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Tinkercad simulation software to optimize online teaching and learning in embedded internet of things

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ABSTRACT

The epidemic of Covid-19 has had an impact on many industries, including education. Institution of higher learning education closures have brought significant disruptions to education. One of the limitations of emergency remote learning is the lack of personal interaction between lecturer and student. Innovation and implementation of alternative educational systems and assessment methodologies are urgently needed. The purpose of this study is to examine students' experiences (people, interaction, and time) during online teaching and learning at Polytechnic Muadzam Shah utilizing Tinkercad simulation software for Embedded Internet of Things subject. The study method applied was a qualitative approach based on Miles and Huberman's interactive model. The result of this study, students are able to design circuits and implement programming using Tinkercad simulation software. Most student showed positive response and good competencies or skills, well to write programming code when using Tinkercad simulation software. Therefore, the usage of new approach in online teaching and learning can fulfil the expected progress in learning performance in Embedded Internet of Things subject with no obstacles experienced by students. The Covid-19 epidemic has provided an excellent opportunity to pave the way for digital learning.

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Introduction

The epidemic of Covid-19 has had an impact on many industries, including education. Institution of higher learning education closures have brought significant disruptions to education. One of the limitations of emergency remote learning is the lack of personal interaction between lecturer and student. The pandemic has forced digital learning and job portal Naukri.com reports a fourfold growth for teaching professionals in the e-learning medium. Naukri.com, India's number 1 job marketplace states that the pandemic has driven a four-fold increase in the number of teaching professionals using e-learning (Darius et al., 2021).

Many schools and universities are now embracing online learning as a substitute of traditional teaching (Abu Talib et al., 2021). Innovation and implementation of alternative educational systems and assessment methodologies are urgently needed. The pandemic situation in 2019 has forced almost all institutions completely shift to classes online. Online distance learning(ODL) widely implemented by many tertiary educations globally and become a popular alternative to replace traditional distance learning(Allen & Seaman, 2017). Educational institutions must immediately switch to remote learning techniques that heavily rely on technology (Abu Talib et al., 2021).

According to Darius (2021), the four essential parts of online teaching are virtual classrooms, individual activities, assessments in real-time, and collaborative group work. Online teaching tools are used to facilitate faculty-student interaction as well as student–student collaborations. The ease of use, the satisfaction level, the usefulness, and the confidence level of the instructor is crucial in motivating the instructor to use online teaching tools (Darius et al., 2021). The virtual learning environment via live Q&A session, video conferencing, discussion forums and chat and online assessment such as Quizzes, Kahoot and etc. as become among popular choices (Herrador-Alcaide et al., 2020).

On the other way around, asynchronous allows students to take their online class at their own time and need. Instructor will provide the learning material digitally such as recorded video and assignment, then student can access at any time and submit on the dateline given. Obviously, hybrid means the integration of asynchronous and synchronous mode (face to face and internet technology) (Jamie & Carol A., 2020). To reduce the impact of this pandemic situation on education, an online education system was introduced.

In this system many online tools (Google class, Email, WhatsApp group, Facebook group, Zoom, MS Office 360, YouTube channel, Recorded PowerPoint presentation, laptop screen recorder and twitter) were used (Sodhar et al., 2020). On the basis of the basic idea of Internet of things, all stuffs will be able to connect with each other physically. IoT structure is based on the obtaining the information sent by actuators, sensors, tags, and storing the data in a cloud structure (Bayani, 2020).

Tinkercad is a free web application (Tupac-Yupanqui et al., 2022) that helps users with basic skills for innovation production, one of the products of Autodesk company that provides services such as 3D (3D Design), Electronics (Electronics), Coding and Augmented Reality (AR) encoding (Coding) and Augmented Reality (AR). Tinkercad is easy to use because it does not need to be installed on a computer or smartphone. In addition to the 3D design menu, Tinkercad also enables electronic circuit design and programs using Circuits and Code blocks menu (Tupac-Yupanqui et al., 2022). This gives the idea that Tinkercad is a web application that can affect computing thinking in terms of creativity, algorithm thinking, cooperation, critical thinking and problem solving (Eryilmaz & Deniz, 2021).

The role of engagement in e-learning is important for effective learning as it is not merely student-student interaction that matters. There are six different forms of engagement that can be identified in distance learning education: (1) teacher-content (2) content-content (3) student-teacher (4) student-student (5) teacher-teacher and (6) student-content (Rawashdeh et al., 2021). The purpose of this study is to examine students' experiences (people, interaction, and time) during online teaching and learning at Polytechnic Muadzam Shah utilizing Tinkercad simulation software for Embedded Internet of Things subject. Thus, to observe implementation online practical work via online distance learning using Tinkercad simulation software compared to physical practical work via face to face.

In addition to the technologies used, the acquisition of 21st-century skills depends on the knowledge, skills, and attitudes of the trainers or instructors who teach technology towards new technologies. In this case, besides providing students with basic skills related to ICT, higher instutions, and instructorss have the most important role in effectively optimizing and integrating technology into the teaching and learning.

Method

This study method uses a qualitative approach. Data collection is based on observation results, and related documentation analysis. Data analysis using the interactive model of Miles Huberman. The components of data analysis in interactive modes are data collection, data reduction, data display and conclusion or verification (Matthew B. Miles, 1994).

Purposive sampling technique was used which sample is an all population. Purposive Sampling, sometimes referred to as purposive and selected sampling, is a sampling approach that qualitative researchers employ to choose individuals who may offer in-depth and through information about the topic under inquiry. The participants in this study were 12 students who taken Embedded Internet of Things subject during session 1 2021/2022. There are 8 males and 4 females as research sample. Data collection based on the results of observation upon student's practical Laboratory Task.

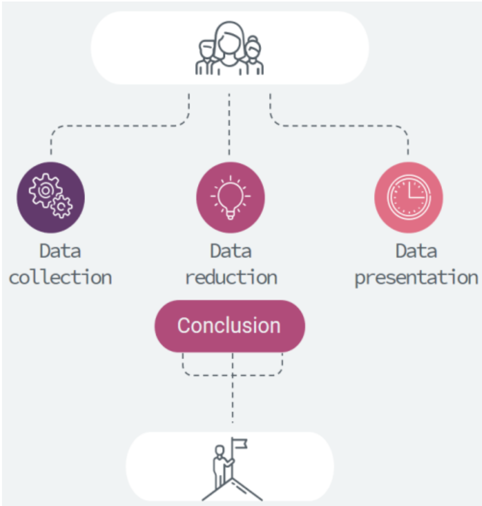

Figure 1 <Interactive Model of Data Analysis (Miles & Huberman, 1994)>

The Embedded Internet of Things subject uses Tinkercad circuits for combining electronic circuit design, programming using Codeblocks or C ++ and simulations to see how electronic components and circuits respond. Tinkercad Circuits contains electrical and electronic components that can be combined into a complete circuit. In addition, Tinkkercad Circuits also provides electronic circuit learning with Arduino Uno R3. There are classifications of various hardware components that can be added and the area code to learn to write programs. Figure 1 shows an example of LED circuits using Arduino Uno R3 designed in the Tinkercad. While the LED circuit program code is shown in Figure 2.

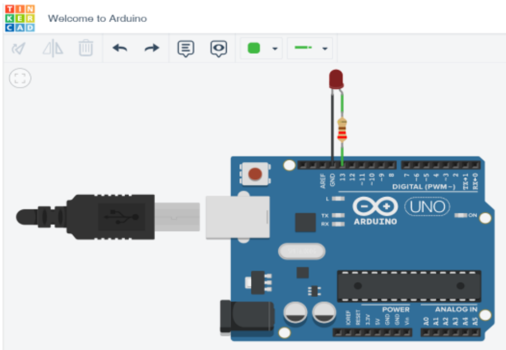

Figure 2 <Example of Electronic Circuit using Arduino in Tinkercad>

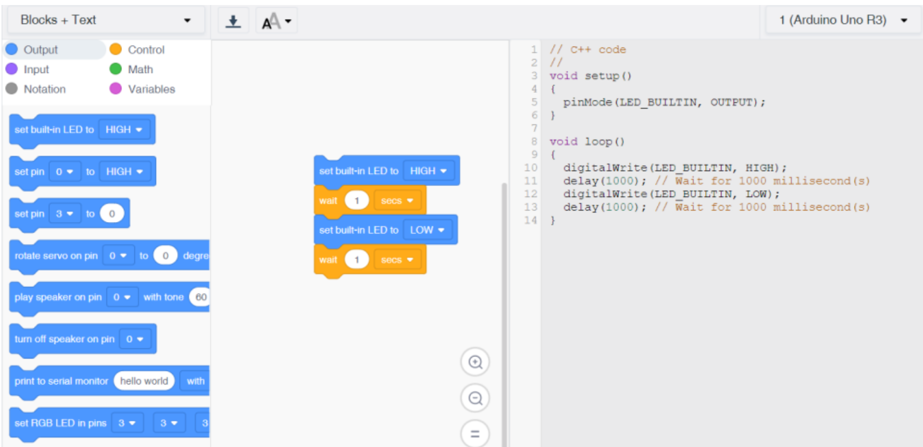

Figure 3 <Program Code for Electronic Circuit using Arduino>

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Arduino is an electronic open platform based on hardware and software that is easy to use and learn (Tupac-Yupanqui et al., 2022). One of the main functions of the Arduino board is to read or receive the input provided to it such as sensors, switches, and even from messages sent from smartphones. The input will be converted to the required output, for example such as activating electrical equipment, output display on the LCD screen or online to display on the website.

Arduino has many benefits to use in the educational environment. The use of Arduino in learning can enhance students' skills in learning C/C ++ programming languages and electronic circuits (Tupac-Yupanqui et al., 2022). The use of Tinkercad Autodesk software can reduce storage space in computer devices as its use is online, without involving any installation process (Saidun et al., 2020).

Instead of rote learning to ensure that students absorb information and maintain it in their memory, information is now transmitted on how to use new technologies, how they can benefit, and most importantly, what they can accomplish with them. Based on the syllabus, Sensors, Actuators and Microcontrollers (SAM) subtopic are chosen as scope and divided into three learning outcomes as shown in Table 1.

Table 1 <Competency Target for in Embedded Internet of Things Subtopic>

Subtopic	Competency	Indicator
Sensors, Actuators and Microcontrollers	Study the components and devices used to build electronic circuits	• Build a simple electronic circuit
	Assemble microcontroller programs with variety of components	• Build a simple system controlled by a microcontroller
	Perform microcontroller configuration to monitor a variety of sensor/inputs	• Build a simple program that use photoresistor sensor, ultrasonic sensor, temperature sensor and button input.
		• Use microcontroller to control more complex actuators such as DC servo motor

This study focuses on topic 2 that require students to conduct microprocessor configurations to monitor various sensors and inputs. Students are first exposed to the types of electronic components and microprocessor lab kits. Students also need to develop a simple program using a variety of sensors such as photoresistor sensors, ultrasonic sensors, and temperature sensors. In addition, students need to use microprocessors to control more complex drivers such as motors Servo DC, Motor AC and LED. To achieve these learning outcomes, students implement configurations and simulations using Tinkercad circuits online and monitored and supervised by their lecturer.

The teaching and learning session for SAM subtopic lasts for four hours a week in four weeks. Teaching and learning activities are summarized as shown in Table 2.

Table 2 <Activity Plan in Classroom>

Date	Activity
October 7, 2021	Introducing the use and features of Tinkercad simulation software Students are explained how to build a series circuit using basic electronic components. Students build a simple parallel circuit to light three LEDs.
October 8, 2021	Students modelled the LED light circuit and programming using the Arduino UNO microcontroller. Students design a three-junction traffic light simulation.
October 14, 2021	Students build circuits and programs using photoresistor sensors.
October 15, 2021	Students build circuits and programs using ultrasonic sensors.
October 21, 2021	Students build circuits and programs using PIR sensors and buzzers.
October 22, 2021	Students build a circuit and program using a temperature sensor with 1 LED output. Students modify the temperature sensor circuit with 3 LED output according to the temperature level and LCD display.
October 28, 2021	Students design a circuit simulation for a pressure sensor with an LCD display LED and a buzzer.
October 29, 2021	Students design a circuit simulation for motor control by Arduino and motor driver L293D with four push buttons to control the direction of motor movement.

Results and Discussions

There are numerous ways to conduct practice-based online learning including autonomous learning, live video conferencing, and online exercise (Ping et al., 2020). In this study, autonomous learning with online training is combined using Tinkercad simulation software. The results of this study are three aspects that are measured according to the student's ability. The first aspect is to test whether students can complete their assignments properly using Tinkercad simulation software.

Then to find out the response (feedback) of the students when using Tinkercad simulation software. Whereas the third is to find out the achievement of students (compensation) based on the assignments. Student achievement for the Embedded Internet of Things subject is evaluated based on the assigned tasks. Some of the tasks performed are as shown in Table 3.

Table 3 <Detail of Student’s Assignment>

Assignment	Detail of assignment
Practical Work 1	Design simulation of a signal light circuit at three junctions.
Practical Work 2	Design pressure sensor circuits as input while LEDs and LCD display as outputs
Practical Work 3	Design a circuit simulation for motor control by Arduino and motor *driver* L293D with four push buttons to control the direction of motor movement.
Mini Project	Design a temperature sensor circuit with 3 LED outputs according to the temperature level and LCD display.

In the early stages of online practical classes, students are exposed to how to design a signal light circuit that can be determined time on the program code written. Subsequently, students were asked to carry out the Practical Work 1 assignment that required the student to transform the circuit into a traffic light for a three junction. Students design with the creativity of each electronic component position used. Students also modify the program code so that they can program the lights the signal lights up in the correct flame.

Figure 4 shows the student work for the Practical Work assignment 1. The students can design the circuit neatly and orderly. The circuit can also be simulated, and the output results obtained meet the requirements of the question. The student named ARA need help in preparing circuits as well as program codes. The components are neatly organized, and the circuit connection needs to be corrected. This show that online learning can be enhanced by giving learners control of their interactions with media and prompting learner reflection(Means et al., 2010).

SAA ARA

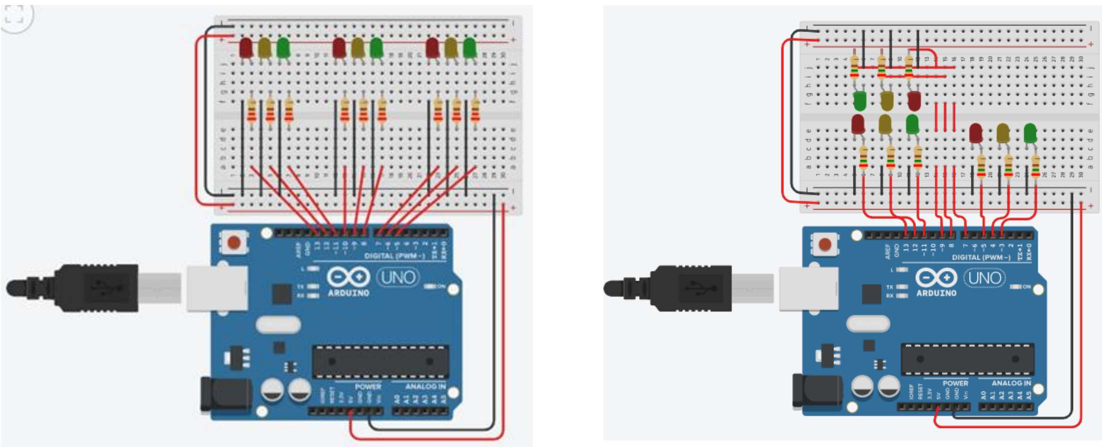


Figure 4 <Sample of student work for Practical Work 1 task.

Practical Wok 2 requires students to design pressure sensor circuits as input while LEDs and LCD display as outputs. The green LED will light up and the LCD display will display the Load Detected if the pressure sensor can detect the load. Instead, the red LED will light up and the No Load display is obtained if no load is detected.

Figure 5 shows the student's work for the Practical Work assignment 2. The student MAR design circuits with minimal use of space and look neater and more organized. MAR also successfully displays output as set. While the student MKA produces less neat circuits and outputs are not as questions. As a result, it has been found that using Tinkercad in 3D design education increases students' motivation for the lesson, and Tinkercad is perceived as an easy and convenient program to use. In addition, Tinkercad has a significant impact on the development of students ' computational thinking skills (Eryilmaz & Deniz, 2021).

MAR MKA

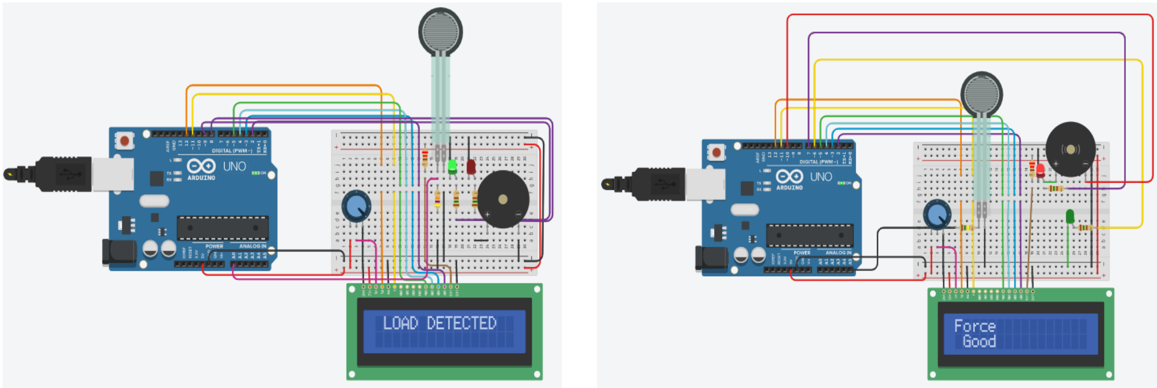
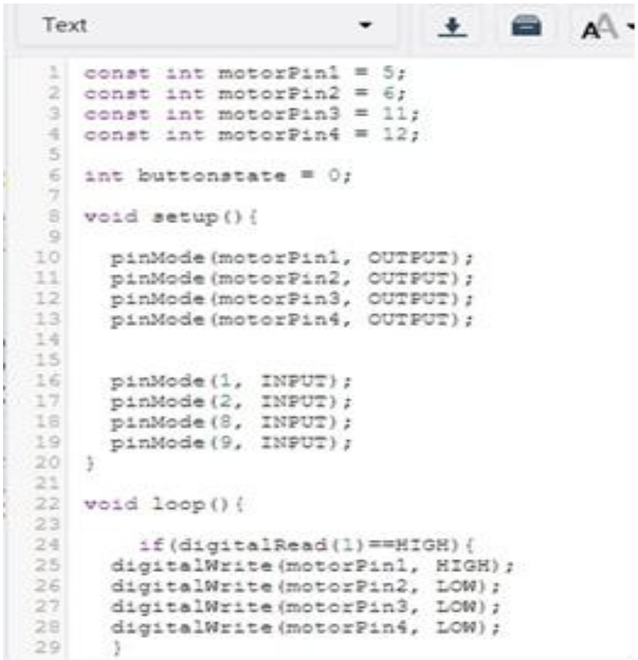


Figure 5 <Sample of student work for Practical Work 2 Task>

Practical Work 3 focuses on students using microprocessors to control more complex drivers such as DC Servo Motor. Students need to design simulation circuits for motor control by Arduino and Motor Driver L293D with four press button switches to control the direction of motor movement. The press switch determines the direction of the motor movement either to the right, left, front and back using code in Figure 6. As formulated in Figure 7, the student ZMS can produce neat and functional simulation circuits. While the student KFS can also produce good simulation circuits with little help from lecturer. The circuit produced by KFS uses a longer connector or connector that causes the resulting circuit to be less neat.


Text

```
const int motorPin1 = 5;
const int motorPin2 = 6;
const int motorPin3 = 11;
const int motorPin4 = 12;

int buttonstate = 0;

void setup(){

  pinMode(motorPin1, OUTPUT);
  pinMode(motorPin2, OUTPUT);
  pinMode(motorPin3, OUTPUT);
  pinMode(motorPin4, OUTPUT);


  pinMode(1, INPUT);
  pinMode(2, INPUT);
  pinMode(8, INPUT);
  pinMode(9, INPUT);
}

void loop(){

    if(digitalRead(1)==HIGH){
  digitalWrite(motorPin1, HIGH);
  digitalWrite(motorPin2, LOW);
  digitalWrite(motorPin3, LOW);
  digitalWrite(motorPin4, LOW);
  }
```

Figure 6 <Sample of Student Coding for Motor Movement Simulation>

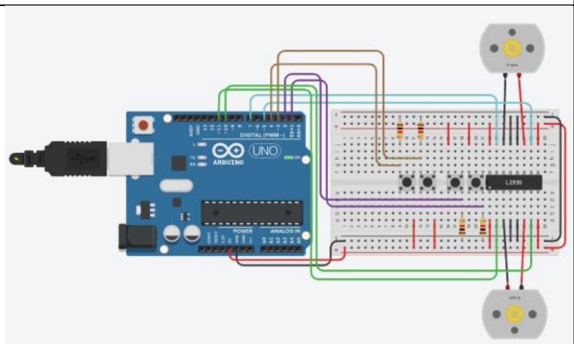
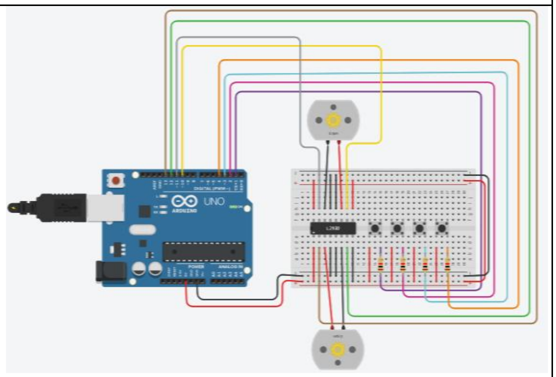
Students Name Initial	ZMS	KFS
Results		

Figure 7 <Sample of Student Work for for Motor Movement Circuit>

For the Mini Project assignment, students are required to design temperature sensor circuits with 3 LED flames of different colors according to temperature and LCD display levels. The green, yellow, and red LEDs will light up according to the specified temperature range. Temperature readings are also displayed on the LCD display according to the temperature detected by the temperature sensor. The student SAA produce a simulation circuit with a program code that works well while the student MAH needs the help of lecturer in the program code section.

A sample work from the student ZMS show that ability to make motor movement circuit correctly and independently and work from the student KFS shows that ability to complete task with little help from the instructor. Circuit design from student ZMS is neater compared to student KFS, this depends on student's creativity.

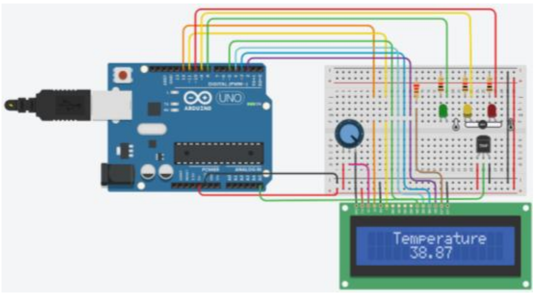
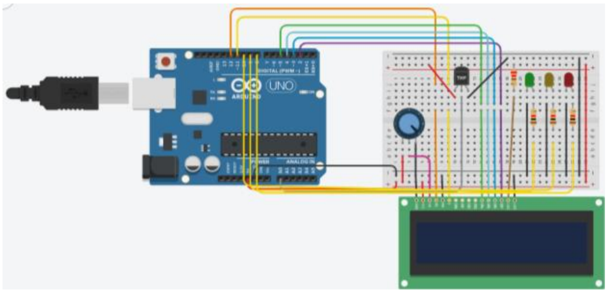
SAA	MAH
	

Figure 8 <Sample of Student Work for Mini Project Task>

From the documentation results of student work and observation results during the study were formulated as shown in Table 4. Student work involves Practical Work 1, Practical Work 2, Practical Work 3, and Mini Project in Figure 8. Some students can complete the assigned tasks independently and there are also students who need little help from the lecturers or instructors. All students also succeeded in submitting all assigned tasks at the appointed time.

Therefore advantages of Tinkercad simulation software is it's easy to use with interface, also can developing many skills such as 3D thinking, critical thinking and creative thinking (Selami Eryilmaz, 2021). In teaching process, different ways can be adopted, such as teachers leading students to solve problems, teachers and students jointly solving problems, and students independently exploring and solving problems (Ping et al., 2020). Ping (2020) also states that teaching has become a process with clear purpose and can motivate students' initiative.

Based on table 4, student achievement in all tasks assigned shows that almost all students can complete the task of performing microprocessor programming using the Tinkercad simulation software application. This indicates that students can achieve the learning outcomes set out in the lesson plan for Embedded Internet of Things subject.

Table 4 <Summarize Result of Student Achievement while using Tinkercad Simulation Software in Task Given>

Student Name Initial	*Practical Work 1*	*Practical Work 2*	*Practical Work 3*	*Mini Project*
ZMS	Complete	Complete	Complete	Complete
MHJ	Complete	Complete	Complete	Complete
NAS	Complete	Complete	Complete	Complete
ARA	With intense help	Complete	Complete	Complete
MAR	With intense help	Complete	Complete	Complete
SAA	Complete	Complete	Complete	Complete
MAH	With intense help	Complete	With intense help	With intense help
KFS	With intense help	Complete	With intense help	Complete
MKA	Complete	With intense help	Complete	Complete
MSK	With intense help	With intense help	With intense help	Complete
NAR	Complete	With intense help	Complete	Complete
FSS	Complete	Complete	Complete	Complete
Improvement (in percentage)	58%	75%	75%	91%

According to (Rawashdeh et al., 2021) Tinkercad simulation software is easy to communicate and learn, able to develop individual skills and increase students' skill in education in using electronics. Online learning activities are more student-centered than teacher centered. It is necessary to have learning media that easy for students to use and also able to train students' skills in order to meet vocational competencies (Sangsawang, 2020).

Conclusions

During the epidemic, lecturer, and student both received new forms of instruction as traditional learning was replaced with online distance learning. This study contributes to practice-based online learning experience by student who affected due to pandemic. Tinkercad simulation software became the choice of autonomous learning as the tool was provided by the institution in learning Embedded Internet of Things subject. According to the findings of this study, Tinkercad simulation software is an excellent option for addressing the demand for electronic skills competency in teaching and learning during COVID-19. Nearly all students respond favorably and comprehend each work that has been given to them. While only a few of students need intense help from lecturer.

However, there were several factors, including poor internet access and an unfavorable setting, that affected student motivation during online learning. Despite these difficulties, students concur that online learning provides a similar sense of fulfilment as face-to-face learning. With the development of technology, it is crucial to have a well-designed instructional between the student and lecturer to enable effective communication and knowledge delivery. The findings of this study can assist lecturers in selecting the application that will transfer knowledge most effectively.

Most students showed positive response and good competencies or skills, well to write programming code when using Tinkercad simulation software. All students also response that use Tinkercad simulation software as simulation tool for their Final Year Project development. Therefore, the usage of new approach in online teaching and learning can fulfil the expected progress in learning performance in Embedded Internet of Things subject with no obstacles experienced by students. The Covid-19 epidemic has provided an excellent opportunity to pave the way for digital learning.

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