

# THE IMPACT OF ONLINE LEARNING DURING THE COVID 19 PANDEMIC ON COMPUTER SCIENCE STUDENTS' PROGRAMMING SKILLS

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**ABSTRACT**— The COVID-19 pandemic happened as a result of fast infection with severe acute respiratory syndrome coronavirus (SARS-CoV-2). As response, many universities around the world suspended traditional education and replaced it with online learning. In Jordan, the educational institutions closure lasted for five semesters, a one year and six months. During the curfew, the students of Information Technology (IT) faculties were prevented from attending faculty's laboratories to avoid contagion. Therefore, students were away from college labs and supervised program implementation for a significant period of time, which could effect on the quality of programming skills of students. This study is cross-sectional study examines the impact of online education of programming languages (PLs) courses at four Jordanian universities on the performance and on the level of programming skills of students. A random sample of undergraduate and graduate students were surveyed to determine their satisfaction with the overall online learning system and with their programming skills after completing online learning of one or more programming language courses. SPSS v28 was used for data analysis and hypothesis testing. The results of the study show that most students are dissatisfied with their programming skills acquired through online learning. By using a multiple regression method, we found that the most important factor for this dissatisfaction was online learning techniques in addition to online learning difficulties.

**Keywords**—Programming languages; Programming skills; Online learning; COVID-19.

## I. INTRODUCTION

### A. The Transition from Traditional Learning to Online Learning System

The global coronavirus disease 2019 (COVID-19) epidemic has posed a danger to public health around the world. COVID-19 was described as dangerous according to the World Health Organization (WHO) as a result of the damages causes to the patient's health, which may lead to death. COVID-19 pandemic happened as a result of fast infection with severe acute respiratory syndrome coronavirus (SARS-CoV-2) that was first identified in patients who were infected at a seafood market in Wuhan City, China on December 2019 [1]. Most of those infected with the COVID-19 virus showed common symptoms that varied in severity from one person to another, such as severe coughing, headaches, diarrhea, and perhaps nausea and vomiting, and other symptoms that varied from one person to another according to the history of his sick record [2]. This virus posed an imminent danger to those people with weak immunity and those with previous diseases such as heart and arterial diseases, gland diseases and cancer diseases, especially the elderly. Many companies which are specialized in the field of medicine attempted to find an effective vaccine [1], [5]. This was accompanied by the emergence of mutated types of the virus, which varied in their characteristics and the causes symptoms that it can cause to patients. Based on WHO, the latest known type of mutated corona virus is called "Omicron" which exposed in many countries, based on the documented samples on November 2021 [1]. After WHO characterized COVID-19 as pandemic due to its severity and fast spread[4], many governments have taken many procedures to limit the spread of the epidemic. Some of them issued instructions prohibiting grouping among people and students in both schools and universities. Educational institutions suspended traditional education (i.e. face-to-face

education) and replaced it with online learning through different platforms such as Google class, Microsoft teams, Zoom and others. While other universities used its own platforms and adapted it with this type of crisis to resume learning electronically to avoid infections between students [6]. In the last period of pandemic many suggestions came with scheduling between presidential and on-line learning which is known as blended learning [7].

In Jordan, the first case of COVID-19 was reported on 2 March 2020 [8]. From the beginning, Jordanian government tried to limit the spread of COVID-19 between Jordanian citizens through a number of preventive and control methods that have been implemented at the local and national levels including closing educational institutions [9][10]. Due to this circumstance, Jordanian Universities suspended face-to-face learning since March 2020 and this continued for a year and a half, following the Ministry of Higher Education instructions [1]. For a year and 6 months, which cannot be considered a short period, students of Jordanian universities were receiving their lectures remotely through electronic platforms. Unfortunately, many Jordanian universities, instructors and students have never experienced online learning in this extensive before, leading them to face many difficulties during classes or exams. After this period and in September 2021, the Jordanian government announced the return of schools and universities to work with face-to-face learning in concurrence with keenness to give the vaccine to most citizens, especially students over the age of fourteen [12][5]. Also Jordan's Ministry of Higher Education has allowed faculties to implement blended education, which integrates online learning with traditional learning under many scenarios based on the nature of given courses [13]. The faculties of Information Technology (IT) in Jordanian universities are affected by this pandemic as well as other universities faculties. One of the most important things that IT students are no longer able to attend laboratories for

programming language courses. Attending labs allows students to learn programming languages through writing codes of programs practically under the supervision of teachers or teacher assistants which could leave an impact on the quality of students programming skills.

### *B. Programming Education*

Several years ago, it became known that programming is one of the basic things associated with the requirements of the modern age [14]. Programming education aims not only learning the programming languages, but also improving student's logical reasoning, problem solving skills and creativity. For this purpose, it is necessary to create a suitable environment in which students are able to actively learn, solve problems and practice in their own way and with self-dependency [16].

In traditional education at universities, most theoretical programming languages (PLs) courses are combined with practical (lab) hours. The reason of including the practical part is the need to bridge the gap between the theoretical representations of type theory and the requirements of a practical programming language [15]. On the other hand, the programming language needs to be practiced and trained so that students can understand and master it. In PL lectures, students learn the theoretical part, which includes the concepts of software life cycle and the development of algorithms to solve problems. Meanwhile, the laboratories with prepared computers and the necessary software are an essential part of the infrastructure of IT faculties in which students can apply the programs after they understand the theoretical part.

For most students, especially beginners, learning programming requires special effort to overcome the difficulties of: using the integrated development environment, learning the syntax of PL, finding errors and correcting code, understanding nested structures (e.g., condition, repetition), designing algorithms to solve tasks, breaking functionality into modules or routines, deriving objects, understanding arrays (i.e., lists), dealing with pointers [36]. On the other hand, programming education should include nontraditional methods that pave the understanding. For example, game-based learning and visual representation of different variables and entities to help students understand relationships and comprehend the outcome [37].

In response to the ban on gatherings due to the spread of the COVID -19 virus in Jordan, Jordanian universities have taught all subjects for a year and six months, including programming languages, by online learning. This means that the practical part in the laboratories of the Information Technology faculties is no longer possible. Therefore, the students programming skills could be affected. For this, our study conducted a questionnaire with three domains as follows: Domain one, focuses on the effectiveness of online learning of programming language courses during the COVID -19 pandemic. The second domain, assesses student interaction during online learning of programming language courses during the COVID -19 pandemic. While the last domain identifies the main challenges during online learning of programming language courses.

### *C. Objectives of This Study*

Educational difficulties are seen as a critical cross-cutting issue over the world [12]. The COVID-19 pandemic has proven to all the governments of the world the necessity of having a readiness for an interruption of education in the traditional way. On the other hand, a number of factors that impact the effectiveness of an online learning environment, some of these include technical problems, distractions and family obligations because of home is the place of taking lectures during lock time, time management challenges, and the availability of resources. Laborites of Information Technology faculties were no longer accessed for considerable time period. All of this has never been experienced by students of information technology colleges, which could make a difference, especially for those who are interested in developing their programming skills.

The student's acquisition of high programming skills is one of the most important goals of Information Technology faculties and is compatible with its vision. As a result, This study focuses on the impact of the transition to online learning on the level of students' programming skills at four universities in south of Jordan. It addresses the role of online learning on the efficiency of programming skills of Information Technology students. Furthermore, examines the difficulties faced by IT students in the south of Jordan, which is considered a remote area that lacks infrastructural services, including poor Internet connectivity. Therefore, we investigate the IT student's satisfaction about online learning and to determine the factor behind dissatisfaction. Furthermore, this study aims to determine if the online learning was sufficient to teach programming languages courses in both theoretically and practically sides and to determine the impact of absence from the practical coding inside labs on student's programming efficiency.

The remainder of this paper is organized as follows: Section II discusses the main related works. The theoretical hypotheses were defined in section III. Section IV defined the methodology of the research. The results of the analysis are presented in Section V, which includes the hypothesis tests. Finally, Section VI contains the discussion of the results, the conclusions and the recommendations.

## **II. RELATED WORKS**

Programming education aims to improve the students' skills in regards to logical thinking and problem solving ability. Invoice students might face difficulty with learning programming. This because some structures of programming languages seem complicated [16]. A study [17] highlights the need of offering a suitable environment to help students learn programming languages. An interactive visual representation tool called Augmented Reality Enhanced Learning System is proposed to help students learn programming 3D applications.

Online learning is considered a suitable method for students to communicate and discuss with their teachers even if they are in different locations. However, the benefits of online learning and the difficulties faced by students and instructors have been discussed in several studies. One of the first studies that focused on the impact of the pandemic lockdown was conducted on a sample of students from West Bengal university [18]. A web-based survey distributed

electronically through various platforms to collect responses from 232 students. This study not only highlights the challenges faced by this group of students, but also recommends building urgent strategies to come with flexible education system that ensures the development of employability and productivity. They also recommend policymakers to support the infrastructural facilities of educational institutions which can control the online learning process in case of future health emergencies.

The effectiveness of the online learning platform is an important factor on students' academic performance, especially in practical courses such as architecture, industrial mathematics, industrial physics, civil engineering, computer science, industrial chemistry, and microbiology. Students from Covenant University, Nigeria, were surveyed in [19] about their experiences with online learning platforms. The results of study showed a positive attitude and willingness to use the Zoom and Moodle platforms.

Many studies have formulated a definition of online learning. Others defined online learning as the process of learning through some kind of technology. They distinguished between distance learning and online learning by defining the latter as a newer version of distance learning that facilitate access to educational resources [32-35].

In the Jordanian context, a study was conducted to investigate the satisfaction of University of Jordan students about online learning during COVID -19 pandemic [20]. Faculty of Education undergraduate and graduate student's satisfaction with online learning was the main focus of the study. The research analysis shows that despite the difficulties, students show a high acceptance of online learning and consider it a non-traditional experience in education. Many recommendations were derived from this study, such as the importance of increasing the quality of electronic materials and providing support to students on various sides to help them overcome the challenges. In another study authors reached the similar conclusion, aimed to determine the viewpoint of both students and instructors about effectiveness of online learning and satisfaction[21]. The analysis results of two questionnaires distributed to 50 faculties and 280 students indicate that online learning via Zoom and other platforms was helpful during the pandemic, but not at the same level as face-to-face education and the blended learning will be a compromised solution if the closure due to the COVID-19 pandemic continued [28]. They found that most of the benefits supporting participant satisfaction were low cost, self-paced learning, and flexibility. In contrast, the analysis results of Maqableh M. in [22] show that more than one-third of the students are dissatisfied with the online learning experience. The responses from participants collected through two online questionnaires to evaluate the transition from traditional learning to online learning. Beside, Ref. [22] tries to determine the factors behind student's dissatisfaction to come up with recommended solutions. One of these recommendation mentioned the serious need for using common international online learning platform to communicate with students and conduct lectures. The analysis of [23] results shows that satisfaction is strongly and positively related to self-efficacy. On the other hand, it is

negatively affected by fear of COVID -19 and generalized anxiety. In this sense, instructors should be aware of these aspects to eliminate the negative effects of fear and generalized anxiety on the efficiency of online learning.

One of the most related studies is one that was conducted to determine the difficulties that students face when learning programming languages. One of the findings is that students find the most useful part of learning a programming language is practical side (Labs). And that students prefer learning by writing programs under the supervision of their lecturer rather than theoretical learning [24].

Although many studies discussed online learning in many scopes, but none of these studies considered the influence of transition to online learning on computer science student's efficiency especially in terms of programming skills.

### III. HYPOTHESES

The purpose of this study is to show the impact of transition to online learning, as response of closure due to COVID-19 pandemic, on programming skills of Information Technology students at four Jordanian universities in south of Jordan. Consequently, this research examines the following hypotheses:

#### 1) Hypothesis 1 (H-1)

The first hypothesis examines student satisfaction from two sides as follows:

- H-1(a): There is a statistical impact of online learning techniques, of programming languages courses, on student satisfaction with online learning systems.
- H-1(b): There is a statistical impact of the smoothness of transition from traditional education to online learning system on students' satisfaction with online learning systems.

#### 2) Hypothesis 2 (H-2)

The second hypothesis examines student performance and the level of programming skills from two sides as follows:

H-2(a): There is a statistical impact of the student's efforts level, which includes (participation during online lectures, show understanding, ask questions, solving exercises), on the student's programming skills level.

H-2(b): There is a statistical influence of difficulties during online learning, such as: financial difficulties, health difficulties, technical difficulties, and time management difficulties or sudden technical problems, on the performance of the students and the level of programming skills. Fig. 1(a) and Fig. 1(b) show the framework model of our research hypotheses.

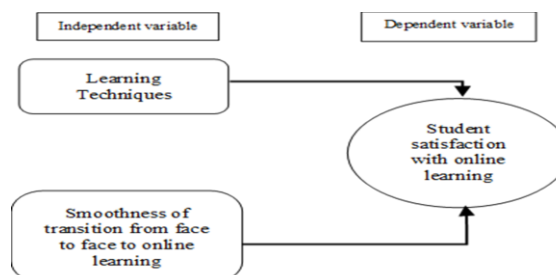


FIG.1(A) INDEPENDENT (LEFT) AND DEPENDENT (RIGHT) VARIABLES OF H-1(A) AND H-1(B)

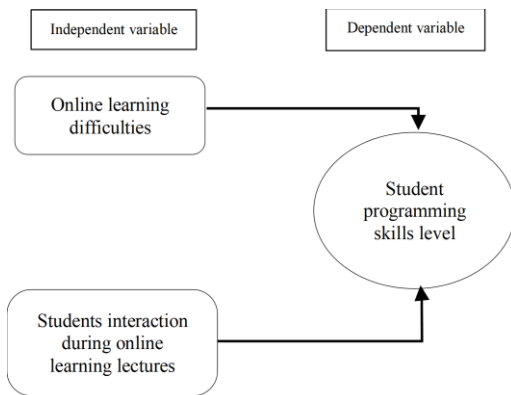


FIG .1(B) INDEPENDENT (LEFT) AND DEPENDENT (RIGHT) OF H-2(A) AND H-2(B)

#### IV. METHODOLOGY

A methodology with number of steps has been created to meet the research's goal, as follow:

##### A. Research Questions

Many researches, prior to COVID-19 pandemic, have stated students' dissatisfaction with online learning, attributable mostly to technical difficulties [30], vague instructions [31] and unwillingness of students to interactive with instructor or with other students during online sessions [32]. Therefore, the key question arises as to how programming learning in south of Jordan, which have limited technological facilities, going with this mode of learning during a danger pandemic like COVID-19. Accordingly, our study is based on three basic research questions as follows:

- 1) How much students satisfied toward online learning of programming courses?
- 2) What are the relationship between satisfaction toward online programming learning during quarantine and learning techniques? ?
- 3) What are the most difficulty that faced students during online learning of programming courses?

##### B. Questionnaire Design

This study is a cross-sectional study conducted using a random sampling, with an online questionnaire created on the Google Forms platform. A questionnaire with 27 questions distributed in three sections was designed to cover the study objectives. The first section of the questionnaire contains items that measure students' satisfaction with the online learning system and learning techniques. Students' satisfaction with their performance and programming skills was investigated using the items of section two. While The main online learning challenges of programming language courses were identified in the third section. The language of the questionnaire was kept simple to make it clear and easy for students to answer.

##### C. Participants

Data were collected from 211 participants. The online questionnaire randomly targeted information technology students from universities in southern Jordan, which are located in remote areas where facing infrastructure challenges. The inclusion criteria include either on-seat

undergraduate or recently graduated students who experienced online learning during COVID-19 pandemic.

##### D. Data Analysis Tool

Data were exported in CSV format for analysis using IBM SPSS STATISTICS for Windows version 28. Descriptive statistics were used to better understand the distribution of study participants.

#### V. ANALYSIS RESULTS

##### A. Participants Data

A total of 211 undergraduate and graduate students volunteered to participate in the questionnaire. The questionnaire was mainly directed to information technology students at four Jordanian universities in the south of Jordan: Mutah University, Tafila Technical University, Al-Hussain University, and Jordan University Aqaba branch. The information technology students were filtered to only who have taken of programming courses through online learning during closure of the universities during COVID -19 pandemic. Table 1 shows that 45% of the students were female, while 55% of the participants were male. The majority of participants was first and second year students, who made up the largest percentage at 50%. While only 29% of third and fourth year students participated, and the participation of recent graduates was 21%. Participants who experienced learning a programming language courses through online learning came from four universities: Mutah University (43%), Al-Hussain University (33%), Tafila Technical University (16%), and Aqaba JU branch (8%). The family income of 108 (51%) of the students is less than 500 Jordanian Dinars, equivalent to 705\$ (USD), and 42% of the students have an income between 500 and 1000JD (~705\$ to 1409\$), while a minority 7% receive a salary of more than 1000JD.

TABLE 1. DEMOGRAPHIC CHARACTERISTICS OF THE STUDY PARTICIPANTS

Gender	Frequency	Percentage (%)
Female	96	45%
Male	115	55%
		100%
Year of Study		
First-Second year	105	50%
Third-fourth year	62	29%
Graduated	44	21%
		100%
University Name		
Al-Hussain University	69	33%
JU-Aqaba branch University	17	8%
Mutah University	91	43%
Tafila Technical University	34	16%
		100%
Monthly Income		
1000 and Above	14	7%
500-1000	89	42%
Below 500	108	51%
		100%

##### B. Hypotheses Testing

In this study, multiple regression analysis was used to test the hypotheses using SPSS v28. Data analysis included a multicollinearity test, a variance inflation factor (VIF), and a



tolerance test for independent variables. A descriptive analysis was also used to summarize the data. The notation of the hypotheses (H1, H-1(a),H-1(b) and H2,H-2(a),H-2(b)) is used as presented in section III. The results of the analysis are described below:

1) *H-1; Satisfaction about Online Learning systems.*

Firstly, Table 2 contains the results of descriptive analysis which shows that out of 211 students 14% and 38% are unsatisfied and very unsatisfied with online learning system in terms of learning programming languages, while only 19% and 25% are satisfied and very satisfied with it. In regards to study levels, Fig .2 shows that the mean of satisfaction between students in first to second years was 3.1 while it was 2.95 of third to fourth year students, respectively. The

**TABLE 2. SATISFACTION ABOUT ONLINE LEARNING SYSTEM OF PROGRAMMING LANGUAGES COURSES**

	Frequency	Percentage (%)
Strongly unsatisfied	81	38%
unsatisfied	29	14%
Neutral	9	4%
Satisfied	40	19%
Strongly Satisfied	52	25%
<b>Total</b>	<b>211</b>	<b>100</b>

graduated student's satisfaction mean was 2.66 which indicate that they are less satisfied.

A multiple regression method was used to test the hypotheses H-1(a) and H-1(b), see section 5 of the hypotheses. This step included the variance inflation factor (VIF) and tolerance test to check the data distribution. As shown in right side of Table 3 the VIF values of the independent variables, Techniques and transition smoothness were less than 2 and the tolerance values were less than 0.6. The both, VIF values and tolerance values indicate that there is no multi-collinearity problem and the data are normally distributed.

Table 3 shows that the p-values of two dimensions that could effect on satisfaction with online learning system are less than 0.05. This result supports hypotheses H-1(a) and H-1(b) of satisfaction dimensions. Between the two dimensions, the techniques of online PL learning have higher impact on student satisfaction than the transition smoothness from traditional to online learning, which means that the effectiveness of techniques has the highest relative importance.

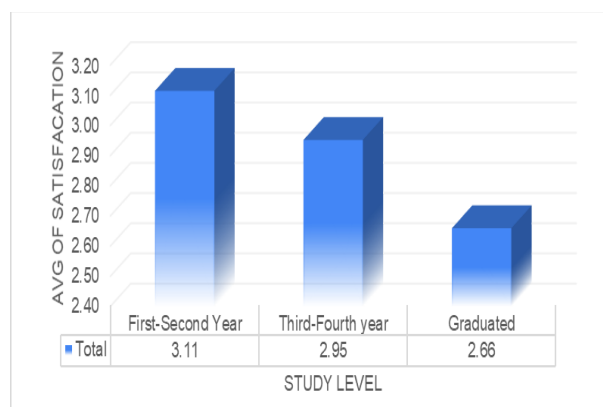
2) *H-2(a); The Performance and Programming Skills level*

To test hypothesis H2(a) (see *Hypotheses section III*), we used the variance inflation factor (VIF) and tolerance to check the data distribution. Table 4 shows that the VIF values for the three variables (Understanding, participation, and solving exercises) were less than 2.1 and the tolerance values were less than 0.6. The VIF values and tolerance values indicate that there is no multi-collinearity problem and the data are normally distributed [25], [26].

**TABLE 3. HYPOTHESIS (1) A & B DIMENSIONS TEST, MULTIPLE REGRESSION TEST RESULTS\***

Model	Unstandardized Coefficients		Standardized Coefficients	t	p-value	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	-0.233						
Techniques of online PL courses learning (Mean)	0.465	0.081	0.380	5.729	0.00	0.509	1.96
Smooth transition to online learning (Mean)	0.273	0.075	0.230	3.627	0.00	0.555	1.80

\* Dependent Variable: satisfaction about online learning system (Mean)



**FIG. 2 THE MEAN OF STUDENT'S SATISFACTION PER STUDY LEVEL**

The results of the multiple regression method in Table 4 show that the significant value (p-value) for all variables was less than 0.05. This confirms that there is a statistical influence of students' understanding, solving exercises, and interaction during online lectures of PL courses on students' programming skills (*H-2(a)*). Among the three dimensions

**TABLE 4. HYPOTHESIS-2(A) TESTING, MULTIPLE REGRESSION TEST RESULTS\***

Model	Unstandardized Coefficients		Standardized Coefficients	t	p-value	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	-.148						
Understanding the theoretical concepts	0.598	0.066	0.541	9.124	<.001	0.556	1.80
Participation with questions and discussions	0.167	0.078	0.134	2.139	.034	0.500	2.00
Solve exercises	0.208	0.059	0.203	3.548	<.001	0.599	1.67

\* Dependent Variable: Acquisition of valuable programming skills (Mean)

related to students' performance and programming skills, understanding the theoretical concepts of PL has the highest relative importance in comparison with solving exercises and discussions participation, respectively.

### 3) H-2(b); Online learning challenges.

In terms of online learning difficulties, we hypothesize that there are four general categories of problems that students might encounter when learning online; The financial difficulties, health difficulties, technical difficulties, and time management difficulties. The results show that 42% of the students reported having difficulties with time management when learning online, followed by technical difficulties with a proportion of 38% of the students (see Table 5). Financial difficulties were experienced by 15% of students, while only 5% of students experienced health difficulties. In this context, we analyzed the data to find the most influential difficulty for each university. Fig.3 shows that the most influential difficulty for the students of Mutah University, Tafila Technical and Jordan University - Aqaba branch were the technical problems. While Al-Hussain University students had more problems with time management (with percentage 48%) than other difficulties. Other difficulties, such as financial difficulties were experienced by only 14% of Mutah University students. While 21% of Tafila Technical University students faced financial issues during online learning period. In Al-Hussain and JU -Aqaba, the percentage of this type of problems is almost the same (12% and 13%, respectively for financial). In the opposite, 23% of the students in JU -Aqaba branch faced health problems, health

progress of online learning. Only 7% of Mutah University students experienced health problems, 3% of TTU students, and 6% of Al-Hussain University students.

## VI. DISCUSSION AND CONCLUSION

This study examined the impact of the transition to online learning due to COVID -19 on the performance of Jordanian IT students in programming skills at four Jordanian universities. It also investigated satisfaction from two sides: first, satisfaction with the online learning system in terms of learning programming language courses. Second, the satisfaction of students with performance and programming skills level. The main findings of this study are that most students are dissatisfied neither with learning programming languages online nor with their programming skills level after completing online PL courses. For this point, we found that the most relative to this dissatisfaction is the learning techniques that were used in online PL learning.

The learning techniques of PL include learning how to solve programming problems through algorithms, expectation of results, student collaboration in writing the codes in a group, program validation and maintenance, program optimization, and summarization of ideas [38]. Many of these PLs learning techniques could not be implemented smoothly during online lectures for various reasons; One of them is the large number of students attended same sessions. In addition, the online learning platforms lack features that support PLs learning.

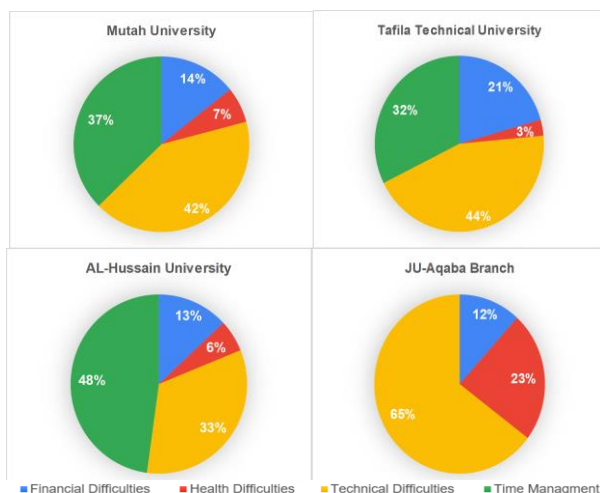
We found that during online learning, understanding the theoretical part of PL has the greatest relative importance for acquiring valuable programming skills. next to the student practicing and solving programming tasks. This result prove that theoretical part of PL paves the way for a deep understanding of the PL codes and the way to implement it. In addition, the programming language needs extensive training by student to be able to master it.

This study also examined the difficulties of online learning. We categorized the difficulties into four general types: financial difficulties, health difficulties, technical difficulties and time management difficulties. Among the four types, the most common difficulty that students at the four universities faced in online learning during the COVID -19 pandemic was technical difficulty, followed by time management difficulty. In this context, we found that these difficulties had a negative impact on students' performance and level of programming skills.

This study comes with several recommendations to reduce the negative impact of online learning period on students programming skills. We recommend that after return to universities and face to face education, Information Technology facilities should allow students to take additional practical sessions of programming languages to review and master their programming skills. Additional hours for lab work will give a chance for students to refine programming skills. Also reducing the number of students in online session to ensure optimal understanding and implementation. For future, we recommend that online learning platforms should be improved for follow the writing of programs and help student's correct errors (i.e. mistakes) in a more interactive manner.

**TABLE 5. PERCENTAGES OF ONLINE DIFFICULTIES THAT FACED BY STUDENTS**

Difficulty Type	Frequency	Percentage (%)
Financial Difficulties	31	15%
Health Difficulties	11	5%
Technical Difficulties	80	38%
Time Management	89	42%



**Fig 3: ONLINE LEARNING DIFFICULTIES PER EACH UNIVERSITY DURING COVID-19**

problems in the other universities had the least impact on the

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