficult for final-year electrical engineering students. As a result, the purpose of this study was to investigate the perceptions of students taking ESE691 in a flipped classroom environment from October 2020 to February 2021. The data was gathered using a qualitative method, and the results were analysed using SPSS. This survey had 68 participants, with 22 female students and 46 male students filling out a google form. The findings show that while using the ODL platform to create a flipped classroom for SCADA, the eight questions are critical. The implementation of the flipped classroom for the internal consistency test has a Cronbach's alpha of 0.819, which is sufficient for the questions' reliability.

Keywords—*SCADA, online and distance learning, flipped classroom, questionnaire, SPSS*

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INTRODUCTION

Higher education institutions are widely recognised as being particularly vulnerable to the COVID-19 virus's community, and practically all colleges have ceased face-to-face academic activity in favour of alternate teaching methods. As a result, an increasing number of universities have taken the required steps to adapt their teaching, including the conversion of laboratory workshops to an online or blended learning format (Gamage et al., 2020). The first case of COVID-19 was discovered in Malaysia on January 25, 2020, and the Prime Minister of Malaysia issued a Movement Control Order (MCO) on March 16, 2020, as the number of positive cases grew (Elengoe, 2020). The scenario has also posed a challenge to the global education system, forcing educators to shift from face-to-face to online teaching. The open and distance learning (ODL) technique is one of the most effective strategies for integrating virtual technology and so allowing the teaching and learning process to continue (Saidi et al., 2021). As a result, Malaysia has been transforming traditional instruction delivery into ODL for more than two years. To adapt to the new standard, several changes were made in teaching and learning activities at all levels, from primary school to university. The teaching and learning process entails the acquisition of knowledge that must be learnt, comprehended, and then applied to lifelong learning situations. Engagement is an important contributor to student satisfaction with an online course, their motivation to learn and their performances (Martin & Bolliger, 2018). A student's ability to engage, reflect, understand material, collaborate, find information, question, understand course requirements, and manage their own learning are all elements of engaged learning (Dziuban et al, 2015).

In engineering and scientific education, laboratory experimentation is critical. Due to the required equipment, space, and maintenance staff, virtual and remote labs are less expensive than traditional hands-on labs. They also have other advantages, such as facilitating remote learning, making labs more accessible to handicapped persons, and improving the safety of dangerous testing. Remote laboratories, particularly in engineering, have become an integral aspect of current teaching and learning (Vergara et al., 2017). Furthermore, the laboratory will enhance students' education by providing interactive, problem-oriented learning on real-world industrial automation components. The goal of the programme is to learn appropriate working methods for designing (engineering) complete automation solutions for machines and plants ranging from simple to medium complicated (Smajic et al., 2020). Control of industrial processes is an area of industrial automation that deals with models, instruments, and computations in order to maintain a certain handle's yield within desired operational parameters (Salih et al., 2017). Within the mechanical sector, the demand for greater quality, more prominent effectiveness, and robotized machinery has grown over time. The creation of a SCADA framework is required to display the plant and provide support in improving human accuracy. SCADA systems, or supervisory control and data acquisition systems, are a type of process management system that is used to handle geographically distributed facilities that span thousands of square kilometres. Pipelines, water supply systems, power lines, train transit, and numerous manufacturing and experimental systems are examples of these systems. SCADA systems vary in complexity depending on the regulated process and unique implementation (Atlagi and Šagi, 2011). SCADA systems include a number of subsystems, such as terminal units (RTUs), human machine interfaces (HMIs), and control logic units (PLCs), all of which must be coordinated to complete a task or operation remotely as shown in *Fig. 1*.

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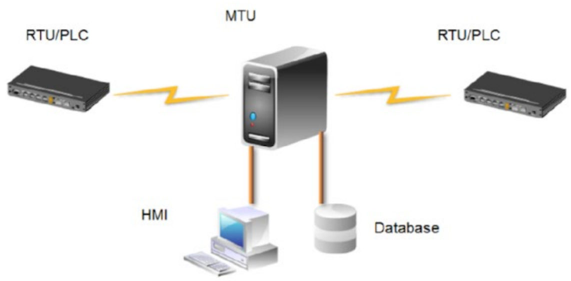

Figure 1: Supervisory Control and Data Acquisition

From electric circuits, signal and systems, electrical, sensor technology, data communication, dynamic and control theories, through digital signal processing and software engineering and design, instrumentation encompasses a wide range of topics. It's critical for monitoring and controlling dispersed industrial systems including electrical power generation, transmission, and distribution, oil and gas production and processing, water management, automobile manufacture, and so on. Having the exposure to this course is an additional skill when they graduate from the university (Wong and Siaw, 2015). The final year course includes a wide range of topics, including electronic circuits, signal and system analysis, communication, control theories, software engineering, and design. It is essential for the monitoring and control of industrial control systems such as electrical power generation, transmission, and distribution, as well as other manufacturing and processing (Moe, 2018). Supervisory Control and Data Acquisition (SCADA) is one of the elective courses provided to final year undergraduate students in the Bachelor's Degree in Engineering (Electronics) Programme as Special Topics II for System Engineering at Universiti Teknologi MARA's School of Electrical Engineering. This course does not have a final examination and is entirely coursework-based, with students entering a laboratory to complete their project assignment as part of their mini-project. The goal of this experiment is to correlate students' PLC knowledge with practical applications. The distribution of SCADA topics may be found in Table 1.

Table 1: 14 weeks of SCADA lesson plan

Week	Topics	Methods	Activity
1	Introduction to SCADA	Pre-class, group chat	Online class
2	PLC Programming Fundamentals	Pre-class, group chat	Online class
3	Introduction to TBox SCADA: Hardware and Software	Pre-class, group chat	Online class
4	SCADA and TBox Communication Set up and Interfacing	Pre-class, group chat	Online class, Assessment
5	Programming TBox: Digital I/O, Analog I/O and Memory	Pre-class, group chat	Online class
6	Programming TBox: Timer, Counter and Sequence Control	Pre-class, group chat	Online class
7	TBox HMI Programming and Interfacing	Pre-class, group chat	Online class, Assessment
8	Industrial Project Proposal	Pre-class, group chat	Online class, Assessment
9	Industrial Mini Projet Assignment (Program Development and Simulation)	Pre-class, group chat	Online class, Assessment
10	Industrial Mini Projet Assignment (Remote Control and monitoring via IoT)	Pre-class, group chat	Online class, Assessment

11	Industrial Mini Projet Assignment (Remote Control and monitoring via IoT)	Pre-class, group chat	Online class, Assessment
12	Industrial Mini Projet Assignment (Remote Control and monitoring via IoT)	Pre-class, group chat	Online class, Assessment
13	Report Writing	Pre-class, group chat	Online class, Assessment
14	Oral Presentation and Report Submission	Pre-class, group chat	Online class, Assessment

This course was initially offered to final-year students in the March 2020 session, with test and mini-project as evaluation components. Unfortunately, the COVID-19 pandemic broke out at this time, and problems with course delivery arose almost immediately, particularly with regard to how students should submit their mini projects when they are unable to enter the laboratory. Not only that, but it also has an impact on the students' learning experience because this course demands students to enter a laboratory for hands-on learning; they must use the theories learned in class and knowledge gained in the laboratory. During the course, students are given a quick overview of SCADA and how to programme using a Programmable Logic Control (PLC). It's pointless to teach PLC in the absence of a laboratory. TBox hardware and software were introduced and taught in the laboratory to help students complete some of their mini project tasks.

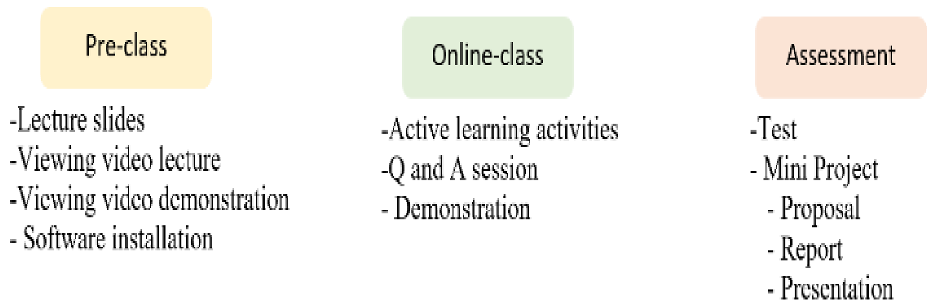

Figure 2: A structure of SCADA flipped classroom

The flipped classroom technique for SCADA is depicted in *Fig. 2.* The benefits of using a flipped classroom approach are numerous. The most essential benefit is that it extends the class's interactive time (Fulton, 2012). Instead of teaching, the teacher uses lecture videos to facilitate interaction between the teacher and the students. As a result, the teacher will have more time to meet the learning and emotional needs of the kids (Goodwin & Miller, 2013). In a flipped classroom setting, students have the option to talk with their teachers, which is not feasible in a regular setting (Bergmann & Wadell, 2012).

a. Flipped Classroom

Educational tactics and methods must be improved and updated to stay up with technological advancements. Up to now, there have been significant changes in the educational system, such as the employment of various methodologies or changes in the responsibilities of teachers and students (Yildririm & Kiray, 2016). With the introduction of a new type of classroom teaching known as the flipped classroom in the last several decades, education has undergone significant changes. It refers to any online technology that may alter the process of learning in a classroom

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setting, allowing teachers to provide greater engagement and a more flexible classroom environment for students. A typical flipped classroom has two primary components: (1) computer-based learning outside of class and (2) interactive learning in class (Bishop & Verleger, 2013). According to Bergmann and Sams (2012), the flipped classroom has many advantages, including assisting struggling students in watching videos multiple times, enhancing interaction between students and teachers, providing a good environment through creating a learning environment, allowing students to learn at their own pace and empower relationships among themselves, as well as information exchange.

The flipped classroom approach is defined as "what is done at school is done at home, homework completed at home is completed in class" in its most basic form (Bergmann & Sams, 2014). In the literature, there are numerous meanings of flipped classroom. According to Bishop and Verleger (2013), a flipped classroom is a student-centered learning strategy that consists of two parts: interactive learning activities during class and individual tutoring on a computer after class. It is characterised by Mull (2012) as an approach in which students prepare for the class through watching videos, listening to podcasts, and reading articles. Milman (2012) describes it as a strategy that tries to improve lesson efficiency by conveying knowledge to students through videos and vodcasts, as well as conversations, group projects, and applications during the course. According to Toto and Nguyen (2009), a flipped classroom is an approach that increases active learning activities and allows students to apply their knowledge in class with teacher guidance. Below are explanations from Bergmann, Overmyer, and Wilie (2011) on what is and is not a flipped classroom method. The flipped classroom approach is a system that allows for increased interaction time between the teacher and the student, the presentation of a situation in which students take responsibility for their own learning, the transition of the teacher's role into that of a guide, the blending of constructivist learning with teaching methods, each student receiving individual education, consistency of learning through repetitions, and the prevention of students falling behind in class for any reason. It is not essential to be a professional video maker to use the flipped classroom concept; any source that describes the subject can be used (PDFs, recorded sounds, websites).

By inverting the usual classroom lecture material delivery, the flipped classroom pedagogy provides students with learning possibilities. Instructors continue to assign homework; however, under the flipped pedagogy, students are obliged to read or watch pre-recorded lectures uploaded online by the instructor as part of their assignment, freeing up class time for student and group activities (Strayer, 2012). According to research, the flipped classroom paradigm allows instructors to concurrently teach course knowledge while also practising how to apply it (Demski, 2013). Students get to experience group discussions and activities in class because they are exposed to the course setting outside of class. This establishes a connection between application and material, such as lectures, textbook readings, and homework, as a result of this experience. Instructors might use class time to examine student work, participate in student group discussions, and respond to students' queries or concerns. This increased connection between the instructor and students, as well as between students and their teammates, encourages critical thinking, communication, and practical experience (Al-Zahrani, 2015).Furthermore, students listen to varied perspectives from colleagues and learn how teammates interact and process ideas through group conversations. Meanwhile, tudents are improving their ability to organise, study, analyse, and evaluate knowledge. As a result, critical thinking skills are fostered through active collaborative learning (Reddan, McNally, & Chipperfield, 2016). Students perceive increased control over their learning as a result of this open teaching technique, which includes meaningful dialogues with instructors and peers, in-

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class instructor support, immersive class activities, and following course content without class limits (Enfield, 2013; Davies, Dean, & Ball, 2013; Butt, 2014; Sengel, 2016). According to Bajurny (2014), the flipped classroom improves students' motivation, knowledge of curriculum subject, and self-regulation. The flipped classroom, according to Bergmann & Sams (2012), gives students "control of the remote" over their own learning. In the meanwhile, according to Nouri (2016), the flipped classroom approach presented promising opportunities to engage students in more effective, supportive, motivating, and active learning, particularly for low achievers and students who struggle with traditional lectures. As a result, the purpose of this study is to examine SCADA students' responses to the ODL platform using a flipped classroom method.

METHOD

The point of the study was to see how SCADA students reacted to the implementation of flipped classroom style. There were eight questions in total. The responses were graded on a 5-point likert scale ranging from strongly agree (5) to strongly disagree (1). This study was done out on undergraduate students who studied the ESE691 course from October 2020 to February 2021. There are a total of 68 students in the class consisted of …. Female () and male (). This study employs the SPSS approach, with a survey being utilised to determine ODL's experience with flipped classroom implementation online. This study is restricted to Universiti Teknologi MARA students who took the ESE691 course at the Shah Alam campus. Data were collected by using questionnaire which was composed of eight questions. two parts. The first part included Table 2 shows the eight types of questions used in the questionnaires.

Table 2: The design of the questionnaires

No	Question
1	Is this subject meet your expectation?
2	What is your level of understanding regarding this subject?
3	How is the quality of notes prepared for this subject?
4	Is the video presentation helps further understanding of this subject?
5	Is this subject relevant to the field of Electrical Engineering?
6	Is this subject relevant to the current technology?
7	Is this subject help prepare the student for the industries?
8	Is this subject suitable to be taught virtually?

RESULTS AND DISUSSION

Despite the fact that it is an elective topic with 100% coursework, students are generally supportive and flexible about the concept of the flipped classroom. This is centred on active exchanges and engagement between the lecturer and the students throughout online lessons, particularly during the Q&A sessions. For 68 undergraduate students, responses to the eight questions were collected and analysed using SPSS.

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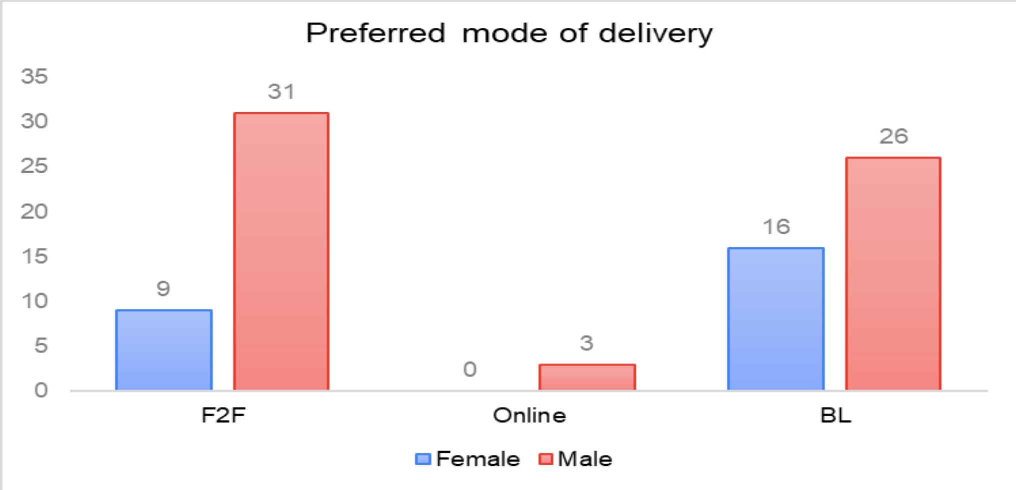

Preferred mode of SCADA delivery during T&L among the students

Overall, the students feel that the flipped classroom assists them in gaining a better comprehension of the material. The number of students who prefer a face-to-face classroom is forty, while the number of students who prefer an online platform is three. A mixed learning platform was selected by 42 students. The mixed learning strategy is shown in Fig. 3 as the most desired way of delivery. The descriptive proportion of survey items linked to the students' response to the flipped classroom methodology is shown in Tables 3 to Table 10.

According to Table 3, the most important factor perceived is video presentation (M=4.31, SD=0.697). This is followed by the subject expectation (M=4.32, SD=0.609) and industry-based skill (M=4.62, SD=0.547). Higher mean for recorded video presentation indicates that many students can understand the content of this subject during the pre-class session.

Table 3: Mean value and standard deviation of the items

Item	Sample (N)	Mean	Variance	Std. Deviaton
Gender	68	1.32	0.22	0.471
Subject Expectation	68	4.32	0.371	0.609
Video Presentation	68	4.31	0.485	0.697
Industry based	68	4.62	0.462	0.547

a. *Expectation*

Table 4 shows the amount of satisfaction with students' expectations for the SCADA course in the first column. Thirty-six pupils agree, twenty-seven strongly agree, and five neutral, according to the frequency column. We can deduct from this that the majority of students agree (52.9%) or strongly agree (39.7%) that the expectations of the SCADA course are reasonable.

Table 4: Expectation of SCADA course

Scale	Frequency	Percent (%)	Cumulative Percent (%)
Neutral	5	7.4	7.4
Agree	36	52.9	60.3
Strongly agree	27	39.7	100.0

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b. Understanding

Table 5 depicts the course's level of understanding regarding this subject. Nine students are neutral, forty-one are in agree, and seventeen are strongly agree.

Table 5: Level of understanding

Scale	Frequency	Percent (%)	Cumulative Percent (%)
Disagree	1	1.5	1.5
Neutral	9	13.2	14.7
Agree	41	60.3	75
Strongly agree	17	25	100.0

c. Quality of Notes

As shown in Table 6, about 8.8% of respondents are neutral, 44.1 percent agree, and 47.1 percent strongly agree with the quality of notes prepared for the pre-class session.

Table 6: The design of the questionnaires

Scale	Frequency	Percent (%)	Cumulative Percent (%)
Neutral	6	8.8	78.8
Agree	30	44.1	52.9
Strongly agree	32	47.1	100.0

d. Video

Table 7 shows the results of the video presentation. Overall, nine students are neutral, twenty-nine agree, and thirty strongly agree.

Table 7: Video presentation helps further understanding.

Scale	Frequency	Percent (%)	Cumulative Percent (%)
Neutral	9	13.2	13.2
Agree	29	42.6	55.9
Strongly agree	30	44.1	100.0

e. Relevancy in Engineering Field

Table 8 shows the percentage of students who believe SCADA is relevant to the subject of electrical engineering. 1.5 percent are indifferent, 23.5 percent agree, and 75% strongly agree.

Table 8: Subject relevancy to electrical engineering field

Scale	Frequency	Percent (%)	Cumulative Percent (%)
Neutral	1	1.5	1.5
Agree	16	23.5	25
Strongly agree	51	75	100.0

f. Current Technology

Table 9 shows the topic matter's relevance to current technology, with 2.9 percent neutral, 22.1 percent agreeing, and 75 percent strongly agreeing.

Table 9: Subject relevancy to current technology

Scale	Frequency	Percent (%)	Cumulative Percent (%)
Neutral	2	2.9	2.9
Agree	15	22.1	25.0
Strongly agree	51	75	100.0

g. Industrial-based skill

The percentage of SCADA courses that helped the School of Engineering educate our students with additional industry skills as part of their human capital after graduation is shown in Table 10.

Table 10: Subject helps preparing the student for the industries skill.

Scale	Frequency	Percent (%)	Cumulative Percent (%)
Neutral	2	2.9	2.9
Agree	22	32.4	35.3
Strongly agree	44	64.7	100.0

h. T&L Suitability

Table 11 demonstrates that the applicability of SCADA is hardly disputed, with 7.4 percent severely disagreeing, 19.1 percent disagreeing, 25% neutral, 30.9 percent agreeing, and 17.6 percent highly agreeing.

Table 11: Suitability subject to be taught virtually.

Scale	Frequency	Percent (%)	Cumulative Percent (%)
Strongly Disagree	5	7.4	7.4
Disagree	13	19.1	26.5
Neutral	17	25.0	51.5
Agree	21	30.9	82.4
Strongly agree	12	17.6	100.0

i. Realibility Test

Table 12 shows that the internal consistency test based on Cronbach's alpha is 0.819, which is sufficient for the items' reliability.

Table 12: The internal consistency test

Cronbach's Alpha	Cronbach's Alpha based on Standardized Items	No of Items
0.819	0.853	8

CONCLUSION

The purpose of this study was to see how SCADA students reacted to the flipped classroom. According to the data, SCADA students respond positively to the flipped classroom style. Facilitating active learning, establishing collaborative teamwork, and increasing classroom interaction were all advantages of its deployment. It demonstrates that one of the most significant advantages of the flipped classroom is an increase in total interaction: teacher-to-student and student-to-student. The current study focuses on student input in a flipped classroom setting. Classroom observation involving lecturers and students in elective subjects can be used to further investigate the implementation of the flipped classroom. Furthermore, another important topic to look into is the impact of adopting a flipped classroom on student achievement.

Author's contribution
Mahanijah Md Kamal - corresponding author, writer, questionnaire, data analysis
Noorfadzli Abd Razak - Coordinator Subject, subject content, questionnaire

Conflict of Interest: None

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