

E-Learning and Blended Learning Methodologies Used in Universities During and After COVID-19

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Abstract—Educational process has changed from face to face to online as a response to COVID-19 pandemic, where various e-learning platforms were used in different universities. E-learning platforms such as Microsoft Teams, Moodle, and Google Classrooms provide different features that may be helpful during the pandemic. In this research, the number of registered students and the activities on e-learning platforms before, during, and after the pandemic are compared in Hashemite University as a case study. The students' preferred learning type is studied with respect to two factors; gender and educational level. The data was gathered by allowing students to fill an online questionnaire with eight study groups of questions. Then, statistical analysis tests are used to analyze the results of the questionnaire. Three learning types are included in our study; face-to-face, blended, and online learning. The results show that the interaction between students and their lecturers has increased by more than 90% across all platforms at the Hashemite University during the pandemic while it has increased by 64% with the Moodle platform. The students' preference is also investigated according to the courses' categories; remedial materials, collage requirements, specialization materials, and free materials. The results show that students preferred online learning for remedial and free materials, with percentage values of 75% and 57%, respectively, but face-to-face learning is chosen for collage requirements and specialization materials, with percentage values of 54% and 78%, respectively.

Keywords—e-learning platforms, Hashemite university, blended learning, online learning

1 Introduction

COVID-19 pandemic has a significant effect on many aspects of human life, including industry, trade, education [1]. COVID-19 should be viewed as a major cause of psychosocial issues as well as a rapid evolution of virus when evaluating its scope and impact [33]. In order to deal with the pandemic while maintaining academic activity, academic institutions have adopted new strategies. As a result, the use of e-learning technologies has become a priority.

One of the challenges of e-learning systems is providing courses to individual students with different learning methods and levels of knowledge which is resolved by adaptive e-learning systems, where a selected path of learning is provided to individual students to suit the requirements of the students [6] [7]. Adaptive e-learning platforms adjust the material, the presentation mode, and the level of difficulty based on each learner [30]. These systems could improve the students experience by providing a convenient and an adaptable environment for the students' requirements. The learning style of a student is one of the variables that can determine student's needs [8] [9]. This is highly recommended for lecturers to utilize e-learning systems' tools to provide the students with different types of learning, either with videos, slides or exercises to accommodate different learning styles.

To deal with COVID-19 pandemic, efforts were provided to shift from classroom lectures to internet-based learning, in which students access their classes online through the internet.

However, shifting to online learning has presented a number of challenges for educational institutions all around the world [2]. The Jordanian Ministry of Higher Education unexpectedly decided to stop class-based learning in all Jordanian universities and switch to distant learning in the second semester of 2020, which surprised many instructors and students because traditional class-based learning and blended-learning were the usual teaching methods in all courses. This transition to online learning was not easy and many difficulties were encountered [3] [4].

Because of the epidemic, educators and students start accessing internet more frequently than ever before to acquaint themselves with and learn about information, resources, tools, and frameworks for online or distant learning [31].

As a result of using e-learning strategy, students are supposed to use digital e-learning tools such as smartphones, desktop computers, laptops, and tablets for longer periods of time, which has a negative effect on their mental health and psychological well-being [5][32].

In this research, three types of learning that have been used before, during and after COVID-19 pandemic are compared; face-to-face, blended and online learning. An analysis is also provided for the registration of students during and after the pandemic in several courses with various e-learning platforms. As a case study, the activities provided on different e-learning platforms as well as the effect of the three learning types that were used before, during, and after the pandemic is also studied in Hashemite University. E-learning platforms that were helpful for teachers in Hashemite University during the pandemic are Microsoft Teams (MS teams), Zoom, Moodle, and Google Classroom.

A questionnaire is designed with a target sample size of 701 students to compare the three types of learning, namely face-to-face, blended, and online learning. The data were gathered by getting participants complete an online questionnaire hosted on Microsoft Teams platform. The questionnaire's results are analyzed using 3-way ANOVA analysis to investigate the preferred learning type with respect to gender and educational level.

The analysis of the number of registered students and their interaction with such platforms shows that students' interaction has increased by more than 90% across all platforms during the pandemic.

The rest of this research is organized as follows; related work is introduced in Section 2, while advantages and disadvantages are discussed in Section 3. Section 4 provides a description of e-learning platforms used in Hashemite University, while Section 5 represents a statistical analysis for the interaction of the students in Hashemite University with different learning types. Finally, the conclusion is provided in Section 6.

2 Related work

Many universities throughout the world have moved from face-to-face courses to online learning utilizing e-learning platforms during the COVID-19 pandemic and the worldwide lockdowns that were enforced in all countries throughout the world, which makes an interested research area, especially in Jordan.

To make the shift from traditional classroom-based learning to online learning as smooth as possible, it is important to recognize the challenges involved with the incorporation and use of e-learning systems as well as the technical and management components that need to be improved. For example, Abu Al Aish [4] tried to look at the obstacles of using e-learning systems in Jordanian universities, as well as the technical factors that influenced the effective implementation and usage of e-learning systems during COVID-19. To achieve the goals of the study, instructors from Jordanian universities were given a questionnaire to fill. There were 184 instructors involved in the study. The results show that there is a need for guidelines for implementing e-learning systems in Jordanian universities to ensure the sustainability and effectiveness either in the pandemic or normal situations.

Coman et al. [10] discussed the hierarchy of the problems that arise in online learning, as well as the changes that occurs in the context of the pandemic. The order in which challenges appear in online learning is also considered. An online survey is conducted using a semi-structured questionnaire. The data was gathered from 762 students at two of Romania's largest universities. Two types of consequences were observed in the context of the pandemic: practical and theoretical implications. In the practical level, a set of helpful advice for teachers can be presented to be successful in improving the quality of educational process in an online environment, while they used the Technology Acceptance Model at the theoretical level to create and modify e-learning platforms that were defined based on the findings of previous studies that have been proposed before the pandemic. The model may also incorporate a number of external variables, and it could even be tested online.

Can & Bardakci [29] used a semi-structured questionnaire with snowball sampling to collect data from 66 teachers. The findings indicate that interactions between students, student-teachers, and teacher-parents are generally lacking in distance education processes. Also, there are other challenges such as inadequate training materials, a lack of socializing, and a lack of technology resources and. They provided a number

of recommendations, including enhancing teacher-student interaction, overcoming technological infrastructure problems, and offering teachers technical and psychological assistance throughout critical distance learning activities.

Katsaris & Vidakis [30] focused on customized solutions to provide a specially designed environment that satisfies the learner's goals and requirements. The adaptive systems frequently employ Learning Styles to provide a better learning experience for the students. E-learning systems incorporate more modern adaptation techniques that must be in line with educational principles. The study recommended improving the theoretical and technological basis of adaptive e-learning systems while highlighting the importance and effectiveness of the use of learning styles in the adaptive learning process.

According to Almaiah et al. [11] the essential components that determine the use of e-learning systems and should be considered by universities in their future plans are technological factors, e-learning system quality factors, cultural aspects, self-efficacy factors and trust factors. Furthermore, the findings revealed that there are three major obstacles for using an e-learning system; changing management concerns, e-learning system technical issues, and financial support issues. They employed interviews to collect data and NVivo software for thematic analysis where 30 students and 31 e-learning system professionals from six educational institutions in Jordan and Saudi Arabia participated in the interview.

Babu & Reddy [12] have evaluated the e-learning environment in developing nations and tried to study the differences between them in terms of the problems and opportunities they encounter in e-learning. The study found that infrastructure, trained instructors, financial backing, government policies, and student preparation are issues that were experienced in developing countries. Due to the fact that e-learning is still in its early stages, it provides extra opportunities.

Akour et al. [13] has tried to examine the students' attitude and understanding of e-learning process. In two countries; Saudi Arabia and Jordan, the attitudes of students from four universities are investigated. They found that institutions still need to improve e-learning quality in terms of course sequencing and flow, as well as student and instructor preparation. According to student input; additional content, such as audio, video, or animations, is required and preferred for e-learning materials.

Medical students preferred the hybrid method of education, according to Al-Balas et al. [14] because online learning presented a huge problem in acquiring necessary clinical medical skills. Previous experiences for students and instructors, as well as their interaction are all important factors for a satisfied e-learning experience. Understanding the technological, financial, and institutional restrictions for students and instructors is critical.

Fayyumi et al. [15] claimed that Hashemite University is at the forefront of institutions that integrate e-learning in the educational process. They used linear regression, one-way ANOVA, and Scheffe tests. They recommend that Hashemite University should maintain working hard and provide all necessary resources to keep pushing forward to be at the top of success institutions that use e-learning and gain more benefits from integrating the e-learning concept in the educational process. This will add

additional weight on decision-makers of the Hashemite University to make strategic decisions to advance e-learning in their institution.

Al-Khasawneh & Obeidallah [16] has investigated and reported factors impacting user acceptance and adoption of ICT at the Hashemite University. The factors that were investigated are independent variables; relative advantage, complexity, compatibility, and behavioral intention. A correlation analysis was used to determine the direction of the association between the independent variables; relative advantage, complexity and compatibility. The variables were positively and significantly related. As a result, the behavioral intention provides significant predictors, while the relative advantage, complexity, and compatibility are important predictors and contributors for e-learning success.

While Obeidat et al. [17] reported that the students' gender and academic specialization are linked to the assessment of e-Learning efficiency where a sample of 399 students participated in an online survey that was conducted for the study. Students with medical specialization have effectively interacted in an e-learning system more than other students. The students observed that an e-learning system improved their learning experiences and outcomes, especially for female students who have been less familiar to such digital tools in e-learning systems.

Obeidat [18] investigated the effect of online learning on students using interviews to highlight advantages and disadvantages of using e-learning systems. He used a mixed technique of research design to investigate the impact of online learning on 130 students through interviews and a questionnaire. The study aimed at highlighting the students' perspective about the e-learning experience and the extent to which students influenced positively or negatively with regard to four categories; psychological state, learning and skill acquisition, level of interaction, and financial state. The study found that student's psychological condition came first, followed by their level of interaction. Furthermore, no significant variation has been observed in the students' replies to the four categories based on their gender, residence area, or type of school they graduated from. The study also found significant differences in the responses of Arts and Information Technology students.

Almomani et al. [19] discussed the obstacles of online learning during the pandemic which have a negative impact on the students' beliefs and thoughts. They employed an online descriptive survey with questions related to student demographic data. Difficulties that prevent a good online learning experience are identified as technical and connectivity issues such as internet speed and availability, as well as electronic accessibility. Despite their concerns about online learning during the pandemic, the majority of students indicated that they learned new skills in electronic and computer software domains.

Al-Oqily et al. [20] investigated the Jordanian youth's usage of social media to participate in higher education, as well as how characteristics unique to such mediated environments may affect young people's interaction and learning. Social networks will reach a wide range of people and will continue to evolve, as long as they provide services that have a positive influence on students, such as effectively representing ideas. Furthermore, when a social network is overused, it takes a negative aspect, while the majority of respondents believe that the negative aspects of social networks

are not a drawback to their use. The Jordanian youth are not yet ready to use social networks to supplement their education.

Our work provides the use of e-learning in Hashemite University as a case study during the COVID-19 pandemic and where the effect of three types of learning, face-to-face, blended, and online learning on the students is studied and a comparison between these types is also provided in different terms, such as interaction between students and lecturers, students' understanding, interactivity of the learning process, and the preferred learning type for the students.

3 E-learning advantages and disadvantages

E-learning is a method of delivering educational programs to students who are located far away. It is a formalized online learning platform that employs a variety of multimedia tools.

According to [21], e-learning ensures that students are fully engaged in the learning process using texts, videos, recorded lectures, collaborative sharing, and interactive with teachers and students. Also, costs related to student necessities, such as travel, accommodation and food are eliminated [22].

Another significant benefit of e-learning is that it allows students to attend classes from any location and at any time. E-learning also accommodates to a wide range of learning approaches by using sufficient interactive content available on the Internet. [23] [22] [24].

To improve the benefits of e-learning, a learning management system (LMS) should be user-friendly, helpful in managing time, simple in managing courses, and provide facilities and reports [25].

However, according to [26], lectures in e-learning are occasionally held through the Internet, resulting in a lack of student participation and involvement. Because of the lack of face-to-face interaction with instructors or teachers, e-learning may be less successful because the evaluations in e-learning systems are typically held online, there is less chance in controlling illegal actions such as cheating, plagiarism in assignments, and online exams. In an online learning environment, the student-student involvement is significantly less of a concern than student-instructor interaction. [27].

The majority of e-learning problems are due to technical concerns. Especially in Jordan, where Jordan's electronic technology may be immature compared to that of other developing countries, which may cause technological difficulties. For example, many rural and distant sections in Jordan may not have a sustainable internet connection, which affects the students' involvement in online learning and neither teachers nor students are familiar with e-learning [18]. However, this has changed during the COVID-19 pandemic, where the whole learning process becomes online and all students and teachers have to learn about the new tools and platforms of e-learning.

4 E-learning platforms in Hashemite university

Hashemite University has used online learning for some courses due to the large number of registered students in such courses and the need for several numbers of sections to be initiated. For example, Pre-computer skills course has been converted to an online course since 2017 using Moodle, where the students have to attend recorded video lectures and solve exercises and online tests designed by the instructor using Moodle’s available tools, such assignments, quizzes, questionnaires, chatting rooms, and more.

Before the pandemic, each department in Hashemite University was required to convert 10% of their courses to become online courses in accordance with the University’s strategic plan to involve distance learning.

By the end of 2018, Hashemite University had become one of the first universities that provide full online courses. The e-learning unit at Hashemite University started to host workshops for the academic staff to help them in designing integrated electronic content for each online course.

At the start of the pandemic, the departments’ members in all faculties increased their work to convert and prepare electronic content for online courses, as the pandemic stops all face-to-face learning. The Hashemite University has signed an agreement with Microsoft Company to provide accounts for students and lecturers on Microsoft Teams platform to start full e-learning courses. Several online workshops have been hosted to train the lecturers on using the new platform. Table 1 shows the educational usage rates of e-learning platforms at the Hashemite University before and during the pandemic.

As shown in Table 1, the interaction between the students and lecturers during the pandemic through all platforms has increased by more than 90% for all platforms, except Moodle, which increased by 64%. Other platforms represent the lecturers’ usage of social media to group their students and let them attend live lectures such as YouTube, Facebook, and others.

Table 1. Summary of educational platforms usage rates

Platforms	Before	During
Microsoft Teams	5%	95%
Zoom	2%	90%
Moodle	35%	99%
Google classroom	2%	50%
Others	15%	90%

During Covid-19 pandemic, many issues have contributed as challenges in the e-learning process, which includes the students’ interaction, students’ satisfaction with the new experience of full online learning courses and technological tools used for learning. For example, a number of the students did not have access to the Internet all the time for attending online lectures and solving quizzes and exercises that were generated during the class. As a result, more than 33% of the students have missed

many assignments, quizzes, exercises, and interactions with their teachers, which represented essential factors for the educational activities assessment. The number of registered students in the Hashemite University on e-learning platforms during the pandemic was 27,345 and 42,511 students after the pandemic.

4.1 Moodle platform

The Hashemite University has used the Moodle platform (learning Materials Management System) since 2007. Moodle provides a suitable platform for teachers and students in terms of studying, exchanging files and videos, announcements about lectures and exams dates, holding interactive meetings, assignments, quizzes, and exams with less than 100 students.

During the COVID-19 epidemic, a demand for more powerful servers has grown. Therefore, the capacity of the servers was increased to accommodate the number of registered students in a session. The capacity reached to 500 students in one session, as well as the storage capacity of the servers, which was increased.

Table 2 shows the number of Hashemite University's users, courses, and exams on Moodle before and during the pandemic, which shows an increase in the percentage of model usage during the pandemic compared to before the crisis, where the percentage of students using Moodle before the pandemic is 53% to 93% during the pandemic.

Table 2. Moodle platform usage before and during the pandemic

Number of	Before	During
Users	46,221	55,902
Courses	1719	2070
Exams	67	189

4.2 Microsoft Teams platform

Hashemite University has started using the Microsoft Teams platform with the start of the lockdowns caused by the pandemic due to the agreement between the university and Microsoft to use this platform for the learning process.

The employees of the technology computer center in Hashemite University are working hard for 10 days without stopping to migrate and link the teachers, students, and courses information that is stored in the university's databases to the Teams platform. This facilitates providing lectures and following up on attendance and making quizzes and exams. Microsoft Teams platform provides lecturers with the benefits of ease of following up the students' attendance and registration in courses. Table 3 illustrates the percentage of students who used Microsoft Teams during the pandemic (99%), while the percentage of students became 46% after pandemic. Table 3 shows that the number of courses on Teams has reduced due to the return of the learning process to university classes.

Table 3. Microsoft Teams usage during and after pandemic lockdowns

Number of	During	After Corona
Users	30,101	20,211
Courses	2070	1078
Exams	2000	780

5 Students' interaction with learning methods

After the decline in the number of coronavirus infections in Jordan, the government decided to allow students to continue their studies at the university campus with some restrictions, such as the number of students registered in a class and make the students and employees take the COVID-19 vaccine. Furthermore, during the first semester after students return to the university campus, Hashemite University uses three methods of learning: face-to-face, blended, and online learning, where each college is required to offer 25% of its courses completely online, 25% of its courses as blended learning and 50% of its courses face to face on campus. This is in accordance with the Ministry of Higher Education's instructions.

To compare the three types of learning; namely; face-to-face, blended, and online learning, questionnaire is created and the target sample size is 701 students. The data is collected after the end of the first term of the academic year 2021/2022 at Hashemite University, using an online questionnaire hosted on Microsoft Teams platforms as a form to be answered by students. Then, the results of the questionnaire are converted into an Excel file. Different lecturers were asked to post the questionnaire on their classes' groups on Microsoft Teams.

Courses are classified into categories such as remedial materials, college requirements, specialization materials, and Free Materials. Therefore, students were asked about their preferred learning method for various types of courses in the questionnaire.

The responses to the questionnaire show that the students prefer online learning for remedial materials and free materials with percentage values of 75% and 57%, respectively, while face-to-face learning is preferred for college requirements and specialization materials with percentage values of 54% and 78%, respectively as shown in Table 4.

Table 4. Preferred learning method for courses types

Courses Type	Learning Method		
	<i>Face-to-face</i>	<i>Blended</i>	<i>Online</i>
Remedial materials	17%	8%	75%
College requirements	54%	25%	21%
Specialization materials	78%	11%	12%
Free materials	23%	20%	57%

Figure 1 shows that face to face learning has the highest percentage values compared to other types of learning in terms of students attending lectures, helping students to understand subjects clearly and submitting assignments with percentage values of 79%, 65%, and 75%, respectively.

Furthermore, the majority of students observed that their total scores before the final exam are higher in face-to-face courses compared with other types of learning and the lecturers always answer their questions in face-to-face learning by a percentage value of 81%.

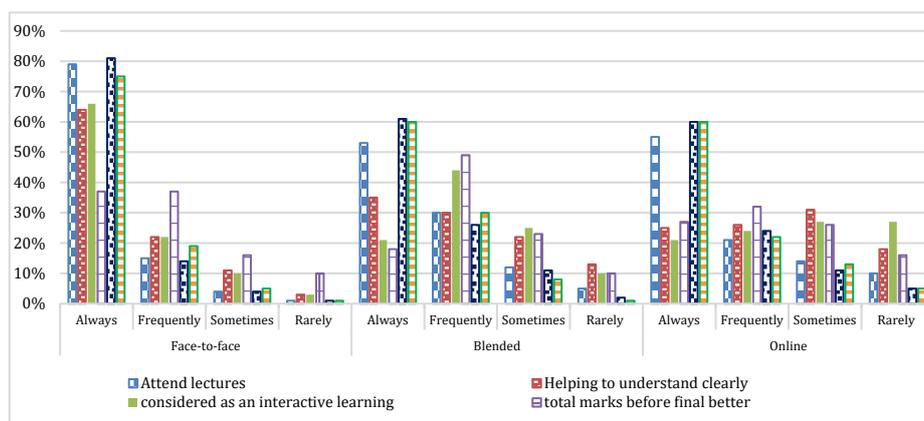


Fig. 1. Comparison between the three learning methods

However, blended learning has the highest percentage values in terms of attending lectures, answering questions by the lecturer, and commitment to assignments with percentage values of 53%, 61%, and 60%, respectively. However, 49% of the students found that they have frequently better scores before the final exam.

On the one hand, 66% of students believe that face-to-face learning is always interactive, while 44% of the students consider the blended learning as frequently interactive and 27% of the students believe that online learning is sometimes or rarely interactive.

50% of the students always attend recorded lectures in online learning, while 60% of students always submit assignments for online courses and they found that lecturers answer their questions. However, 32% of students observed that their total marks before the final exam is frequently better in online courses, while 31% of the students believe that online learning sometimes help toward understanding subjects clearly.

Table 5 shows that 81% of the students always interact with their lecturers, while 32% of the students use Microsoft Teams to interact with their lecturers in a regular manner.

By contrast, the majority of the students communicate with other students in face-to-face learning with a percentage value of 56%, while 30% of the students are rarely interacting with other students in online learning using Microsoft teams.

Table 5. Communication and Interaction with students and lecturers

Communication and Interaction with	Face-to-Face				Microsoft-Teams			
	<i>Always</i>	<i>Frequently</i>	<i>sometimes</i>	<i>rarely</i>	<i>Always</i>	<i>Frequently</i>	<i>Sometimes</i>	<i>rarely</i>
Other students	56%	25%	13%	6%	21%	22%	26%	30%
Lecturer	81%	14%	4%	1%	32%	30%	25%	14%

The students should follow the instructions of the lecturer and attend recorded lectures in online learning, which indicates a self-learning process as they have to study hard and solve the assignments after attending lectures and reading notes that may affect their academic results.

Figure 2 illustrates the students’ success percentage of pre-computer-skills course results in Face-to-Face learning and online learning. The percentage of success decreased when the course is given completely online and the percentage becomes stable, which is expected. Thus, the lecturers should provide more recommendations and revisions for their students in online courses.

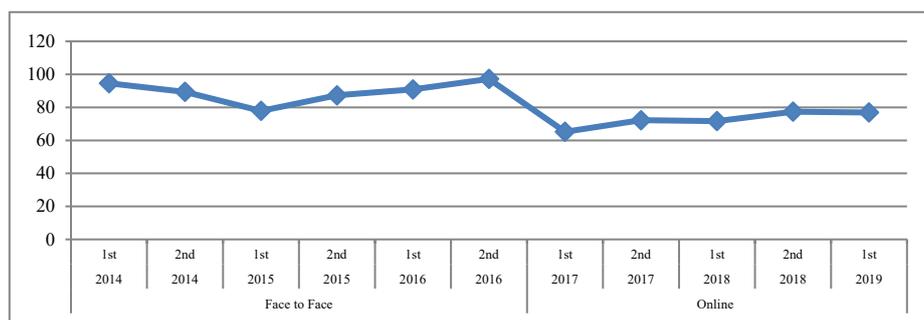


Fig. 2. Pre-computer-skills success percentage

These findings encourage the leadership of the university to change the learning platform of pre-skills courses to Microsoft Teams where lecturers meet their students in online lectures and increase communication and interaction with their students.

5.1 Analysis of students’ responses to the questionnaire

To analyze the responses of students to the questionnaire we studied the effect of two factors on their responses; student’s gender and educational level. To perform the analysis, we used different statistical tests such as 3-way ANOVA and Bonferroni pairwise post hoc comparisons which required measuring means and standard deviations for these responses and then provide an indication if there are significance differences in these adjusted means.

After measuring the means and standard deviation for the students responses about the preferred learning type for Remedial, College, Specialization and free courses, we found that there are statistical significant difference ($\alpha=0.05$) between the means of the students responses with respect to two factors; Gender and academic level. In order to investigate the significance of these differences, 3-way ANOVA with repeated measures has been applied for students' preferred learning type for different courses types and the results are shown in Table 6.

Table 6. 3-way ANOVA with repeated measures analysis for preferred learning type

Source of Variance	Sum of Squares	df	Mean Square	F	Sig	Partial η^2
Tests of Within-Individuals Effects						
Mauchly's W=0.79, Approx. $\chi^2=167.67^*$, df=5, ϵ (Greenhouse-Geisser)=0.88						
Preferred Learning	70.70	2.64	26.75	65.61*	0.00	0.0860
Preferred Learning*Gender	0.24	2.64	0.09	0.22	0.86	0.0000
Preferred Learning*Education Level	6.41	7.93	0.81	1.98*	0.05	0.0080
Preferred Learning*Gender*Education Level	1.70	7.93	0.21	0.52	0.84	0.0020
Error(Preferred Learning)	747.83	1834.49	0.41			
Tests of Between-Individuals Effects						
Gender	0.11	1	0.11	0.14	0.70	0.0000
Education Level	5.46	3	1.82	2.51	0.06	0.0110
Gender*Education Level	2.04	3	0.68	0.94	0.42	0.0040
Error	503.81	694	0.73			

* $p \leq 0.05$

As shown in Table 6 there are statistical significance differences ($\alpha=0.05$) between the adjusted means for the responses of the students about the preferred learning type for different courses types. Because the preferred learning type is variable within individuals, Bonferroni pairwise post hoc comparisons test is used and the results are shown in Table 7.

Table 7. Bonferroni pairwise post hoc comparisons test results for the adjusted means of the students preferred learning type

Preferred Learning for	Specialization materials	Collage Requirements	Remedial materials	
Bonferroni	Adj. Mean	1.41	1.77	1.91
Collage Requirements	1.77	0.36*		
Remedial materials	1.91	0.50*	0.14*	
Free Materials	1.97	0.57*	0.20*	0.07

* $p \leq 0.05$

The results in Table 7 show that the students preferred online learning type for free courses more than the students who studied specialization courses and preferred face-to-face learning type then the students who studied collage requirement courses and preferred online learning. It is also shown that the students preferred on-line learning

for university remedial courses more than the students who preferred face-to-face learning for specialization courses then the students who studied collage requirement courses and preferred online learning. Also, the students who preferred online learning for collage requirement courses are more than those who preferred face-to-face learning for specialization courses.

The results also show that there are statistical significance difference ($\alpha=0.05$) between the adjusted means of the preferred learning type for different courses due to the interaction between learning type and student's educational level but there is no effect for the gender factor on the students responses.

To identify the interactive issues responsible for the essential interaction between the preferred learning type and the educational level, Bonferroni pairwise post hoc comparisons test is applied and the results of the test are shown in Figure 3.

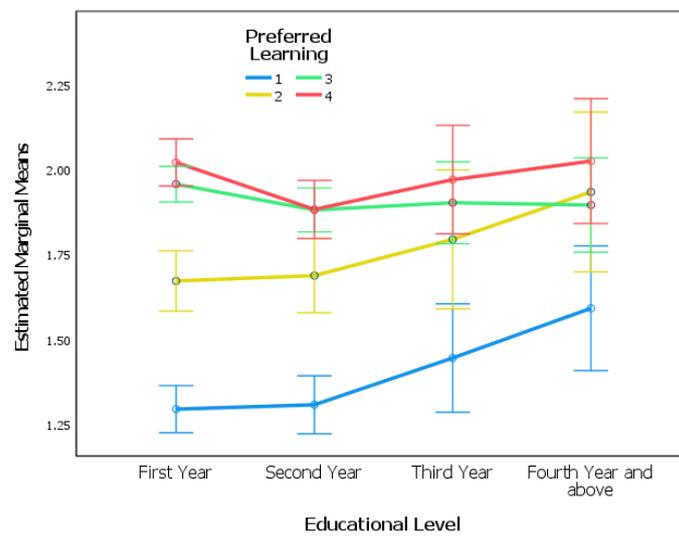


Fig. 3. Bonferroni pairwise post hoc comparisons test results for the adjusted means of preferred learning type according to learning type and student's educational level

We found that the students in the fourth level preferred online learning for specialization courses more than those of the first and second level who preferred face-to-face learning for specialization courses. It is noticed from Figure 3 that the students from the first and second level who preferred online learning for the free courses are more than those who preferred face-to-face learning for specialization courses. Also, it is shown that the students who preferred online learning for the remedial courses are more than those who preferred face-to-face learning for specialized courses.

Also, we found that there are observed differences in the means of the students' responses to the way of students Commitment to do their assignments in online, face-to-face and blended learning courses. In order to investigate the significance of these differences, 3-Way ANOVA analysis with repeated measures is applied. The results of 3-Way ANOVA analysis are shown in Table 8.

Table 8. 3-Way ANOVA with repeated measures for the means of students commitment to assignments

Source of Variance	Sum of Squares	df	Mean Square	F	Sig.	Partial η ²
Tests of Within-Individuals Effects						
Mauchly's W=0.71, Approx. $\chi^2=241.47^*$, df=2, ϵ (Greenhouse-Geisser)=0.77						
Commitment to Assignments	10.65	1.55	6.89	16.46*	0.00	0.0230
Commitment to Assignments*Gender	0.49	1.55	0.32	0.76	0.44	0.0010
Commitment to Assignments*Education Level	2.60	4.64	0.56	1.34	0.25	0.0060
Commitment to Assignments*Gender*Education Level	0.66	4.64	0.14	0.34	0.88	0.0010
Error(Commitment to Assignments)	449.06	1072.47	0.42			
Tests of Between-Individuals Effects						
Gender	1.63	1	1.63	1.58	0.21	0.0020
Education Level	2.00	3	0.67	0.65	0.59	0.0030
Gender*Education Level	0.15	3	0.05	0.05	0.99	0.0000
Error	714.39	694	1.03			

* p<0.05

Table 9 shows that the students who studied face-to-face courses always do their assignments more than students who studied either online or blended course and frequently do their assignments. In addition, there are no significance differences ($\alpha=0.05$) between the adjusted means of the students' commitment to doing assignments for online, face-to-face and blended courses due to the interaction between students' commitment with gender and educational level.

Table 9. Bonferroni pairwise post hoc comparisons test of the students' commitment in doing assignments

Commitment to Assignments in		Commitment to Assignments in online courses	Commitment to Assignments in blended courses
Bonferroni	Adj. Mean	3.42	3.47
blended learning courses	3.47	0.05	
face-to-face learning courses	3.65	0.23*	0.18*

* p<0.05

After measuring the means and standard deviation for the students' responses to answering questions by the lecturer, a statistical significant difference ($\alpha=0.05$) is found between the means of the students responses with respect to the gender and the academic level. In order to investigate the significance of these differences, 3-way ANOVA with repeated measures is performed for answering questions by the lecturers. The results are illustrated in Table10.

It is shown in Table 10 that there are statistical significance differences ($\alpha=0.05$) between the adjusted means for the responses of the students about answering questions by their lecturers in face-to-face, blended and online learning courses.

Table 10. 3-Way ANOVA with repeated measures for the means of students’ questions answered by lecturers

Source of Variance	Sum of Squares	Df	Mean Square	F	Sig.	Partial η ²
Tests of Within-Individuals Effects						
Mauchly's W=0.83, Approx. $\chi^2=126.17^*$, df=2, ϵ (Greenhouse-Geisser)=0.86						
Answering Questions	20.72	1.72	12.08	32.31*	0.00	0.0440
Answering Questions*Gender	0.75	1.72	0.44	1.17	0.31	0.0020
Answering Questions*Education Level	2.96	5.14	0.58	1.54	0.17	0.0070
Answering Questions*Gender*Education Level	2.55	5.14	0.50	1.32	0.25	0.0060
Error(Answering Questions)	444.93	1189.93	0.37			
Tests of Between-Individuals Effects						
Gender	1.70	1	1.70	1.56	0.21	0.0020
Education Level	7.15	3	2.38	2.19	0.09	0.0090
Gender*Education Level	2.57	3	0.86	0.79	0.50	0.0030
Error	754.27	694	1.09			

* p<0.05

Bonferroni pairwise post hoc comparisons test is used since answering students’ questions is variable within individuals. The results of Bonferroni test are illustrated in Table 11.

Table 11. Bonferroni pairwise post hoc comparisons test of the answering students’ questions by their lecturers

Answering Questions by Lecturer in		Online learning	blended learning
Bonferroni	Adj. Mean	3.36	3.44
Blended learning	3.44	0.09*	
Face to face learning	3.68	0.32*	0.24*

* p<0.05

The results in Table 11 show that the questions asked by students in face-to-face learning had the highest value of being answered by lecturers followed by online then blended learning. It is worth to notice that there are no significant differences ($\alpha = 0.05$) between the adjusted means for students' performance on the method of asking questions because of gender or academic level. In addition, we computed the means and standard deviation for the students’ responses to the question about their total of marks, and then differences in the means and standard deviation were observed for face-to-face, blended and online learning; according to the gender and academic level factors. To study the significance of these differences, 3-Way ANOVA analysis with repeated measures is performed and the results are shown in Table 12.

Table 12. 3-Way ANOVA with repeated measures for the means of students’ responses to Total of marks

Source of Variance	Sum of Squares	df	Mean Square	F	Sig	Partial η^2
Tests of Within-Individuals Effects						
Mauchly's W=0.71, Approx. $\chi^2=234.34^*$, df=2, ϵ (Greenhouse-Geisser)=0.78						
Students' total marks	21.64	1.55	13.92	12.81*	0.00	0.0180
Students' total marks *Gender	1.75	1.55	1.12	1.03	0.34	0.0010
Students' total marks*Education Level	4.11	4.66	0.88	0.81	0.53	0.0030
Students' total marks*Gender*Education Level	2.33	4.66	0.50	0.46	0.79	0.0020
Error(Students' total marks)	1172.61	1078.55	1.09			
Tests of Between-Individuals Effects						
Gender	0.11	1	0.11	0.11	0.74	0.0000
Education Level	5.80	3	1.93	1.81	0.14	0.0080
Gender*Education Level	2.26	3	0.75	0.71	0.55	0.0030
Error	739.73	694	1.07			

* p<0.05

It is clear from Table 12 that there are statistical significance differences ($\alpha=0.05$) for the adjusted means of students’ total marks in online, face-to-face and blended learning courses. Therefore, Bonferroni pairwise post hoc comparisons test is applied because the Students’ total marks varied within individuals. As shown in Table 13, students' total marks for face-to-face courses have the highest value, followed by online then blended learning. In addition, there are no significant differences ($\alpha = 0.05$) between the adjusted means of students’ total marks according to either gender or academic level.

Table 13. Bonferroni pairwise post hoc comparisons test of the students’ responses to Students’ total marks

Students’ Total Marks in		Students’ total marks better in online learning	Students’ total marks better in blended learning
Bonferroni	Adj. Mean	2.64	2.71
blended learning	2.71	0.07	
face to face learning	2.97	0.32*	0.26*

* p<0.05

The arithmetic means and standard deviations of students' performance on the method of Commitment to Attending were calculated for face-to-face, blended and online learning according to gender and academic level, 3-Way ANOVA analysis with repeated measures is applied as shown in Table 14.

Table 14. 3-Way ANOVA with repeated measures for the means of students’ performance on the method of Commitment to attending lectures.

Source of Variance	Sum of Squares	Df	Mean Square	F	Sig.	Partial η ²
Tests of Within-Individuals Effects						
Mauchly's W=0.85, Approx. $\chi^2=115.89^*$, df=2, $\epsilon(\text{Greenhouse-Geisser})=0.87$						
Commitment to Attending lectures	43.45	1.73	25.07	40.82*	0.00	0.0560
Commitment to Attending lectures*Gender	3.39	1.73	1.95	3.18*	0.05	0.0050
Commitment to Attending lectures*Education Level	4.85	5.20	0.93	1.52	0.18	0.0070
Commitment to Attending lectures*Gender*Education Level	3.99	5.20	0.77	1.25	0.28	0.0050
Error(Commitment to Attending lectures)	738.71	1202.78	0.61			
Tests of Between-Individuals Effects						
Gender	0.19	1	0.19	0.17	0.68	0.0000
Education Level	19.96	3	6.65	6.17*	0.00	0.0260
Gender*Education Level	0.29	3	0.10	0.09	0.97	0.0000
Error	747.94	694	1.08			

* p≤0.05

As shown in Table 14, there are statistical significance differences ($\alpha=0.05$) for the adjusted means of students' Commitment to attending lectures in face-to-face, online and blended learning courses and because of the variation within individuals responses to the students' commitment of attending lectures, Bonferroni pairwise post hoc comparisons test is applied. The results of Bonferroni test are shown in Table 15.

Table 15. Bonferroni pairwise post hoc comparisons test of the students’ responses to the commitment to attending lectures.

Commitment to Attending Lectures in		Commit to attending lectures in blended learning	Commit to attending lectures in online learning
Bonferroni	Adj. Mean	3.18	3.20
Online learning	3.20	0.02	
Face-to-face learning	3.61	0.43*	0.41*

* p≤0.05

It is shown from Table 15 that there are statistically significant differences ($\alpha = 0.05$) between the arithmetic means adjusted for the students’ commitment to attending lectures, due to the interaction between attending lectures and gender which is varied within individuals, Bonferroni's test was used for two-dimensional comparisons between arithmetic means adjusted for the students' commitment to attending lectures as shown in Figure 4.

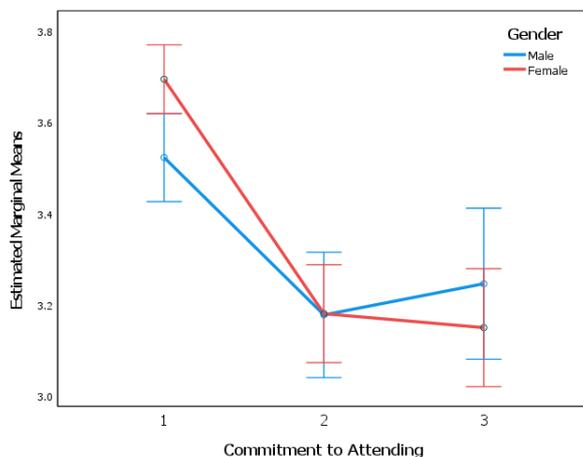


Fig. 4. Bonferroni pairwise post hoc comparisons test of the students’ performance on the method of Commitment to attending related to gender

It is clear from Figure 4 that female students always attend lectures in face to face learning more than male students who always attend lectures in face to face. In addition, the results show that male students' commitment to attending lectures in face to face courses had the highest value, followed by blended and then online learning courses.

Table 16 shows the results of 3-way ANOVA analysis for the repeated measures between arithmetic means of students' responses to the question of understanding materials taught in face to face, online learning courses according to both gender and academic level. It is clear from Table 16 that there are significant differences ($\alpha=0.05$) between the adjusted means of students’ understanding in face-to-face learning courses and online courses.

Table 16. 3-Way ANOVA with repeated measures for the means of students ’understanding of materials

Source of Variance	Sum of Squares	df	Mean Square	F	Sig.	Partial η^2
Tests of Within-Individuals Effects (Sphericity Assumed)						
Understanding Materials	87.23	1.00	87.23	79.4*	0.00	0.1030
Understanding Materials*Gender	7.38	1.00	7.38	6.72*	0.01	0.0100
Understanding Materials*Education Level	13.37	3.00	4.46	4.06*	0.01	0.0170
Understanding Materials*Gender*Education Level	10.49	3.00	3.50	3.18*	0.02	0.0140
Error(Understanding Materials)	762.37	694.0	1.10			
Tests of Between-Individuals Effects						
Gender	0.33	1	0.33	0.55	0.46	0.0010
Education Level	4.34	3	1.45	2.45	0.06	0.0100
Gender*Education Level	0.67	3	0.22	0.38	0.77	0.0020
Error	410.44	694	0.59			

* $p \leq 0.05$

Since understanding materials is variable within individuals, Bonferroni test is used to distinguish these essential differences according to the interaction between material understanding, gender and academic level as shown in Figure 5.

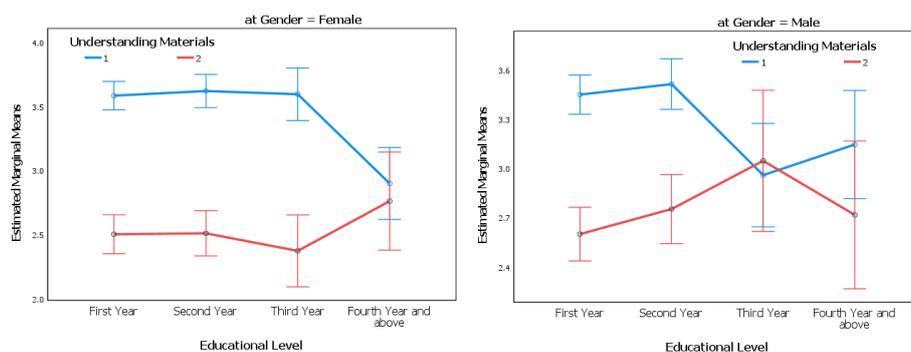


Fig. 5. Bonferroni pairwise post hoc comparisons test results for the adjusted means of students' understanding according to gender and student's educational level

Figure 5 demonstrates that at all educational levels, students understand face-to-face lectures within a degree of “always” is more than understanding face to face lectures within a degree of “often”. Also, it is shown that the third year male students are able to comprehend online lectures within a degree “often” more than the third year female students within a degree of “sometimes”. The second-year students' understanding of face-to-face lectures within a degree “often” is more than the second-year students' understanding of online lectures within the degree “often”.

3-way ANOVA analysis is also conducted for the repeated measures between the means of students' responses about considering a learning type as an interactive learning; face-to-face, blended, or online learning according to gender and academic level. Then, Bonferroni pairwise post hoc comparisons test is applied to investigate the significance of the differences between these resulted means. Bonferroni test results are shown in Table 17.

Table 17. Bonferroni pairwise post hoc comparisons test of the students' responses to considering an interactive learning

Considered as an interactive Learning		Online learning as interactive learning	Blended learning as interactive learning
Bonferroni	Adj. Mean	2.41	2.67
Blended learning	2.67	0.26*	
Face-to-face learning	3.39	0.98*	0.72*

* $p < 0.05$

It is clear from Table 17 that students consider face-to-face learning as interactive within a degree “often” more than students who consider online learning as interactive within a degree of “sometimes” then, blended learning is considered as interactive within a degree “often”. Also, Table 17 shows that students consider blended

learning as interactive within a degree more often than students consider online learning as interactive learning within a degree of “sometimes”.

The arithmetic means and standard deviations of students' responses to the interaction and communication with lecturers and other students in face to face learning and online learning using, MS Teams, were calculated with respect to gender and academic level. Then, 3-Way ANOVA analysis with repeated measures is applied as shown in Table 18.

Table 18. 3-Way ANOVA analysis with repeated measures for the means of students communication with lecturers and other students

Source of Variance	Sum of Squares	Df	Mean Square	F	Sig.	Partial η ²
Tests of Within-Individuals Effects						
Mauchly's W=0.96, Approx. $\chi^2=29.65^*$, df=2, ϵ (Greenhouse-Geisser)=0.96						
Communication and Interaction	129.41	1.92	67.42	77.76*	0.00	0.1010
Communication and Interaction*Gender	0.08	1.92	0.04	0.05	0.95	0.0000
Communication and Interaction*Education Level	13.71	5.76	2.38	2.75*	0.01	0.0120
Communication and Interaction*Gender*Education Level	7.89	5.76	1.37	1.58	0.15	0.0070
Error(Communication and Interaction)	1154.95	1332.2	0.87			
Tests of Between-Individuals Effects						
Gender	1.31	1	1.31	0.89	0.35	0.0010
Education Level	1.97	3	0.66	0.45	0.72	0.0020
Gender*Education Level	2.28	3	0.76	0.52	0.67	0.0020
Error	1023.85	694	1.48			

* p<0.05

The results in Table 18 demonstrate that there are statistical significance differences ($\alpha=0.05$) for the adjusted means of the interaction between students in face to face, the interaction between students in Microsoft teams, and the communication with their lecturers on MS teams, and because of the variation within students' interaction and communication with each other and with lecturers, Bonferroni pairwise post hoc comparisons test is applied and the results are shown in Table 19.

Table 19. Bonferroni pairwise post hoc comparisons test for the students communication and interaction

Communication and Interaction		Interaction with other students through MS-TEAMS platform	Communicate with lecturer through MS-TEAMS
Bonferroni	Adj. Mean	2.43	2.82
Communicate with the lecturer through MS TEAMS	2.82	0.39*	
Interaction with other students in face to face learning	3.26	0.84*	0.45*

* p<0.05

It is clear that the student's interaction and communication within face to face learning has the highest value than the communication with their lecturers through MS teams platform, then the interaction with other students on MS teams. Also there are no differences in the adjusted means of communication and interaction according to the gender.

We found that there are observed differences in the students' interaction and communication with each other and with lecturer in face-to-face and online learning using MS teams, due to the interaction and communication according to the academic level. Therefore, Bonferroni pairwise post hoc comparisons test is used and the results are shown in Figure 6.

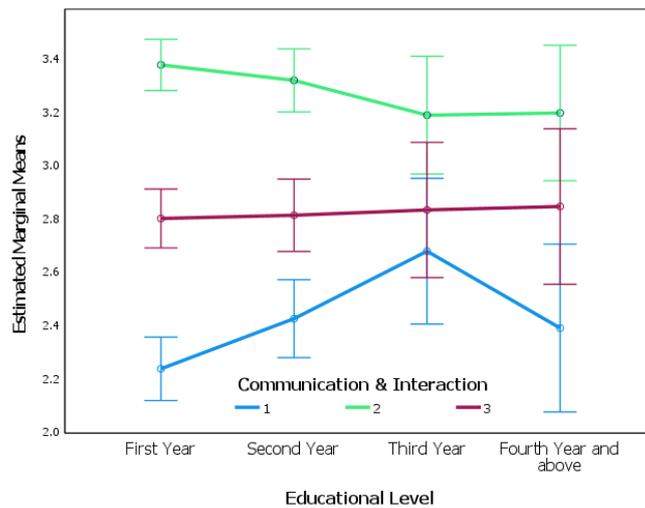


Fig. 6. Bonferroni pairwise post hoc comparisons test results for the adjusted means of students' communication and interaction according to the gender and educational level

From Figure 6, it is found that the highest degree of the student's interaction and communication for all levels is in face to face learning, then the interaction with their lecturers on Microsoft teams platform, then student's interaction with other students on Microsoft teams. In addition, it is clear that the interaction of the third-year students with their classmates via MS teams platform within a degree of “often” is more than the interaction of the first-year students with their classmates via MS teams platform within a degree of “sometimes”.

These results provide some recommendations for optimizing the learning process and satisfying the course learning goals. Encouraging students to ask their lecturers questions so they may better understand the course materials through e-learning platforms is one of these suggestions. Additionally, it is advised that instructors allow more time for discussion in their lectures.

6 Conclusion

COVID-19 pandemic affects several aspects of people's lives, where lockdowns are imposed on all countries around the world. Learning in universities is one of these aspects that were affected. The solutions that were proposed in this study to be used to let the students continue their learning are examined during the pandemic and after that, where the students are allowed to return to their universities. Three learning methods that are used in Hashemite University are investigated as a case study using a questionnaire. To analyze the responses of the students to the questions in the questionnaire, we used 3-Way-ANOVA and Bonferroni pairwise post hoc comparisons tests.

The interaction of the students with Face-to-face, blended and online learning methods are explored and compared in two main terms; the interaction between students and their lecturers and how students use these learning methods to get knowledge. The comparison show that Face-to-face learning method is more preferred by the students where their commitment is high to attend their lectures and solve their home works and communicate with their lecturers and other students in their class.

Face-to-face learning receives the highest percentage values compared with other types of learning in terms of students attending lectures (79%), fully understanding subjects (65%), and submitting assignments (75%). In addition, the majority of students reported that their total scores before the final test are higher in the face-to-face courses compared with other learning types, while lecturers always answer their questions in face-to-face learning by an average of 81%. Moreover, 81% of students always contact their instructors in face-to-face learning, while 32% of students utilize the Microsoft Teams platform to communicate with their lecturers on a daily basis.

These findings make some suggestions for enhancing learning experience and achieving course learning objectives. We recommend enhancing Moodle platform with additional features to encourage class participation in online learning courses. One of these tools is the interactive program Kahoot Puzzle¹, which is used by lecturers to format their assignments as mazes or quick games to be solved by their students.

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