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A Comparative Analysis of Student Performance in Learning Assembly Programming Language using Online EdSim51 Simulator vs. In-lab Micro TRAK/51-C2 Kit

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Abstract: *The purpose of this study was to determine which method proved more effective in learning assembly programming language over the period of 6 years. This study was implemented in microcontroller laboratory CPE-364 at Computer Engineering Department, Kuwait University. The first group is composed of 120 students attending the traditional in-lab classes, while the second group comprises 86 students attending online classes due to the Covid-19 pandemic. The study determines which modality resulted in better student performance to learn the assembly language. In microcontroller laboratory, students usually learn to become familiar with programming model and instruction set of 8051, understand the process of assembling and running an 8051 program, debug and run the program. The in-lab students use the Micro TRAK/51-C2 kit with the Micro IDE software. However, the online students use the 8051 Simulator EdSim51. Data was analyzed using one-way ANOVA and t-test. Results from the current study showed that there are no significant differences between the two group scores. The p-value= 0.072> α =0.05 for both tests, where α is the significance level of the test. These data translate the similarity of students' performance in learning assembly programming language in both in-lab Micro TRAK kit with Micro IDE software and online EdSim simulator.*

Keywords: Scores, T-Test, One-way ANOVA, face-to-face (F2F)
2021 Mathematical subject classification: 62M10

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1. Introduction

Covid-19 has affected the education system across the world. As a result, people became isolated and most of educational institutions have moved to the online teaching strategy. Countries did not use online learning were mostly affected from the closure of educational institutions via covid- 19 crisis. The education system was transformed from face to face into online teaching [1].

Therefore, students were required to use new recourses such as internet and online learning. Education institution were also required to prepare curriculums with teaching plans to recover the lost period during their closure [2].

Kuwait University underwent forced closures to limit the virus spread. Therefore, online learning was vital to continue the education system in the country. During the closures, the Computer Engineering Department designed a teaching-learning strategies for all courses and laboratories. Many strategies were prepared to recover lost learning during the forced closures and to manage students' return once reopen. The microcontroller laboratory was switched from using the in-lab Micro TRAK/51-C2 Microcontroller kit with the Micro IDE software to the online 8051 Simulator EdSim51. Micro TRAK/51-C2 kit modules consist of MINI-MAX/51-C2 Microcontroller board, Micro TRAK Carrier Board, TB-1 Training Board, PROTO-1 Prototyping Board, 8051 I/O Module, LCD242-BK LCD, and 4X4 Keypad. On the other hand, EdSim is a virtual 8051 software which consists of virtual peripherals such as a keypad, motor, display, UART, etc. Students can write assembly programs, debug the code, and execute to get results in memory and peripherals.

This study compares the students' performance in learning assembly programming language using Online EdSim simulator vs. in-Lab Micro TRAK/51-C2 kit with IDE software. This study sought to compare the total lab score which is based on five levels of assessments:1) attendance, 2) lab works, 3) quizzes, 4) exams, and finally 5) a project. Through this comparison, we investigated whether one modality was more effective than the other. The overall scores of both groups were analyzed to provide additional measures to determine if students performed better with real kits or virtual simulators. The result of this study serves future studies due to similarity of students' performance in learning assembly programming language in both in-lab or online classes and the potential need of online hardware laboratories.

The Scope of the Study

The scope of the study is attempted to tackle the following goal:
Assessing performance of students in learning assembly programming language using in-lab Micro TRAK kit with Micro IDE software vs. online EdSim simulator.

2. Literature Review

The study results show that students' performance in learning assembly programming language is almost identical for both online EdSim simulator and in lab Micro Trak kit. There is no typical study evaluating same modalities. Most previous studies comparing the regular in class learning vs F2F learning with many factors such as certain courses, prices, qualitative analysis over many years [3]. A study evaluating the conversation of a graduate level course. Teachers, online course academic quality, and outcomes were evaluated. The study evaluated instructors' ability to design online courses with a low-cost multimedia-interactive models which would help students and teacher to communicate. The online platform delivers information effectively in which tested students properly achieved learning outcomes as to F2F-course students [4]. One more study comparing the similarities differences between online and F2F learning due to student satisfaction. This study concluded that both F2F and online have similar course satisfaction due to qualitative feedback. However, using qualitative feedback will result in less course satisfaction for the online than the F2F [7]. However, another study concluded that that there is no difference between online learning vs F2F in student success due to feedback data [5]. A qualitative study consisting of 170 students was evaluated. The students were from two different engineering departments. The study result was pointing to the need of using both synchronous in addition to asynchronous learning to enhance learning performance and skills [14]. Another study was implemented on a sample of 30 students and 31 information-technology experts from six universities in Jordan and Saudi Arabia using interview guidelines instead of structural questions. The study target was to enhance online education efficiency during covid-19 pandemic in developing countries [17]. A recent study was applied in U.S. at California State University. The study sample consists of 110 faculty members and 627 students from six engineering departments. They answered questions related to online learning during covid-19. Their answers reflect their experience during the online semester in Spring

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2020. Results of the study recommended educational strategies that would fill the technology gap and enhance the online engineering learning [16].
From the literature review, there are no studies that have done in this context in Kuwait, and hence conducting the current study is timely and relevant.

3. Methodology

3.1 Participants
The study sample consisted of 206 students who completed the Embedded Systems laboratory between 2015 and 2021. The final lab grades of the participants served as the primary comparative factor in assessing performance differences between the Mirco-TRACK kit and the EdSim simulator. Of the 206 total participants, 86 students attended online classes, while 120 students attended the traditional in-lab classes. No preferences or weights were given to the selected students. Each student was considered a single, discrete entity or statistic. The study included 11 in-lab sections from 2015 to 2018 (before the Covid-19 pandemic) and 4 online sections from 2019 to 2021 (during the Covid-19 pandemic). Both in-labs and online meet once weekly. Each lab lasted 2 hours and 50 minutes. Online labs covered the same material as the in-class labs but were done wholly on-line using Microsoft teams MS. Class attendance, lab work, quizzes, exams, and project to engage students were all combined in the learning process.

All lab sections included in this study were conducted by one tutor who had a teaching experience in microcontroller and embedded systems laboratories for over 15 years.

3.2 Programming Tools
Two programming tools were used and compared in the current study among student groups. The in-lab students used the Micro-Track/51-C2 kit with Micro IDE software to write, assemble, and execute assembly programs in the embedded systems laboratory. However, the EdSim simulator was used by students attending online labs.

3.2.1 Micro TRAK/51-C2 kit [9] (Figure 1)
The Micro TRAK/51-C2 Complete kit modules peripherals are, Micro TRAK Carrier Board, MINI-MAX/51-C2 Microcontroller board, TB-1 Training Board, PROTO-1 Prototyping Board, 8051 I/O Module, LCD242-BK LCD, and 4X4 Keypad, as follows:
- **The Micro TRAK Carrier Board** is Universal Carrier Board for Micro TRAK Training/Project Kits.
- **TheMINI-MAX/51-C2 Microcontroller board** includes, ATMEL AT89C51ED2 micro-controller, 64K Flash program memory, 1792 bytes Expanded RAM (XRAM), 512-byte serial EEPROM (Optional up to 128Kbyte EEPROM), 2K Bytes of data EEPROM, RS232 Serial Port, 32 Digital Input/Output Lines, 5-Channel 10-Bit Analog/Digital Converter (ADC), LCD, keypad and expansion connectors, In-system programming/debugging, Micro IDE, Micro C Compiler, Serial loader, simulator and debugger, Unregulated 6-12 Volts DC operation, 22.1184 MHz clock speed, and 6 Volts DC Adapter, serial cable and serial downloader included.
- **TB-1 Training Board** includes, 3 Traffic light LED's (red, yellow, green), 2 interrupt inputs, 2 switch inputs (in parallel with interrupt inputs), 2 timer/counter inputs, 4 channels of 8-bit analog inputs, 0 to 2.5V range, Programmable buzzer, and Expansion bus to other boards.
- **PROTO-1 Prototyping Board** with a 20-pin universal expansion connector to add analog inputs/outputs, temperature sensors, relays, displays and many other circuits.

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- **8051 I/O Module** Access to all input/output (I/O) ports of the 8051. It includes, 32 switches to control the 8051 microcontroller inputs, 32 LEDs to indicate the port statuses as logic LOW or logic HIGH.8051, and 36-pin input/output connector.
- **LCD242-BK LCD** is a 24 Characters x 2 lines LCD LED Backlit Display. It Connects directly to MINI-MAX boards using the included cable.
- **4X4 Keypad** is 4 columns by 4 rows matrix keypad.
- **System Requirements:** Personal Computer (PC) with, Minimum 256MB memory and 200 MB of available hard disk space, One COM (RS232 Serial) Port (or a USB to COM converter), Operating System →Windows 98/ME/NT/2000/XP/Vista/Windows 7(32-bit or 64-bit) or higher. Figure 1 shows a Micro TRAK/51 kit.

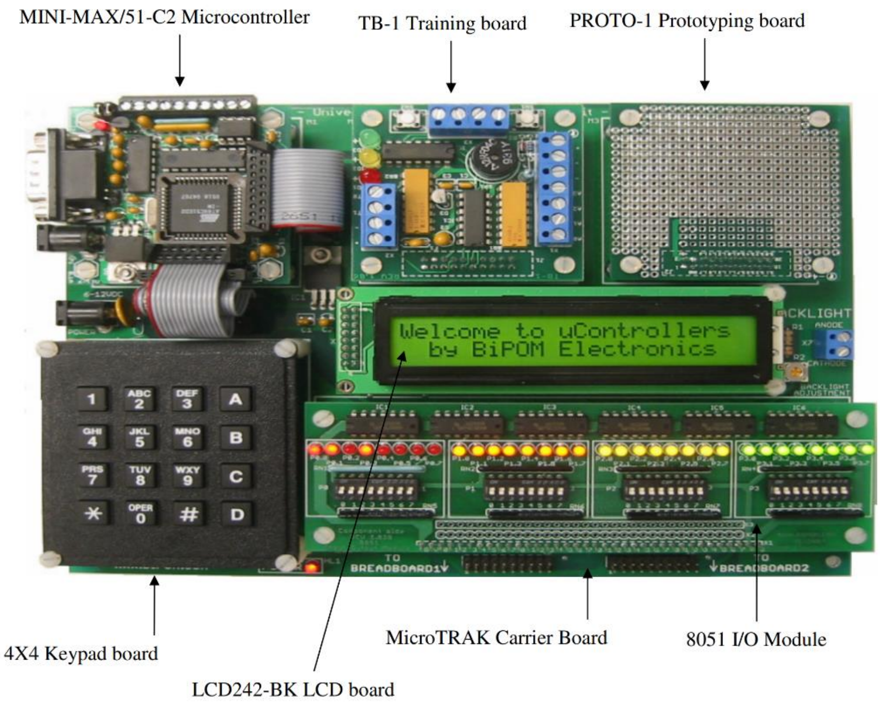

Figure 1: Micro TRAK/51 kit.

3.2.2 EdSim 51 simulator

The Virtual Peripherals of the EdSim 51 simulator includes, Analogue-to-Digital Converter (ADC), Comparator, UART, 4 Multiplexed 7-segment Displays, 4 X 3 Keypad, 8 LEDs, DC Motor, 8 switches, 4 Multiplexed 7-segment Displays, and Digital-to-Analogue Converter (DAC) - displayed on oscilloscope. **Figure 2** [9] shows an active running program sample on EdSim**.** The top left box gives the user access to all the 8051's registers, data memory and code memory. The center is a textbox where the user either loads an assembly program or writes the code directly. On the right is a list of the 32 port pins and what each one is connected to. The bottom panel shows all the peripherals that are connected to the 8051. The logic diagram of the EdSim simulator is shown in **figure 3** [9].

System requirements of the EdSim51 simulator can be installed and run using windows. However, since it is Java™ based, therefore it should run on any operating system that has the Java Runtime Environment installed.

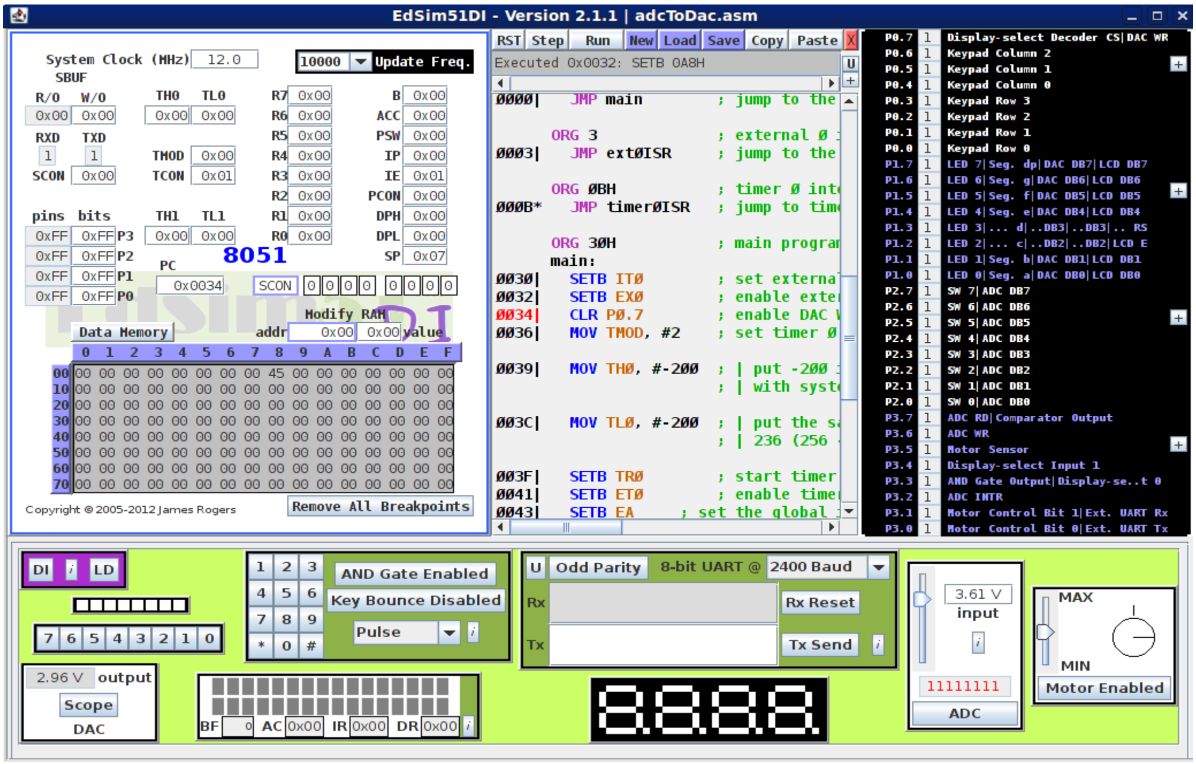

Figure 2: Active running assembly program on EdSim.

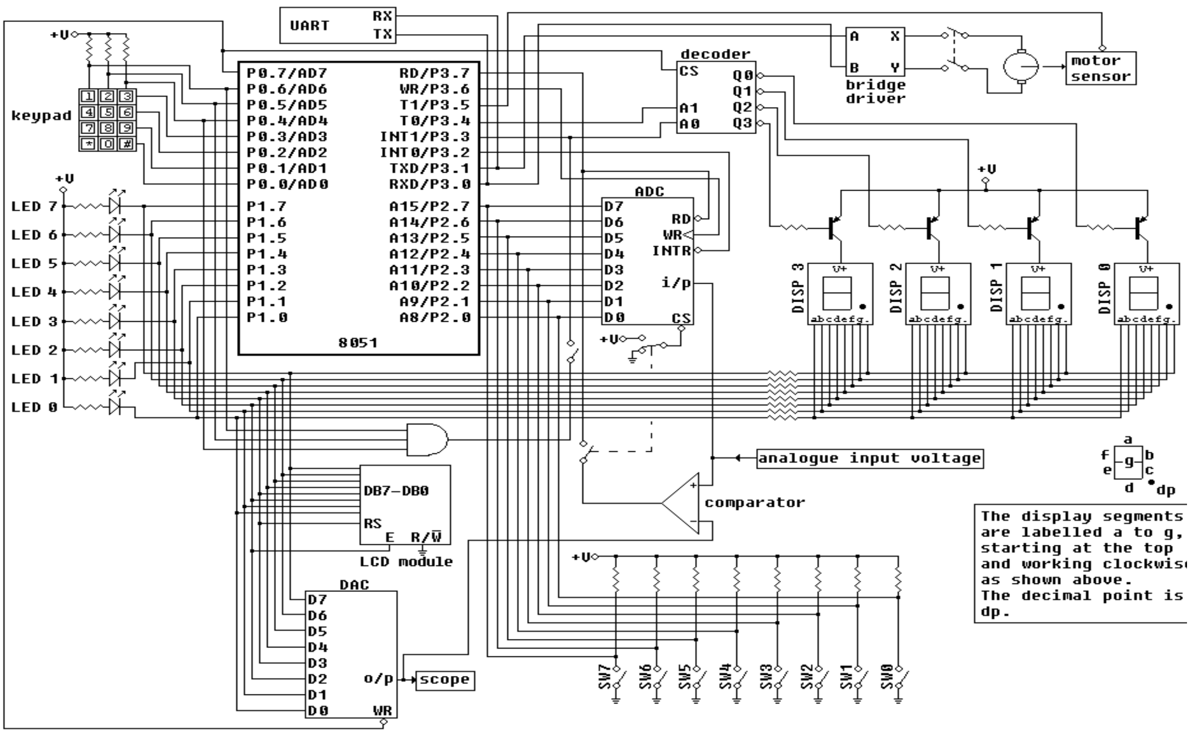

Figure 3: Logic diagram of EdSim 51 simulator.

3. 3 Assembly Programming Language:

Assembly language is a low-level programming language for a computer or other programmable device specific to a particular computer architecture. Therefore, a student requires an extensive understanding of the architecture of the Microcontroller to be able to write assembly programs. Programming model of 8051 shown in **Figure 4** which describes available registers, addresses, and functions that the programmer could use [10].

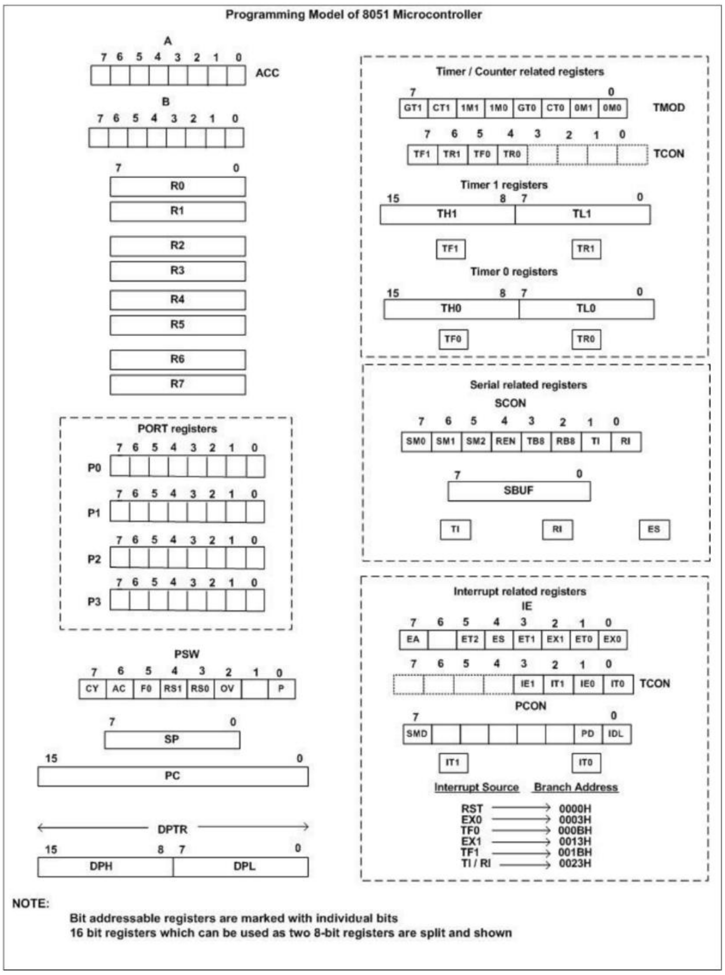

Figure 4: 8051 Computer model

3. 4 Measured outcomes

In this study, student performance was operationalized by final course grades. The final course grade was obtained from attendance, lab work, quizzes, exams, and project scores. The five mentioned assessments were useful in generating objective performance measurements. The final grades were converted from numerical scores to GPA letters according to Kuwait university grading system.

Attendance: 5%. Attendance is mandatory. According to KU rules, missing 3 lab sessions will result in FA grade. Moreover, missing any lab will result in loosing attendance points for that lab.

Lab work: 10%. Student should solve the exercise attached after each lab experiments. This lab work should be completed within lab hours. The exercise is related to the experiment topic explained with modifications.

Quizzes: 20%. 4 quizzes are assigned for this lab, where each is weighted out of 5.
Exams: 50%. Two midterm exams are assigned for this lab. 1st midterm weight 20% and the 2nd midterms weight 30%.

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Project: 15%. Includes 4 phases which are required to be submitted with project report and final practical exam.

3. 5 Data Collection Procedures

The grades of the sample 206 students were obtained from the embedded systems laboratory offered by Kuwait University, where 86 students learned assembly language using the online simulator EdSim51 during the Covid-19 pandemic, and 120 students learned the assembly language using Micro TRAK kit with Micro IDE software during regular in-lab sessions at the University campus before Covid-19.

3.6. Data Analysis

The obtained data were analyzed through one-way ANOVA and t-test to calculate specific values and draw conclusions.

4. Results

Two statistical procedures were conducted to analyze the data statistically: one- way ANOVA and t-test.

Hypothesis Resolution

H0: There is no statistically significant differences in scores between the two groups.
Versus the following alternative hypothesis.
H1: The in class group statistically significantly outperform the online group.

Validity of the tests

The tests should stratify the following criterion.
1) Equality of Variances for scores of the two groups.
2) Normality assumptions for scores of the two groups.

Table 1: Test of Homogeneity of Variances

Levene Statistic	df1	df2	Sig.
1.227	1	202	.269

It is clear from **Table 1** that the Levene Test for homogeneity of variances is not significant at 5% significance level. The $p - value \ = \ 0.269 > \alpha = 0.05$ for both tests. Based on Levene test, it can be concluded that the variance of scores for the two groups are equal.

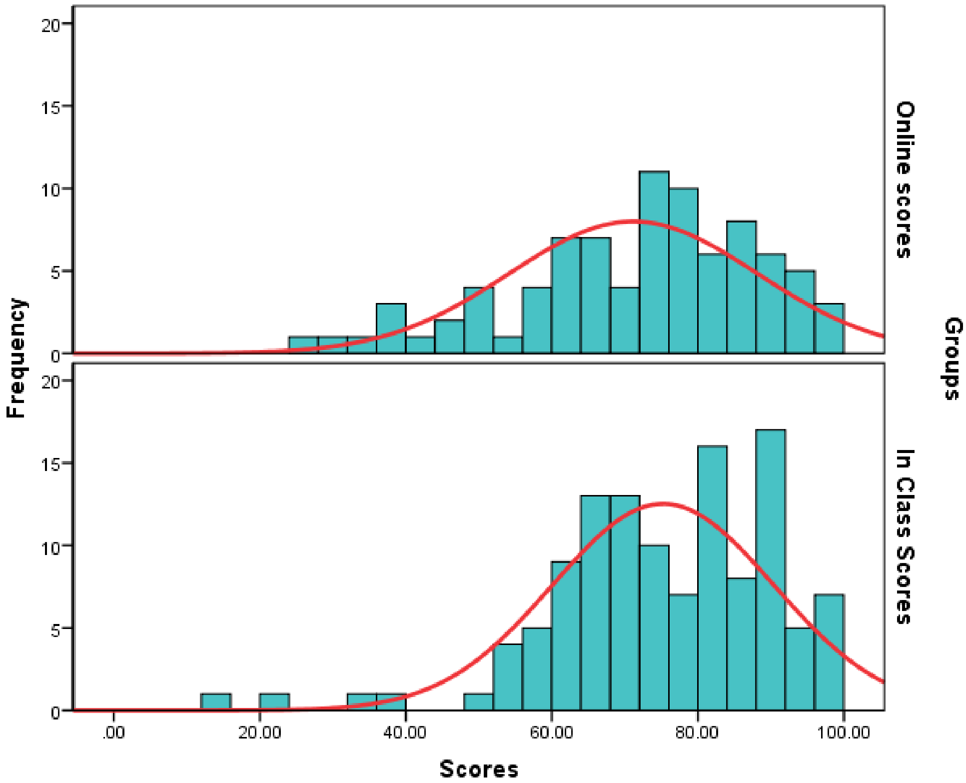

Figure 5: Normal curves for scores of the groups

It is clear from **Figure 5** that the scores of the two groups satisfy the normality assumptions.

Table2: A descriptive statistics for scores of the two groups

Group Statistics					
Groups		N	Mean	Std. Deviation	Std. Error Mean
Scores	Online scores	85	71.1456	16.96564	1.84018
	In Class Scores	119	75.2378	15.16642	1.39030

The means and the standard deviations of the scores are almost equal as shown in **Table 2.**

Table 3: t-test results

Independent Samples Test

		Levene's Test for Equality of Variances		T-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	90% Confidence Interval of the Difference	
									Lower	Upper
Scores	Equal variances assumed	1.227	0.269	-1.808	202	0.072	-4.09217	2.26231	-7.83263	-0.35171
	Equal variances not assumed			-1.774	168.244	0.078	-4.09217	2.30634	-7.90677	-0.27757

It is clear from **Table 3** that $p - value \ = \ 0.072 > \alpha = 0.05$ which implies that there are no significant differences between the mean scores for the two groups. That is the test will support the null hypothesis of equal means with 5% level of significant.

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Table 4: One-Way ANOVA test results

Scores	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	830.315	1	830.315	3.268	0.072
Within Groups	51320.368	202	254.061		
Total	52150.682	203			

One-way ANOVA analysis results are shown in Table 4. The same conclusion drawn from results of **Table 3** can be applied here.

The F-Ration test is not significant as $p - value = 0.072 > \alpha = 0.05$.

5. Discussion

The outcomes of the study show that although there were sample size issues and study limitations, there is no significant difference in students' performance to learn assembly programming language using online EdSim simulator vs in-lab Micro TRAK kit and Micro IDE software. Results obtained from the statistical tests reflect this fact obviously. The variance of scores for the two groups of the study are equal, the means and the standard deviations of the scores are almost equal, and the F-Ration test is not significant. In the current literature, many studies evaluated the effectiveness of in-class vs online lectures/classes on students' performance. However, there is no study found to compare their performance in learning assembly programming language using online simulator Vs in-lab kit. Studies measuring the performance may differ in the factors examined for measurement. Most studies use students' achievement to measure their performance [5]. One study used factors such as class rank and gender. The study found that there is no significant difference in performance according to class rank or gender. [1]. Another study discussed the factors that negatively influenced the online engineering education. This study recommended all stakeholders to use new technological techniques, strategies, and tools to improve the online engineering education.[16]. One more study explored critical and challenging factors affecting the online learning. The study relied the success of online learning on factors and challenges that are not identified. It also provided suggestions to enhance online learning [17]. This study was important since it addressed a timely essential computer engineering topic. It compared two groups of students using different assessments levels (such as attendance, lab work, quizzes, midterms, and a project) by measuring their performance according to their final grade obtained. The study aim was to determine which modality will result in better student performance in learning assembly language. On the other hand, more studies with same idea need to be performed before judging that using online simulator vs using lab kit will result in same outcomes. In future, more attention will be turned on to these types of studies. The limitations of the study turn around the nature of the sample. The study did not consider class rank since this laboratory is taught to both electrical and computer engineering students. Also, student skills and intelligence were not considered. One more thing is the ability to get unacceptable external help during online assessments (cheating cases). This would be managed properly by applying online learning with in-lab exams for future semesters if possible.

6. Conclusion

Based on the analysis of scores and the output **Table 3** and **Table 4**, it can be concluded that this study assessed the fact that students' performance using in-lab kits does not outperform online simulators for learning assembly programing language.

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