Effects of using blended instruction on undergraduate Information Technology students' achievement in post COVID-19 era

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Abstract*: This study examined the effects of using blended instructional mode on undergraduate students' academic performance and knowledge retention in a technology-based university in Ghana. A sample of 140 second year Information Technology (IT) students, who were offering Data Structures and Algorithms, was selected using the purposive random sampling technique for this study. All the 140 students were taught face-to-face during the first 6 weeks of this study, and then split into two groups for the next 6 weeks. The experimental group had the classes synchronously and asynchronously online (OL) while the control group attended the same classes face-to-face (FTF). Three 30-item multiple-choice scholastic tests (namely: pre-test, post-test and delayed test) were administered to the students at the end of weeks 6, 12 and 16, respectively, of the 1st semester of 2021/2022 academic year. The data was analyzed using descriptive statistics and ANOVA. The results showed that the use of blended instruction mode enhanced the academic performance and knowledge retention of undergraduate students more than when the conventional (FTF) teaching method is used. It found that statistically significant differences existed in the mean post-test and delayed test scores between students in the control (FTF) group and those in the experimental (OL) group, in favour of the experimental group. Also, this study revealed that there was a statistically significant difference between the academic performances of male and female students, in favour of the female students, when the blended instructional mode is used. Furthermore, this study proffered some recommendations to make the blended instructional method usage more efficient and to increase its adoption and adaptation in higher educational institutions.

***Keywords*: Blended instruction, video-conferencing, constructivist theory, synchronous teaching, academic performance**

I. INTRODUCTION

Since the relaxation of COVID-19 restrictions, many institutions have adopted a blended instructional model comprising in-person (or face-to-face) instructional technique (FTF) and teacher-led online technique (OL). To forestall harmony, effectual monitoring, and maintain high level of teaching and learning experiences, institutions have developed blended instructional protocols with clear goals and expectations to guide lecturers and students.

The COVID-19 pandemic has changed the way teaching and learning are conducted in schools and universities globally. There is a paradigm shift from the use of face-to-face instructional technique to the use of technology to curtail the spread of the COVID-19 infections. Lecturers and students adopted various technology tools for synchronous and asynchronous teaching and learning activities. In many cases, however, such adoptions had not been very smooth. With the abatement of the COVID-19 infection rates and the lifting of its restrictions, many universities have adopted the use of blended instructional mode. [1] and [2] assert that blended instructional mode is superior and more effective than the face-to-face mode of teaching in schools and universities.

Lecturers in many universities are using video-conferencing facilities and associated whiteboards to enable both online (OL) and face-to-face (FTF) students to participate in the same lessons without disadvantaging any group. However, internet connectivity issues, malfunctioning data projectors, poor audio and video receptions, and electricity power outages, among others, seem to adversely affect the smooth use of the blended instructional model [3]. Sometimes, lecturers are stressed out in redesigning their instructional materials to simultaneously satisfy the two groups of students. Students are also overwhelmed with the volume of online learning materials and assignments they are given per course in each semester. These issues call for proper integration of the two teaching/learning methods to promote excellent teaching/learning experiences [4] as well as proper assessment of the relative effect that this integration has on students' academic achievement. This study, therefore, examined the effect of the use of blended instructional mode on undergraduate Information Technology students' performance in Data Structures and Algorithms in a Ghanaian public university.

This study's objectives are outlined as follows:

i. To examine the effect of blended instructional mode usage on students' performance in Data Structures and Algorithms.

ii. To determine if a significant difference exists in information-retention and performance between face-to-face (FTF) students and blended/online (OL) students in Data Structures and Algorithms.
iii. To determine if there is a significant difference in performance between male and female students in Data Structures and Algorithms.

This study's research questions (RQs) are outlined as follows:

RQ1. What is the effect of blended instructional mode usage on students' performance in Data Structures and Algorithms?
RQ2. Is there a significant difference between the performance of blended/online and face-to-face students in Data Structures and Algorithms?
RQ3. Is there a significant difference in retention of information between blended/online and face-to-face undergraduate students in Data Structures and Algorithms?
RQ4. Is there a significant difference in performance between male and female students in Data Structures and Algorithms?

There are persistent calls from educational policy protagonists (including think-tanks) for the development of innovative constructivist-based instructional tools, methods and strategies for use in schools, colleges and universities. The results of this study will strengthen debates on the efficacy of blended instructional method in higher education and strategies to make it more efficient and increase its adoption, adaptation and use.

II. LITERATURE REVIEW

CONCEPTUAL FRAMEWORK

This study is underpinned by both the Community of Inquiry framework and the Constructivist theory.

Community of Inquiry Framework (CoI)

[5] constructed the CoI conceptual framework for use in computer-mediated communication in educational settings. It involves a group of individuals creating their individualized meanings and confirming shared understanding of topics discussed. An implication of this framework for blended instruction and learning is that learners naturally reflect on topics discussed in class so as to have a deeper understanding to enable them do assignments asynchronously.

The Community of Inquiry framework, as depicted in Fig. 1, contains three interconnected learning dimensions/presences: "cognitive presence, social presence and teaching presence" [5], p. 88. Cognitive presence refers to learners' ability to meaningfully create and confirm their views through discussion and reflection. Social presence refers to the level of connectedness among online learning participants; or the ability of an individual to establish purposeful relationships with others online. It involves social interaction, cohesion and participants' emotions [5], [6]. On the other hand, teaching presence connotes "the design, facilitation, and direction of cognitive and social processes for the purpose of realizing personally meaningful and educationally worthwhile learning outcomes" [7], p. 5. It involves teachers designing learning materials and activities skillfully, facilitating discourse among students meaningfully and purposefully, and providing intellectual and scholarly leadership to learners.

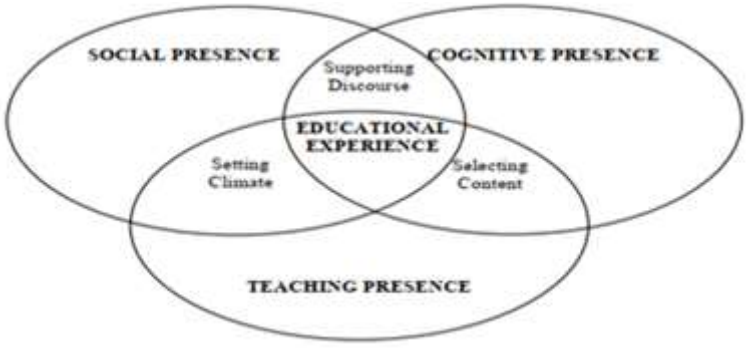

Fig. 1 Community of Inquiry Framework [5], p. 88

Constructivist Theory

The constructivist theory postulates that learners acquire knowledge through social interaction with the environment and others; and utilize their past knowledge and experience to build new knowledge [8]. It is, therefore, "an approach to learning that holds that people actively construct or make their own knowledge and that reality is determined by the experiences of the learner" [9], p.256. The implication of this theory for education is that blended instructional and learning model, when implemented with appropriate content and quality delivery, can provide an enabling environment for goal-oriented social (teacher-student and student-student) interactions where learners build their knowledge [10].

Cognitive constructivism, social constructivism and radical constructivism are the three types of the constructivist theory identified in pedagogical literature. Cognitive constructivism postulates that learners actively construct knowledge using their prevailing cognitive structures [11]. Social constructivism asserts that learners acquire knowledge in collaboration with others and through their social interactions [12]; while radical constructivism states that learners create new knowledge based on an already existing knowledge; and that knowledge is not perceived sensually [13].

Learners' active quest for knowledge and the meanings they construct from experiences and social interactions with the learning environment and others, are concisely central to the constructivist theory [14], [15], [16]. This, therefore, calls for teachers to create interactive, student-centred, and collaborative problem-solving blended instructional environments and facilitate learners' active participation in learning.

Concept of Blended Instructional mode

[17] defined blended instruction as the combination of computer-aided instruction and face-to-face instruction in education. Similarly, [18] defined it an "integration of electronic teaching media with traditional teaching methods" (p. 29). [19] asserted that blended instructional technique harnesses the advantages of both information technology and conventional teacher-led learning for building cogent educational programs. The goal of blended instruction model is, therefore, to individualize learners' experiences to enable them demonstrate competence in thinking skills, sense of purpose (including relationships building and self-efficacy), success habits development (including mindsets and dispositions), and content management [20].

The importance of blended instructional mode in pedagogy cannot be overstated. It is time-saving, efficient, socially interactive, learner-friendly, cost-effective, increases engagement between instructors and learners and among learners, pedagogically rich, optimizes learning outcomes, and easy to revise [21]-[25]. Existing studies on the use of blended instructional technique revealed that the quality and quantity of interaction of blended instructional environments greatly influence students' learning and communication skills, experience, and academic achievements [26], [27], [28].

Effectiveness of Blended Instruction

Studies relating to the effectiveness of blended instruction and learning in comparison with the conventional face-to-face method have produced mixed results due to availability of diverse ways of measuring learning environments. Some researchers revealed that the effectiveness of blended instructional method has statistically significant advantage over face-to-face method [29], [30]; whilst others found no statistically significant difference between the effectiveness of the two instructional methods [31], [32].

In his study of the effectiveness of blended instructional technique and students' performance using 145 undergraduate Botany students in Salem City in India, [2] found that blended learning classes were effective and students in the experimental (OL) group outperformed those in the control (FTF) group. Similarly, [33]'s study involving 41 biology students emphasized the effectiveness of blended instruction and concluded that statistically significant differences exist between the performances of students in the experimental (OL) group and those in the control group; and that those in the experimental group did better.

Furthermore, in a study of 34 students from Cuba City High School in Southwest Wisconsin to determine the effectiveness and efficiency of blended teaching and learning relating to advanced algebra, [34] created 2 sub-samples of 17 students each. One group (Control group) was offered face-to-face lessons daily; but the second group (experimental group) was offered online classes for 2-3 days per week coupled with 2-3 days of face-to-face lessons. The students answered 14 pre-test questions before the study; and they answered another 14 post-test questions after the study. The study found no statistically significant difference in students' performances in advanced algebra between the two teaching/learning methods.

Though effectiveness of blended instruction can influence students' academic performance in a university, researchers have identified some other crucial factors. These include environmental, institutional, personal, socio-economic, and psychological factors [35], [36]. Similarly, researchers have reported other factors such as students' self-concept, teaching tools and methods, as well as burdensome course load [37], [38].

Blended Instruction and Academic Performance

Using 53 6th grade students in Turkey for their study, [39] conducted pre- and post- academic achievement tests and used the scores for their analysis. They posted ideas, assignments, videos, quizzes and examinations on bayazpano.com learning management platform for all the students to access. However, online lectures were conducted using google hangout and you-tube channel for the experimental group. During the 7-week experimental period, they conducted two hours of face-to-face lectures for the control group weekly; but for the experimental group, they conducted one hour face-to-face followed by one hour of online instruction weekly. They found a more statistically significant difference between the experimental group's pre-test and post-test scores than those of the control group. They, therefore, concluded that the students in the experimental group were more successful academically than those in the control group.

[40] used a sample of 326 undergraduate students offering Chemistry during the first term of 2019/2020 academic year for their study. This comprised 163 students in control (face-to-face) group and the remaining 163 students in experimental (online) group. The two groups took a pre-test. The control group were taught 10 topics using the face-to-face method for 10 weeks. During the same period, the experimental group was also taught the same topics using online videoconferencing facilities. The researchers then administered a post-test comprising multiple-choice questions to the students. Using t-test, they found that statistically significant differences exist in the achievement of the two groups of students; and that the experimental (OL) group outperformed the control (FTF) group. They concluded that the blended instructional technique had increased students' understanding of, and performance in, Chemistry. Gender-wise analysis using one-way ANOVA test, on the other hand, revealed that there are no statistically significant differences in the experimental group's performance in Chemistry. [41] had similar findings from a survey with two

groups of 42 students of Tai Solarin University of Education in Nigeria. Specifically, the study revealed a statistically significant positive effect of blended instructional technique on students' academic performance; and no significant difference gender-wise in the experimental group.

In sharp contrast, [42] found from a review of 355 studies that no significant difference exists between blended and traditional modes of instruction and learning. Furthermore, in a survey of 125 preservice teachers comprising a control group (n=61) and experimental group (n=64), [32] conducted a pre-test for the participants; and grouped them into three categories (poor, average and good) based on their pre-test scores. After conducting 11 weeks' classes using face-to-face for the control group, and using a combination of synchronous and asynchronous settings for the experimental group, the researcher conducted a post-test. Also, a delayed test was conducted four weeks after the course to measure the participants' knowledge-retention. The survey revealed that the two modes (face-to-face and blended instructional modes) have statistically similar effects on participants' academic performances. In addition, it showed that face-to-face mode was statistically more effective than blended instructional mode when it comes to participants' retention of knowledge after the classes (as measured by the delayed test).

III. METHODOLOGY

This study covers second year undergraduate Information Technology students in a public university in Ghana. The population of these students is 218. Using [43]'s table for sample-size determination, a sample of 140 students was selected using purposive random sampling technique for this study. Data Structures and Algorithms was chosen for this study because it is a core course that all Information Technology students take in Level 200.

All the 140 students were taught Data Structures and Algorithms face-to-face during the first 6 weeks of the 1st semester of 2021/2022 academic year. For the next 6 weeks, however, the students were split into two equal groups; namely: experimental group and control group. While the experimental group attended the Data Structures and Algorithms lectures online (OL), the control group attended the same lectures face-to-face (FTF), at the same time.

The instrument comprised of three 30-item multiple-choice scholastic tests: pre-test, post-test and delayed test. Also, each of the three test documents has 3-item biographical data (age, gender, and program) asked for; followed by the test questions. The instrument was developed and duly validated by three university professors with expertise in students' assessment instruments design and evaluation in conformity with Bloom's taxonomy. The researcher administered the pre-test, post-test, and delayed test at the end of weeks 6, 12 and 16, respectively, of the 1st semester of 2021/2022 academic year.

Cronbach alpha reliability values greater than the 0.70 threshold [44] were attained indicating internal consistency of the instrument's data items. Also, composite reliability (CR) values of at least 0.80 [45] were attained signifying convergent validity of the instrument. Furthermore, values for average variance extracted (AVE) that are bigger than the 0.50 threshold [46] were attained, indicating convergent and discriminant validity. Thus, the instrument passed the validity and variability tests. The data was analyzed using descriptive statistics (mean, standard deviation, frequency, percentage), and ANOVA. The gender and program distributions of the sample (participants) for this study are presented in Table 1.

Table 1. Distribution of Gender and Program of Participants

Grouping	Gender/Program	N	Percentage
Control	Male	42	60%
	Female	28	40%
Total		70	100%
Experimental	Male	42	60%
	Female	28	40%
Total		70	100%
Control	Engineering (ENG)	16	23%
	Computer Science (CS)	23	33%
	Information Technology (IT)	31	44%
Total		70	100%
Experimental	Engineering (ENG)	16	23%
	Computer Science (CS)	23	33%
	Information Technology (IT)	31	44%
Total		70	100%

Table 1 showed that the sample from each of the two (Control and Experimental) groups has 42 males and 28 females, constituting 60% and 40%, respectively. Also, 16 (23%), 23 (33%) and 31 (44%) of the students in each of the Control and Experimental groups, are pursuing Engineering, Computer Science and Information Technology degree programs, respectively.

IV. RESULTS

Table 2 presented the participants' mean scores on the three scholastic tests conducted for this study. It revealed that the means and standard deviations of the pre-test achievement scores of students in the Control group and Experimental group were Mean = 16.20, SD = 3.805 and Mean = 14.79, SD = 3.730, respectively. The results for the post-test achievement scores for students in the Control group and Experimental group were Mean = 20.93, SD = 3.838 and Mean = 24.06, SD = 3.702, respectively. Furthermore,

in the delayed test, students in the Control (FTF) group obtained Mean =23.93, SD =3.177 and those in the Experimental (OL) group got Mean = 26.46, SD = 3.184 . Thus, students in the Control (FTF) group outperformed those in the Experimental (OL) group in pre-test, while the latter group outperformed the former group in both post-test and delayed test.

Table 2. Mean and Standard Deviation for Scholastic Test Scores

Test	Group	N	Mean	SD	Mean Gained	Percentage Mean Gained
Pre-test	Control	70	16.20	3.805		
	Experimental	70	14.79	3.730		
Post-test	Control	70	20.93	3.838	4.73	29.2%
	Experimental	70	24.06	3.702	9.27	62.7%
Delayed test	Control	70	23.93	3.177	3.00	14.3%
	Experimental	70	26.46	3.184	2.40	9.9%

Table 2 further showed that students in the Control group had a mean gain of 4.73 scores between the pre-test and post-test (constituting a 29.2% increase); while those in the Experimental group had a much higher mean gain of 9.27 scores (constituting a 62.7% increase) between pre-test and post-test. Also, between the post-test and the delayed test, the students in the Control (FTF) group had a mean gain of 3 scores (representing 14.3% increase) while those in the Experimental (OL) group obtained a mean gain of 2.40 (constituting a 9.9% increase).

ANOVA test results for the determination of significance of differences in the mean scores on the tests were presented in Tables 3, 4 and 5.

Table 3. Single Factor ANOVA for Pre-test Achievement Scores

Source of Variation		SS	df	MS	F	P-value	F crit
Pre-test	Between Groups	70.00714	1	70.00714	4.931626	0.028	3.909729
Variable	Within Groups	1958.986	138	14.19555			
	Total	2028.993	139				

α = 0.05 level of significance

Testing the pre-test data at α =0.05 level of significance, Table 3 revealed that a statistically significant difference exists in the mean scores between face-to-face (control) group and online (experimental) group since p-value < 0.05 and F(1,138) = 4.932. This statistical significance is in favour of the control (face-to-face) group as shown in Table 2 since the mean pre-test score for control group (Mean =16.20) is larger than that of the experimental (online) group (Mean = 14.79).

Table 4. Single Factor ANOVA for Post-test Achievement Scores

Source of Variation		SS	df	MS	F	P-value	F crit
Post-test	Between Groups	342.5786	1	342.5786	24.09065	0.000003	3.909729
Variable	Within Groups	1962.414	138	14.22039			
	Total	2304.993	139				

α =0.05 level of significance

Since the p-value of 0.000003 shown in Table 4 is less than α value of 0.05, there is a statistically significant difference between the mean post-test scores of the two groups; and F(1,138) = 24.091. This statistical significance is in favour of the experimental (online) group as shown in Table 2 since the mean post-test score for experimental (online) group (Mean = 24.06) is larger than that of the control (face-to-face) group (Mean = 20.93).

Table 5. Single Factor ANOVA for Delayed Test results

Source of Variation		SS	df	MS	F	P-value	F crit
Delayed test	Between Groups	223.7786	1	223.7786	22.12115	0.00001	3.909729
Variable	Within Groups	1396.014	138	10.11605			
	Total	1619.793	139				

α =0.05 level of significance

In the same vein, Table 5 revealed the existence of a statistically significant difference in the mean delayed test scores between the two groups, (p = 0.00001, α = 0.05, F(1, 138) = 22.1212), since the p-value is less than the α value. This statistical significance is in favour of the experimental (online) group as shown in Table 2 since the mean delayed test score for the experimental (online) group (Mean = 26.46) is larger than that of the control (face-to-face) group (Mean = 23.93).

The gender distribution and ANOVA for the participants' mean achievement scores in the three scholastic tests are presented in Tables 6, 7, 8 and 9.

Table 6. Mean and Standard Deviation for Scholastic Test Results by Gender

	Control Group				Experimental Group			
Test	**Gender**	**N**	**Mean**	**SD**	**Gender**	**N**	**Mean**	**SD**
Pre-test	Male	42	14.60	3.55	Male	42	14.81	3.96
	Female	28	18.61	2.81	Female	28	14.75	3.43
Total		70				70		
Post-test	Male	42	21.43	4.51	Male	42	22.02	3.19
	Female	28	22.32	3.72	Female	28	27.11	1.87
Total		70				70		
Delayed test	Male	42	23.88	2.73	Male	42	25.21	3.44
	Female	28	24.00	3.80	Female	28	28.32	1.39
Total		70				70		

Table 6 revealed that female students in the control group performed better in the Data Structures and Algorithms pre-test than the male students in that group (Mean for females = 18.61, Mean for males = 14.60); while the male students in the experimental (Online) group performed better than the female students in that group (Mean for males = 14.81, Means for females = 14.75). However, in the post-test, the female students performed better than the male students in both the control and experimental groups since 22.32 > 21.43 and 27.11 > 22.02 for the control and experimental groups, respectively. In the delayed test too, the female students outperformed the male students in both the control and experimental groups since 24.00 > 23.88 and 28.32 > 25.21 for the control and experimental groups, respectively.

Table 7. ANOVA for Control Group's Pre-test Achievement Scores by Gender

Source of Variation		**SS**	**df**	**MS**	**F**	**P-value**	**F crit**
Gender	Between Groups	270.4024	1	270.4024	25.22972	0.000004	3.981896
Variable	Within Groups	728.7976	68	10.71761			
	Total	999.2	69				

α =0.05 level of significance

Table 7 showed that there is a statistically significant difference between the mean pre-test achievement scores of male and female students in the control group since the p-value is less than the α value (p = 0.000004, F(1, 68) = 25.23, α = 0.05).

Table 8. ANOVA for Experimental Group's Post-test Achievement Scores by Gender

Source of Variation		**SS**	**df**	**MS**	**F**	**P-value**	**F crit**
Gender	Between Groups	434.1167	1	434.1167	57.69502	0.00000	3.981896
Variable	Within Groups	511.6548	68	7.524335			
	Total	945.7714	69				

α =0.05 level of significance

Table 8 revealed that a statistically significant difference exists between the mean post-test scores of the male and female students in the experimental (online) group in this study because the p-value is less than the α value (p = 0.0000, α = 0.05, F(1, 68) = 57.70); and Table 6 showed that this difference in the mean post-test scores is in favour of the female students (because their mean post-test scores are greater than that of the male students).

Table 9. Single Factor ANOVA for Delayed Test Results for Experimental Group by Gender

Source of Variation		**SS**	**df**	**MS**	**F**	**P-value**	**F crit**
Gender	Between Groups	162.1929	1	162.1929	20.53156	0.00002	3.981896
Variable	Within Groups	537.1786	68	7.899685			
	Total	699.3714	69				

α =0.05 level of significance

Table 9 showed that a statistically significant difference exists between the mean delayed test performances of males and female students in the experimental group because the p-value is less than the α value (p = 0.00002, α = 0.05, F(1,68) = 20.5316); and Table 6 showed that this difference in the mean delayed scores is in favour of the female students (because their mean delayed test score is greater than that of the male students). However, Table 10 showed that the mean delayed test scores for male and female students in the control (face-to-face) group for this study are similar since the p-value is greater than the α

value (p = 0.8793, α = 0.05, F(1, 68) = 0.0232). Thus, there is no statistically significant difference between the mean delayed test performances of the male and female face-to-face students.

Table 10. Single Factor ANOVA for Delayed Test Results for Control Group by Gender

Source of Variation		SS	df	MS	F	P-value	F crit
Gender	Between Groups	0.238095	1	0.238095	0.023249	0.879264	3.981896
Variable	Within Groups	696.4048	68	10.24125			
	Total	696.6429	69				

α =0.05 level of significance

V. DISCUSSION

RQ1: What is the effect of blended instructional method on students' performance in Data Structures and Algorithms course?

This study revealed in Table 2 that the peformance of students in the experimental (online) group improved from their mean pre-test score of 14.79 to their mean post-test score of 24.06 representing a gain of 62.7%. The performance of students in the control (face-to-face) group, however, improved by a comaparatively smaller margin from their mean pre-test score of 16.20 to their mean post-test score of 20.93, representing a gain of 29.2%. Furthermore, a comparison of the mean pre-test scores and mean delayed test scores revealed that the students in the experimental (online) group significantly improved their performance from their mean pre-test score of 14.79 to their mean delayed test score of 26.46, representing a gain of 78.9%. The performance of students in the control (face-to-face) group, however, improved by a comaparatively smaller margin from their mean pre-test score of 16.20 to their mean delayed test score of 23.93, representing a gain of 47.7%. This finding shows that the blended instructional method had benefitted the experimental (online) group greatly resulting in such a large percentage mean gain over their mean pre-test score level.

This study, therefore, revealed that the blended instructional method had enhanced the academic achievement of students in the experimental (online) group in Data Structures and Algorithms by a larger percentage margin than those in the control (face-to-face) group. This finding is consistent with earlier studies done by [2], [29], [33], [47]-[51]. However, [52], in their study of 60 Iranian technical students to examine the effects of online and face-to-face instructional methods on students' academic achievement, found that face-to-face method was significantly more effective. They concluded that "utilization of online training cannot ensure academic success" (p. 795). Also, [53] conducted a study of the effects of blended instructional method on students' satisfaction and academic achievement using a sample of 36 undergraduate students offering Education at University of Isfahan. That study found that though blended instructional method significantly influenced students' satisfaction, it did not significantly affect their academic performance.

RQ2: Is there a significant difference between the academic performances of blended/online and face-to-face students in Data Structures and Algorithms?

Table 4 revealed a statistically significant difference in the mean post-test scores between students in the two groups: control (face-to-face) group and experimental (online) group [p=000003, and α =0.05 and F(1,138) = 24.091]. This statistical significance is in favour of students in the experimental (online) group whose mean post-test score of 24.06 is larger than that of students in the control (face-to-face) group who obtained mean post-test score of 20.93, as shown in Table 2. Similarly, Table 5 showed the existence of a statistically significant difference in the mean delayed test scores between students in the two groups (p = 0.00001, α = 0.05, F(1, 138) = 22.1212). This statistical significance is also in favour of students in the experimental (online) group whose mean delayed test score of 26.46 is larger than that of students in the control (face-to-face) group who got mean delayed test score of 23.93, as in Table 2.

This finding is consistent with those of [39], [40], [54], and [55]. In their quasi-experimental study of the effect of blended instructional approach on students' achievement in computer studies with a sample of 112 secondary school students in Onitsha in Anambra State of Nigeria, [54] found a significant difference between the mean scores of students in the blended learning group and those in face-to-face group in favour of the former group.

In their study of the impact of blended instructional approach on students' performance in mathematics, [56] utilized a sample of 196 students and found that a statistically significant difference in performance existed between students in the control and experimental groups in favour of the experimental (blended instruction) group. Also, [50] investigated the effects of using blended instructional method on undergraduate Fine-Arts students' performance in two Nigerian Universities. With a sample of 100 students and using gender and institution as variables, they found significant differences in students' performances when blended instructional method is used. They, therefore, highly recommended the use of blended instructional method in Nigerian universities.

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RQ3: Is there a significant difference in retention of information between face-to-face and blended/online undergraduate students in Data Structures and Algorithms?

The purpose of conducting the delayed test in this study was to gauge students' ability to retain information that was learned during the Data Structures and Algorithms course during the 1st semester of 2021/2022 academic year. This study showed in Table 5 that there is a statistically significant difference in the mean delayed test scores between the two groups of students in favour of the experimental (online) group. Thus, barely four weeks after the course had ended, students in the experimental (online) group

had a higher level of information retention than those in the control (face-to-face) group (as shown in Table 2). This finding reinforces the benefits that students can derive from blended (online) pedagogy where the teacher uses appropriate constructivist strategies, tools and methods to make classes practical, interesting, student-centred, collaborative, thought-provoking and problem-solving environments.

This finding is consistent with that of [57]. They used a sample of 80 secondary school students and found a statistically significant difference in students' knowledge-retention level between the utilization of blended instructional method and that of the conventional/face-to-face method. They concluded that this difference is in favour of the blended teaching method. In contrast, [32], in a survey of 125 preservice teachers, showed that face-to-face mode of instruction was statistically more effective than blended instructional mode when it comes to participants' retention of knowledge after the classes (as measured by the delayed test).

RQ4: Is there a significant difference in performance between male and female students in Data Structures and Algorithms?

This study revealed in Table 6 that female students outperformed the male students in both control (face-to-face) and experimental (online) groups in the post-test and delayed test. Furthermore, Table 8 showed that there is a statistically significant difference between the mean post-test scores of male and female experimental (online) students; and Table 6 revealed that this difference is in favour of the female students.

Though Table 10 showed that there is no statistically significant difference between the mean delayed test performances of the male and female students in the control (face-to-face) group, Table 9 revealed that there is a statistically significant difference between the delayed test performances of students in the experimental (online) group; and Table 6 revealed that this difference is in favour of the female students.

This finding is consistent with those of [58], and [59] who independently found that female students obtained greater mean scores than the male students when blended instructional method is used; and that there is a significant difference between the academic performances of males and females, in favour of the female students. However, [50] found no significant difference between the performances of male and female undergraduate Fine-Arts students in two Nigerian Universities.

VI. CONCLUSION AND RECOMMENDATIONS

This study examined the effects of blended instructional mode usage on undergraduate students' academic performance and knowledge retention. The results showed that the use of blended instruction mode in universities enhanced the academic performance and knowledge retention of students more than when the conventional/face-to-face teaching method is used. It found that statistically significant differences exist in the mean post-test scores and mean delayed test scores between students in the control (face-to-face) group and those in the experimental (blended/online) group, in favour of the experimental group. Furthermore, this study revealed that there is a statistically significant difference between the academic performances of male and female students, in favour of the female students, when the blended instructional mode is used.

These findings, therefore, offer insight into the adoption and use of innovative constructivist-based pedagogical strategies, tools and methods to enhance students' performance and information-retention in universities. Also, this study strengthens the debate on the efficacy of using blended instructional method in higher educational institutions.

From this study, the following recommendations are proffered to make blended instructional method usage more efficient and to increase its adoption and adaptation:

i. Teachers should carefully plan the content of their lessons, and identify appropriate blended instructional delivery tools and strategies to use.
ii. Teachers should make their blended instructional environments student-centred, interactive, and friendly; then enthusiastically facilitate discussions in class.
iii. Teachers should give timely feedback on formative assessments (asynchronous assignments and quizzes) to students.
iv. Authorities in higher education should develop blended instructional and learning protocols to guide teachers and students, and foster uniformity in the level of instructional blending of classes in their institutions.

This research covered only one university, which is a technology-based institution, so the findings were not surprising. Future research may consider covering a number of universities in a bid to do a comparative analysis of the effects of blended instructional mode on students' academic performance. Furthermore, it may consider identifying appropriate levels (or percentages) of instructional blending of classes to promote effectiveness of use, and boost students' academic performance.

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