BYOD IN HIGHER EDUCATION: A CASE STUDY OF KUWAIT UNIVERSITY

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ABSTRACT

One key trend in the educational application of new technologies involves the integration of the "bring your own device" (BYOD) initiative. This study's objective was to determine the impact and usefulness of a BYOD program for students' learning and academic excellence at Kuwait University (KU). A quasiexperimental design was employed that compared classroom assessment scores and final grades for control (i.e., non-BYOD) and experimental (BYOD) student groups. The results showed that BYOD intervention had a statistically significant positive effect on students' learning and achievement, as measured by improvement in test scores, quality of work on projects, and final grades, along with heightening students' motivation, attitudes, and involvement in the course.

Keywords: Bring Your Own Device (BYOD), mobile learning (m-learning), ICT integration, academic achievement, students' learning, students' attitudes, higher education, university students

INTRODUCTION

Information and communication technology (ICT) has long promised to transform teaching and learning processes and practices in both PK-12 schools and postsecondary education and to deliver great benefits for individuals and organizations. ICT has changed not only *what* we need to teach and learn but *how* we teach and learn. There is an ICT tool/service for every aspect of the educational process: brainstorming, thinking, presenting, writing, revising, researching, analyzing, assessing, communicating, collaborating, sharing, and even administrating. These various tools present benefits such as usability, versatility, portability, multifunctionality, adaptability, and customizability. Thus, the advent of ICT in education has proceeded alongside its broader societal embrace of ICT (Moreira, Ferreira, Santos, & Durão, 2017; Safar, 2012).

Survey reports from the EDUCAUSE Center for Analysis and Research (ECAR) over the past two decades attest that ICT use in academic environments has greatly increased (educause.edu; EDUCAUSE is a nonprofit association whose mission is to advance higher education through the use of ICT.) In doing so, it has had major effects on students' learning experiences and academic achievement (Safar, 2012). Numerous research studies focusing on the impact of ICT use in general and 1:1 ICT-enriched e-teaching/e-learning initiatives/programs in particular on students' achievement and learning have acknowledged the close linkages between scholastic success and ICT use. Both regular students and those with special needs, across all levels of education, show:

1. significant increases in academic achievement measures, across disciplines and grade levels (e.g., in cumulative GPA, individual course grades, and standardized norm-referenced test scores);
2. greater ease of work as well as productivity and quality of work;
3. more collaboration and communication skills and better research skills;
4. intensified interest, motivation, attentiveness, and engagement or involvement in their own learning/studies and growth;
5. improved accessibility/delivery of course content and teaching/learning resources;
6. and more fun learning.

The usage of ICT affects teachers too, augmenting their practice (e.g., teaching strategies, curriculum delivery, and classroom management) (Afreen, 2014; Falloon, 2015; O'Bannon & Thomas, 2014; O'Bannon & Thomas, 2015; Safar, 2012; Safar

& Alkhezzi, 2013; Safar, Jafer, & Alqadiri, 2014).

OBJECTIVES OF THE STUDY

Current trends in education emphasize ICT tools and services and the role they play in achieving the goals of education and improving students' learning experiences and outcomes. One prevailing trend involves the integration of "bring your own device" (BYOD) or "bring your own technology" (BYOT) initiatives. BYOD is an ICT-mediated 1:1 mobile learning (m-learning) model that encourages learners to bring their own personal device(s) with various apps and embedded features/functions to school to use them for learning (and teaching) purposes (Cochrane, Antonczak, Keegan, & Narayan, 2014; Kong & Song, 2015; O'Bannon & Thomas, 2015; Song, 2014). BYOD enables individuals to access an organization's computer network with their own ICT device in order to complete their work tasks (Afreen, 2014). Learners generally find it more desirable to use their personal mobile devices for their academic work (Zahadat, Blessner, Blackburn, & Olson, 2015). The practice of BYOD facilitates the creation of a "learning hub" for individual learners to learn anytime from anywhere (Wong, 2012). This study's main objective was to identify the impact and usefulness of the application of BYOD program for students' learning and academic excellence in flipped and blended classrooms at Kuwait University (KU). To that end, the following research questions were asked:

1. What is the effect of a BYOD program on KU undergraduate students' learning achievement in terms of their scores on tests and final course grades?
2. What is the effect of the BYOD program on the quality of work in the students' assigned course projects?
3. What is the students' level of satisfaction with the course taught using BYOD?

ASSUMPTIONS AND LIMITATIONS OF THE STUDY

This study hypothesized that BYOD has positive impacts on students' learning and academic achievement, as measured by their scores on academic tests, their final grades, and the quality of their class work. The study also hypothesized that implementing BYOD at KU would stimulate and motivate students academically, thereby affecting their level of engagement in creating their own learning. However, the research took place in only one class context: four sections of a three-hundred-level education course called "Instructional Media and Technology." Therefore, it would be interesting to conduct the same study with other ICT classes as well as with humanities and social sciences courses, considering that these are non-ICT classes that do not focus as heavily on technology. Moreover, other limitations, specifically in regard to the participants involved in this study, include the fact that the students' past educational performances in ICT courses taken prior to the introduction of the BYOD program are not considered and that only 100 female senior undergraduate students from the College of Education (COE) at KU participated in this study. This creates less variation within the demographics studied and may introduce inaccuracies in the results. The lack of access to students' past records limits the analysis of the findings because the scale of progression regarding their academic performances prior to and after the introduction of BYOD cannot be deduced.

SIGNIFICANCE OF THE STUDY

The Measuring the Information Society (MIS) Report is an annual document published by the International Telecommunication Union (ITU) that presents a global overview of the latest developments in ICT tools and services, based on internationally comparable data and agreed methodologies using a unique benchmark called the ICT Development Index (IDI), which consists of 11 quantitative indicators distributed over three subindexes: (1) ICT access, which contains five indicators; (2) ICT use, which contains three indicators; and (3) ICT skills, which contains three indicators. It provides an objective assessment of performance among member countries (175 in total as of 2016) in the field of ICT and underlines areas that need improvement. The 2016 edition of the report asserted that during the last decade across all IDI measures tremendous development has occurred globally in the field of ICT in general and in mobile and Internet tools and services in particular. According to the report, the State of Kuwait's IDI value is 6.54 points out of 10, which is above the global average of 4.94 points; Kuwait ranks 53rd globally and 5th regionally after Bahrain, the United Arab Emirates, Saudi Arabia, and Qatar. More specifically, Kuwait's subindex scores were as follows: ICT access, 7.40 (44th

globally), ICT use, 6.15 (40th), and ICT skills, 5.59 (107th). The findings indicate that most members of Kuwaiti society (i.e., 80% and above), including learners, have access to and are using ICT tools and services in their daily lives, (International Telecommunication Union, 2016; Safar, 2017). Yet, different ICT tools and services, or the same ones used differently, may have different impacts on students' learning outcomes and experiences.

Moreover, many research studies have recognized the considerable influence that ICT in general and BYOD in particular have on students' learning and thinking. However, the present researcher found very little evidence of such studies in Kuwait or other Gulf Cooperation Council (GCC) countries.

Therefore, and because Kuwait is undergoing widespread educational reform that in part entails the integration of ICT tools and services into education, this study is timely and valuable. Its findings should provide a reference for policy- and decision-makers as well as education practitioners, particularly in the area of BYOD and m-learning implementation and especially in Kuwait and elsewhere in the Gulf. If the findings support the application of BYOD at KU, this will save a lot of expenditure on stationary equipment (such as desktop computers, projectors, etc.) that can then be applied to greater benefit elsewhere.

LITERATURE REVIEW

The literature discussed in this section looks at the effects of BYOD-supported e-teaching/e-learning environments on students' learning experiences, academic achievement (learning outcomes), improvement, attitudes, motivation, engagement, and satisfaction, and the impact of BYOD on teaching practices.

One research study carried out in a higher education institution in Hong Kong (Kong & Song, 2015) examined the effect of a "personalized learning hub" program involving BYOD on students' reflective engagement in flipped classroom settings, using a model of reflective engagement with three facets: intellectual, personal, and social reflective engagement. The participants were K-12 teachers enrolled in a teacher professional development program on e-learning; they were asked to bring and use their own portable ICT device as a "personalized learning hub" to sustain and reinforce their reflective engagement. Quantitative and qualitative data from surveys and interviews revealed that the intervention was perceived to have a significantly positive effect on learners' achievement of reflective engagement in all three facets and on the e-learning content. The learners likewise recognized the value of BYOD and perceived that group collaboration with peers and experts might expand their knowledge. This kind of reflective engagement fostered by BYOD should help lead to deep learning and personal growth.

Looking at another aspect of BYOD, another study (Parsons & Adhikari, 2016), implemented at a secondary school in New Zealand undergoing a BYOD initiative, scrutinized perceptions of the initiative among students, teachers, and parents after two years using qualitative and quantitative survey data, which were analyzed in terms of three sociocultural dimensions (structures, agency, and cultural practices) and the interactions among them. The study's data illuminated the obstacles encountered by participants in moving towards a BYOD classroom as well as the latent educational benefits of BYOD for teaching, learning, and preparing learners for a knowledge-driven digital era. Most of the participants in the study reported positive changes in learning and classroom management; however, a few teachers also expressed concerns regarding the drastic nature of the change to BYOD. The findings also indicated that BYOD had an especially profound effect on structure and agency domains, as opposed to culture, within the classroom. The responses of some parents—mainly those who lack ICT skills—were somewhat problematic with respect to the agency domain, because they felt that they were being gradually separated from their children's learning activities.

A similar study (Falloon, 2015), also in New Zealand but in an elementary school, examined the impact of using iPads (via a BYOD program) on learners' ability to work collaboratively. A total of 100 students, 7–10 years old, who utilized iPads on a daily basis to accomplish most of their academic tasks, participated in this study. Data were collected over a three-year period (2012–2014), using surveys, researcher observation notes from informal conversations with teachers and students, oral exchanges between students, and display-capture video/audio data. The results showed that

BYOD using iPads had a significantly positive effect on students' ability to work collaboratively, and, combined with the use of cloud-based ICT tools/apps and services such as Google Docs, allowed this collaboration and communication to be extended to much broader audiences well beyond classroom boundaries and to merge formal and informal teaching and learning environments.

A U.S. study (O'Bannon & Thomas, 2014) with 1,095 experienced K-12 teachers (mostly secondary and middle school) investigated the correlation of another variable, teachers' age (the independent variable; mean age, 41.80, *SD* = 11.35), with their responses to various dependent variables, such as: (a) the type of mobile device(s) they owned and their use of the device(s); (b) their support for BYOD initiatives in the classroom; (c) their views on the utility of certain mobile features for accomplishing schoolwork; and (d) their opinions about the instructional benefits and challenges of using mobile devices in the classroom. The data were collected using an online survey questionnaire. The findings showed that participants under 32 years old or 33 to 49 years old (i.e., digital natives) showed no significant differences in responses among them, but that significantly differed from respondents over 50 years old (digital immigrants) on all the aforementioned dependent variables. Thus, teachers' age should be considered before the application of any BYOD initiative in the classroom. Further, digital native teachers also exhibited significantly more favorable responses to BYOD than digital immigrant teachers, who were less likely to own smartphones, less supportive of using mobiles in the classroom, less excited about the useful features of mobiles for completing school-related tasks, less convinced of the instructional benefits of BYOD, and more concerned about barriers associated with BYOD.

O'Bannon and Thomas also conducted a study (2015) into the views of preservice teachers (the bulk of them early childhood or elementary teachers) in the United States on the aforementioned four dependent variables as well as their perception of disruption caused by BYOD. The participants' mean age was 22.93 (*SD* = 5.69), and most participants were experienced users of ICT. The data were collected using a cross-sectional online survey and showed that nearly half (45%) supported the use of BYOD, while one-fourth (25%) did not support BYOD and almost one-third (30%) were uncertain. The findings also indicated that over half of the participants frequently used the 22 identified mobile features and recognized them as valuable and beneficial in the classroom. Preservice teachers also perceived positively the benefits of using BYOD in the classroom that were highlighted in the survey: increased ICT access, motivation, engagement, creativity, productivity, communication, collaboration, and ICT fluency, along with opportunities for differentiation of instruction, anytime/anywhere teaching and learning opportunities, and reducing the digital divide. The results also indicated that preservice teachers perceived several impediments to the implementation of BYOD: disruptions, cheating, accessing inappropriate content, and cyberbullying.

A study with an at-risk middle school population in the United States (Dunleavy & Heinecke, 2008) investigated the impact of BYOD on students' achievement in specific topic areas, namely, math and science. The objective of the program was to increase the efficiency of curricular and instructional processes in order to achieve greater success as measured by traditional indicators such as state standards test scores, Scholastic Aptitude/Assessment Test (SAT) test scores, grades, referrals for disciplinary action, grade retention rates, and preparation for future workplace skills. The researchers used a pretest-posttest research design; between-group Analysis of Covariance (ANCOVA) was applied to longitudinal data to compare standardized math and science achievement test scores of students randomly assigned to BYOD or non-BYOD classrooms. Students were exposed to the treatment for two years. The analysis revealed a significant positive main effect of BYOD on science, but not math, posttest scores, as well as a significant further benefit by gender (male BYOD students outperformed female ones in science). The lack of an effect for math was interpreted as being due to differences in content between disciplines.

Further, the National Center for Education Statistics (NCES) in the United States reported that in the 2003-2004 school year, approximately 30% of fourth-grade pupils attending U.S. public schools did not attain grade-appropriate levels of literacy proficiency on national standardized tests—the "fourth-grade slump" phenomenon. ICT tools and services might have the potential to

overcome the academic shortfalls associated with the phenomenon (Safar & Alkhezzi, 2013). In light of this, a U.S. study by Suhr, Hernandez, Grimes, and Warschauer (2010) investigated the effects over two years of a BYOD initiative on fourth- and fifth-grade students' English language arts (ELA) scores on the California Standards Test (CST). BYOD students significantly outscored their control peers in the traditional group in ELA.

Additionally, Hawkes and Hategekimana (2009) explored the impact of ICT on U.S. student achievement at a university embracing widespread integration of ICT into all disciplinary areas. The study applied a quasiexperimental research design comparing classroom assessment scores for control (nonmobile computing) and experimental (mobile computing) student groups in one- and two-hundred-level introductory courses: Math 102 ("College Algebra"), English 101 ("Composition"), CIS 251 ("Business Applications Programming"), and History 121 ("World Civilization"). The selected courses included students from a variety of majors. To ensure data quality, only grades earned on tests and quizzes that were administered in the classroom under instructor supervision were included in the final analysis. The results indicated that positive differences in assessment outcomes were found in courses with the ICT intervention. Interestingly, this includes the math course, in contrast to the findings of Dunleavy and Heinecke (2008).

In the specific context of science instruction, although dissection is the most efficient, concrete, and creative way of teaching and learning anatomy and physiology, its use in science classrooms is controversial for a range of reasons: moral, ethical, emotional, religious, personal, and cultural. However, controversy can be healthy and good, as it may bring about change and improvement. It breathes new life into human and societal concerns and can prompt reexamination and even renewal. Further, to overcome the controversies surrounding animal dissection in schools, several creative alternatives have been proposed, including the use of marine specimens, modeling clay, preconstructed models, films, pictures, charts, interactive videodiscs, and interactive computer simulations. Particularly, several studies have examined interactive computer simulation as a viable alternative either to replace or supplement actual dissection. One such study was conducted by Akpan and Strayer (2010) to examine the instructional effectiveness of an interactive computer simulation of frog dissection for students' learning outcomes as an alternative to the conventional "hands-on minds-on" dissection method in high school biology classes in the United States. The study involved 36 student participants with no experience in either actual or simulated animal dissection, and it investigated their achievement and attitudes towards dissection, computers, school, and science, using a pretest/posttest design. Students were divided into two groups: one performing traditional dissection (non-BYOD setting) and the other performing computer-simulated dissection using their own ICT tools (BYOD setting). Data were collected using varied measurement tools, such as the Dissection Assessment Test (DAT) and Attitude Assessment Scales (AAS). Independent sampling methods, such as a one-way ANOVA, were used to evaluate the two different classes' achievement and attitudes. The results of the study revealed that both classes experienced statistically significant improvement from pretest to posttest; however, the simulated (BYOD) group significantly outperformed the conventional dissection (non-BYOD) group on the posttest and also experienced statistically more positive attitudes than the students in the conventional class on all three attitude subscales.

A similar study (Song, 2014) was conducted on 28 students in a Grade 6 science class at an elementary school in Hong Kong, examining learners' achievement in content learning based on science inquiry (it focuses here on one topic of several investigated, "Anatomy of Fish") in a seamless inquiry-based 1:1 e-learning environment supported by BYOD. The study aimed to illuminate how learners developed their content knowledge in science inquiry and investigate their insights into their BYOD-supported learning experience using a mixed research design. Data were collected over a one-year period using a self-reported survey questionnaire, pre- and postdomain tests, learners' artifacts, class observations, and field notes. To trace learners' knowledge advancement, both content analysis and learners' artifacts tracing methodologies were used in the data analysis. The results indicated that the BYOD intervention significantly improved learners' comprehension of the anatomy of fish beyond what was presented in their textbooks. Also, their motivation and engagement were very

high and they had significantly positive attitudes towards the intervention.

Moving on from subject matter to the issue of ICT usage type, Lei (2010) conducted a study on U.S. middle-schoolers in a school embracing rich ICT resources, through a 1:1 laptops initiative and a BYOD program. The research focused on ICT-in-context, looking for associations between quantity and quality of ICT use and students' outcomes. Five ICT usage categories were identified according to purposes and nature of use: (1) subject-specific ICT uses; (2) social-communication ICT uses; (3) construction ICT uses; (4) exploration/entertainment ICT uses; and (5) general ICT uses. Four major measures were used: (1) students' academic achievement; (2) technology proficiency; (3) learning habits; and (4) developmental outcomes, with quantitative and qualitative data including student survey, teacher and student interview data, and students' GPAs. Student respondents were selected based on their level of interest in using ICT. Although the findings indicated no strong correlation between quantity of ICT use and any of the DVs, for quality of usage statistically significant relationships (correlations, not causal relationships) were found with most outcomes. Hence, the results support the ideological notion that different ICT uses have different influences on different students' outcomes. This study concluded by asserting the need for longitudinal empirical research to identify the long-term impact of ICT on students' learning outcomes (Lei, 2010).

Another recent research study, conducted by Song and Kong (2017) at a higher education institution in Hong Kong, focuses on identifying and demonstrating the affordances and constraints of BYOD for teaching and learning in higher education from the perspectives of teachers. To do so, a "framework of affordances and constraints of BYOD-supported/mediated teaching and learning environment in higher education" was deployed (p. 40). A total of 17 faculty members from eight departments and centers participated in this study. The data were collected over a one-year period using class videos, class observations, field notes, teacher interviews, teaching plans, and resources on an institutional BYOD web site and were analyzed using content analysis. The analysis yielded seven BYOD affordances for a variety of teaching and learning uses: (1) resource access tool; (2) resource collection tool; (3) resource submission tool; (4) resource sharing tool; (5) communication tool; (6) knowledge construction tool; and (7) representation and augmented reality tool. The results also indicated three teacher-perceived constraints of BYOD in pedagogical practice: (1) technical constraints (e.g., app functionality, screen size limits, Wi-Fi infrastructure, lack of recharge facility, and relative computing power of desktop vs. m-device); (2) social constraints (e.g., equity, teaching support and lack of face-to-face communication); and (3) personal constraints (e.g., technical competence of teaching staff, technical competence of learners, unwillingness to use BYOD, time consumption, app choice, and BYOD-appropriate pedagogy).

Taking the above-cited studies all together, we see that a broad range of research has shown that the integration of 1:1 ICT-mediated BYOD into education can enhance learning and teaching outcomes, and that there are close associations among ICT use, scholastic success, curriculum content, and BYOD-supported teaching and learning environment—with BYOD students doing better in national standardized tests, becoming more fascinated by and involved in their own studies, and even having more fun learning. Thus, ICT intervention into education via BYOD seems to hold potential to create a solid foundation for stimulating, student-centered environments that promote meaningful learning across all disciplines and grade levels.

METHODOLOGY

Research Design

A quasiexperimental research design was employed to compare classroom assessment scores and final grades and to evaluate their attitudes toward, motivation regarding, engagement in, and perceptions of the intervention for two student groups: an experimental (BYOD) group and a control (non-BYOD) group. The students were taught the same content by the same instructor (the researcher) using the same delivery method, a flipped/blended classroom environment. The experimental group brought their own personal mobile ICT device(s) (e.g., laptops, tablets, and smartphones) into the classroom while the control group used desktop PCs provided by the institution. This research model was intended to enable the

examination of data reflecting the participants' experience, thereby elucidating the effect of BYOD on students' learning and academic achievement.

Sample

A sample of 100 female senior undergraduate students from the COE at KU enrolled in four sections of a three-hundred-level undergraduate education course entitled "Instructional Media and Technology" for the fall 2016 semester participated in this study. The learners were divided into two groups (control and experimental) of the same size (50 each) and gender (all female). The sample evidenced a similar mix of ethnic and socioeconomic backgrounds and included students from a variety of majors. The course is a three-credit mandatory class for all undergraduate teacher preparation programs.

Data Collection

The data were collected over a four-month period (over the semester) and took the form of various indicators: test scores, project/assignment marks, final grades, attendance and participation logs, class observations, field notes, students' artifacts, assessments of students' communication and collaboration skills, and interviews. Participants were assured that their data would be kept confidential and would only be used for statistical analysis purposes.

Methods of Analysis

Several methods of statistical analysis were used to explore the collected data. These techniques met the basic parametric assumptions required for their implementation. The descriptive analysis procedures applied were calculations of frequency, percentage, mean, and standard deviation. A series of comparisons—independent-samples *t*-tests—were also employed to assess the differences between the two groups of students in terms of academic performance (that is, their scores on tests and assigned objective-oriented projects completed in the classroom under supervision of the instructor/researcher) as well as their attitudes, motivations, engagement, and perceptions. An alpha threshold of 0.05 was selected for the inferential tests.

Data Analysis

Three main criteria were used to measure students' learning outcomes: (1) students' scores on tests and their final course grades; (2) quality of work on assigned projects; and (3) students' level of satisfaction with the course (attitudes, motivation, engagement, and interest) along with their attendance and participation. Each criterion was analyzed and presented separately.

Research Question No. 1: What is the Effect of BYOD on Students' Academic Achievement?

This question addressed the effect of BYOD on KU undergraduate students' learning achievement as measured by their scores on two e-tests and final course grades. The results indicated that the experimental group significantly outperformed their counterparts in the control group on Test 1 and Test 2 and in their final grades. Independent-samples *t*-test for Test 1 produced a statistically significant difference between the two groups, $t(34.168) = -3.843$, $p < 0.001$ ($p = 0.000$). The experimental group achieved very high scores ($M = 22.44$, $SD = 1.816$) compared to the control group ($M = 18.84$, $SD = 4.116$). Independent-samples *t*-test results for Test 2 likewise yielded a statistically significant difference between the two groups, $t(32.004) = -4.121$, $p < 0.001$ ($p = 0.000$); the experimental group attained very high scores here ($M = 22.84$, $SD = 1.784$) in comparison to the control group ($M = 18.56$, $SD = 4.673$). The findings also showed a strong significant impact of BYOD on students' final grades, $t(33.800) = -4.810$, $p < 0.001$ ($p = 0.000$); the BYOD students achieved very high grades ($M = 88.96$, $SD = 6.769$) in comparison to the control group ($M = 71.84$, $SD = 15.668$). Thus, a significant positive correlation between instruction with BYOD and learner achievement at KU was evident.Table 1.

Research Question No. 2: What is the Effect of BYOD on the Quality of Students' Work?

This question addresses the effect of BYOD as evidenced in students' quality of work on four objective-oriented curriculum-centered assigned course projects. The results clearly indicate that the experimental group significantly outscored the control group in scores on Project 1, Project 2, Project 3, and Project 4, and demonstrated solid evidence that the types of educational access and opportunities provided by the BYOD teaching and learning environment led to statistically significant positive changes in the quality of students' work. The independent-samples *t*-test for Project 1 produced a statistically significant difference between the two

Table 1. Frequencies and Percentages for Students' Achievement Scores on Test 1, Test 2, and Final Grades

	Type of Group											
	Control						Experimental					
	BA		A		AA		BA		A		AA	
Category	N	%	N	%	N	%	N	%	N	%	N	%
Test 1 Scores	16	32	19	38	15	30	0	0	14	28	36	72
Test 2 Scores	20	40	15	30	15	30	0	0	12	24	38	76
Final Grades	28	56	13	26	9	18	3	6	19	38	28	56

Note. BA = Below Average, A = Average, and AA = Above Average.

Table 2. Means and Standard Deviations of Students' Achievement Scores on Test 1, Test 2, and Final Grades

Category	Type of Group	N	M	SD
Test 1 Scores	1 . Control	50	18.84	4.116
	2 . Experimental	50	22.44	1.816
Test 2 Scores	1 . Control	50	18.56	4.673
	2 . Experimental	50	22.84	1.784
Final Grades	1. Control	50	71.84	15.668
	2. Experimental	50	88.96	6.769

Table 3. Independent-Samples t-tests for Students' Achievement Scores on Test 1, Test 2, and Final Grades, Showing Differences by Group with Regard to Research Question No. 1

		Levene's Test for Equality of Variances		T-Test for Equality of Means		
		F	Sig.	t	df	Sig.
Test 1 Scores	Equal variances assumed	11.722	.001	-3.843	98	.000
	Equal variances not assumed			-3.843	34.168	.000
Test 2 Scores	Equal variances assumed	21.176	.000	-4.121	98	.000
	Equal variances not assumed			-4.121	32.004	.000
Final Grades	Equal variances assumed	20.492	.000	-4.810	98	.000
	Equal variances not assumed			-4.810	33.800	.000

groups, $t(38.103) = -4.454$, $p < 0.001$ ($p = 0.000$). The majority of the experimental group's work on Project 1 was classified as high or medium quality, and they achieved very high scores ($M = 8.36$, $SD = 0.754$) in comparison to the control group, whose work was mostly categorized as medium or low quality ($M = 6.96$, $SD = 1.400$). Similarly, the independent-samples *t*-test for Project 2 yielded a statistically significant difference between the two groups, $t(38.134) = -4.846$, $p < 0.001$ ($p = 0.000$). The majority of the work on this project by experimental group was classified as high or medium quality, and the students attained very high scores ($M = 8.52$, $SD = 0.725$) in comparison to the control group students, whose work was mostly categorized as medium or low quality ($M = 7.04$, $SD = 1.345$). The results also showed a statistically significant positive effect of BYOD on the quality of students'

Table 4. Frequencies and Percentages for Students' Quality of Work on Project 1, Project 2, Project 3, and Project 4

	Type of Group											
	Control						Experimental					
	LQ		MQ		HQ		LQ		MQ		HQ	
Category	N	%	N	%	N	%	N	%	N	%	N	%
Project 1 Scores	11	22	30	60	9	18	0	0	32	64	18	36
Project 2 Scores	9	18	34	68	7	14	0	0	23	46	27	54
Project 3 Scores	9	18	32	64	9	18	0	0	13	26	37	74
Project 4 Scores	10	20	33	66	7	14	0	0	14	28	36	

Note. LQ = Low Quality, MQ = Medium Quality, and HQ = High Quality

Table 5. Means and Standard Deviations of Students' Quality of Work Scores on Project 1, Project 2, Project 3, and Project 4

Category	Type of Group	N	M	SD
Project 1 Scores	1 Control	50	6.96	1.400
	2 Experimental	50	8.36	.754
Project 2 Scores	1 Control	50	7.04	1.345
	2 Experimental	50	8.52	.725
Project 3 Scores	1 Control	50	6.88	1.393
	2 Experimental	50	9.00	.637
Project 4 Scores	1 Control	50	7.00	1.443
	2 Experimental	50	9.02	.788

Table 6. Independent-Samples t-tests for Students' Quality of Work Scores on Project 1, Project 2, Project 3, and Project 4, Showing Differences by Group with Regard to Research Question No. 2

	Levene's Test for Equality of Variances		T-Test for Equality of Means		
	F	Sig.	t	df	Sig.
Equal variances assumed	11.722	.001	-3.843	98	.000
Equal variances not assumed			-3.843	34.168	.000
Equal variances assumed	21.176	.000	-4.121	98	.000
Equal variances not assumed			-4.121	32.004	.000
Equal variances assumed	20.492	.000	-4.810	98	.000
Equal variances not assumed			-4.810	33.800	.000

work for Project 3, $t(35.040) = -6.729$, $p < 0.001$ ($p = 0.000$). The majority of the work on this project by the BYOD group was classified as high or medium quality, and the students achieved very high scores ($M = 9.00$, $SD = 0.637$) in comparison to the control group, whose work on this project was mostly categorized as medium or low quality ($M = 6.88$, $SD = 1.393$). Likewise, the independent-samples t-test for Project 4 showed a statistically significant difference between the two groups, $t(39.587) =$

-5.942, $p < 0.001$ ($p = 0.000$). The majority of work on this project by the experimental group was classified as high or medium quality, and the students attained very high scores ($M = 9.02$, $SD = 0.788$) in comparison to the control group, whose work was mostly categorized as medium or low quality ($M = 7.00$, $SD = 1.443$). Thus, a significant positive connection between BYOD and students' quality of work was demonstrated.

Research Question No. 3: What is the Students' Satisfaction Level?

This question tackled the effect of BYOD on students' satisfaction with the course and analyzed students' perceptions of, attitudes about, motivation regarding, engagement with, and interest in the course, along with attendance and participation logs. The findings demonstrated that the experimental group showed much greater satisfaction than the control group (78% compared to 18%). Specifically, the results of the independent-samples *t*-test for "Attendance & Participation" yielded a statistically significant difference between the two groups, $t(33.760) = -5.080$, $p < 0.001$ ($p = 0.000$). BYOD group students achieved very high scores ($M = 9.01$, $SD = 0.810$) compared to the control group students ($M = 6.80$, $SD = 1.865$). Hence, the BYOD teaching and learning setting had a statistically significant positive impact on students' perceptions, attitudes, motivation, and engagement with the academic course and hence their satisfaction.

DISCUSSION

The findings of this research indicate that BYOD can serve as a "lever" for teaching and learning. The BYOD program had a significant positive effect on students' academic achievement. Specifically, it had the following effects: (a) improving students' test scores; (b) improving the quality of students' project work (and their marks on the projects); (c) strengthening students' collaboration, communication, and research skills; (d) intensifying students' interest, motivation, and involvement in their own learning and growth, and their satisfaction with the course; and ultimately (e) enhancing students' final grades. Thus, these results validate the study's assumptions. Additionally, the findings of this research are consistent with those reported from other studies conducted over the past decade measuring students' learning and scholastic success across disciplines and education levels (Akpan & Strayer, 2010; Dunleavy & Heinecke, 2008; Falloon, 2015; Hawkes & Hategekimana, 2009; Kong & Song, 2015; Lei, 2010; O'Bannon & Thomas, 2014; O'Bannon & Thomas, 2015; Parsons & Adhikari, 2016; Safar, 2012; Song, 2014; Song & Kong, 2017; Suhr et al., 2010).

This study presented empirical evidence of the effectiveness and meaningfulness of a BYOD program for improving teaching practice and enhancing students' learning outcomes. However, the findings cannot fully help educational administrators and instructional technology

Table 7. Frequencies and Percentages for Students' Level of Satisfaction with the Course

	Type of Group											
	Control						Experimental					
	LS		AS		HS		LS		AS		HS	
	N	%	N	%	N	%	N	%	N	%	N	%
Level of Satisfaction with the Academic Course	21	42	20	40	9	18	0	0	11	22	39	78

Note. LS = Less Satisfied, AS = Averagely Satisfied, and HS = Highly Satisfied.

Table 8. Means and Standard Deviations for Students' Attendance and Participation

	Type of Group	N	M	SD
Attendance and Participation Scores	1 Control	50	6.80	1.865
	2 Experimental	50	9.01	.810

Table 9. Independent-Samples t-tests for Students' Attendance and Participation, Showing Differences by Group with Regard to Research Question No. 3

		Levene's Test for Equality of Variances		T-Test for Equality of Means		
		F	Sig.	t	df	Sig.
Attendance and Participation Scores	Equal variances assumed	11.722	.001	-3.843	98	.000
	Equal variances not assumed			-3.843	34.168	.000

researchers ascertain appropriate solutions to educational challenges. These results cannot necessarily be validated and generalized and, therefore, more research studies (both quantitative and qualitative, and including longitudinal research) need to be conducted with a larger range of learners, disciplines (ICT and non-ICT classes), settings, and independent/factor variables (e.g., gender, major, GPA, prior ICT knowledge, and prior performance/achievement). This provides more variation within the demographics to be studied and can present more accuracies, validation, and trust in the findings. Thus, the scale of progression regarding learners' academic achievement before and after the introduction of BYOD can be deduced.

CONCLUSIONS AND RECOMMENDATIONS

ICT use has a meaningful potential to enhance teaching and learning. Students' developmental and learning outcomes, such as achievement, behavior, attitudes, engagement, motivation, attentiveness, self-esteem, learning habits, social skills, ICT proficiency, and productivity, are positively influenced by the use of ICT-mediated 1:1 technology/computing programs in educational settings, including BYOD in the classroom (O'Bannon & Thomas, 2015) for all levels of education and across disciplines (Falloon, 2015). This author makes the following recommendations for future studies:

1. Quantitative and qualitative studies are desirable to be carried out with a wide scope of students, subjects (ICT and non-ICT classes), environments, and variables.
2. Qualitative methods of analysis should be used, and in quantitative research, other demographic independent variables (e.g., gender, major, GPA, prior ICT knowledge, and prior performance/achievement) should be taken into consideration.
3. BYOD initiatives require creative pedagogical frameworks (Cochrane et al., 2014) and upcoming research studies should take this important issue seriously.
4. BYOD has great potential benefits, as shown here, and small investment cost. Yet, it certainly has considerable operational cost over time. The deployment of a BYOD program in any organization requires attention to a lot of factors, including security concerns, which need to be considered in more detail in the future. However, as an alternative to the conventional technology approach, future researches should focus on the following dimensions of BYOD: technology, policy, management system, user integration, and environmental factors (Afreen, 2014; Dhingra, 2016; Zahadat et al., 2015).

To conclude, the availability of 1:1 ICT-mediated initiatives such as BYOD can help create a paradigm shift from the teacher as the central facilitator who integrates ICT into the classroom to students' becoming more responsible for their own learning and growth. Teachers nevertheless still need to be well informed about when and how to efficiently use and integrate ICT tools and services as meaningful instructional aids across learning contexts and for all kinds of learners, and also how to spread that knowledge to their students (Safar & Alqadiri, 2013; Safar, Alqudsi-ghabra, & Qabazard, 2012; Safar et al., 2014).

REFERENCES

Afreen, R. (2014). Bring Your Own Device (BYOD) in higher education: Opportunities and challenges. *International Journal of Emerging Trends & Technology in Computer Science*, *3*(1), 233–236. Retrieved from http://www.ijettcs.org/Volume3Issue1/IJETTCS-2014-02-25-117.pdf

Akpan, J., & Strayer, J. (2010). Which comes first: The use of computer simulation of frog dissection or conventional dissection as academic exercise? *Journal of Computers in Mathematics and Science Teaching*, *29*(2), 113–138.

Cochrane, T., Antonczak, L., Keegan, H., & Narayan, V. (2014). Riding the wave of BYOD: Developing a framework for creative pedagogies. *Research in Learning Technology*, *22*(1), 1–14. doi:10.3402/rlt.v22.24637

Dhingra, M. (2016). Legal issues in secure implementation of Bring Your Own Device (BYOD). *Procedia Computer Science*, *78*, 179–184. doi:10.1016/j.procs.2016.02.030

Dunleavy, M., & Heinecke, W. F. (2008). The impact of 1:1 laptop use on middle school math and science standardized test scores. *Computers in the Schools*, *24*(3), 7–22. doi:10.1300/J025v24n03_02

Falloon, G. (2015). What's the difference? Learning collaboratively using iPads in conventional classrooms. *Computers & Education*, *84*, 62–77. doi:10.1016/j.compedu.2015.01.010

Hawkes, M., & Hategekimana, C. (2009). Impacts of mobile computing on student learning in the university: A comparison of course assessment data. *Journal of Educational Technology Systems*, *38*(1), 63–74. doi:10.2190/ET.38.1.g

International Telecommunication Union. (2016). *Measuring the information society report 2016*. Geneva, Switzerland: International Telecommunication Union. Retrieved from http://www.itu-ilibrary.org/science-and-technology/measuring-the-information-society-2016_pub/80de56e8-en

Kong, S. C., & Song, Y. (2015). An experience of personalized learning hub initiative embedding BYOD for reflective engagement in higher education. *Computers & Education*, *88*, 227–240. doi:10.1016/j.compedu.2015.06.003

Lei, J. (2010). Quantity versus quality: A new approach to examine the relationship between technology use and student outcomes. British Journal of Educational Technology, 41(3), 455–472. doi:10.1111/j.1467-8535.2009.00961.x

Moreira, F., Ferreira, M. J., Santos, C. P., & Durão, N. (2017). Evolution and use of mobile devices in higher education: A case study in Portuguese higher education institutions between 2009/2010 and 2014/2015. *Telematics and Informatics*, *34*(6), 838–852. doi:10.1016/j.tele.2016.08.010

O'Bannon, B. W., & Thomas, K. (2014). Teacher perceptions of using mobile phones in the classroom: Age matters! *Computers & Education*, *74*, 15–25. doi:10.1016/j.compedu.2014.01.006

O'Bannon, B. W., & Thomas, K. M. (2015). Mobile phones in the classroom: Preservice teachers answer the call. *Computers & Education*, *85*, 110–122. doi:10.1016/j.compedu.2015.02.010

Parsons, D., & Adhikari, J. (2016). Bring Your Own Device to secondary school: The perceptions of teachers, students and parents. *The Electronic Journal of e-Learning*, *14*(1), 66–80. Retrieved from http://www.ejel.org/issue/download.html?idArticle=487

Safar, A. H. (2012). The impact of one-to-one computing on students' academic excellence at Kuwait University. *Journal of the International Society for Teacher Education*, *16*(2), 68–78.

Safar, A. H. (2017). Educators' perceptions toward the Law on Combating Information Technology Crimes in the State of Kuwait. *Educational and Social Studies*, *23*(1), 43–122.

Safar, A. H., & Alkhezzi, F. A. (2013). Beyond computer literacy: Technology integration and curriculum transformation. *College Student Journal*, *47*(4), 614–626.

Safar, A. H., & Alqadiri, M. A. (2013). Mind maps and its educational applications: A qualitative descriptive analysis reference study. *Revue Sciences Humaines*, *39*(1), 49–87.

Safar, A. H., Alqudsi-ghabra, T. M., & Qabazard, N. M. (2012). Use of concept mapping and visual learning software in education at Kuwait University. *Education*, *132*(4), 834–861.

Safar, A. H., Jafer, Y. J., & Alqadiri, M. A. (2014). Mind maps as facilitative tools in science education. *The College Student Journal*, *48*(4), 629–647.

Song, Y. (2014). "Bring Your Own Device (BYOD)" for seamless science inquiry in a primary school. *Computers & Education*, *74*, 50–60. doi:10.1016/j.compedu.2014.01.005

Song, Y., & Kong, S. C. (2017). Affordances and constraints of BYOD (Bring Your Own Device) for learning and teaching in higher education: Teachers' perspectives. *The Internet and Higher Education*, *32*, 39–46. doi:10.1016/j.iheduc.2016.08.004

Suhr, K. A., Hernandez, D. A., Grimes, D., & Warschauer, M. (2010). Laptops and fourth-grade literacy: Assisting the jump over the fourth-grade slump. *Journal of Technology, Learning, and Assessment*, *9*(5), 1–46. Retrieved from http://www.eric.ed.gov/PDFS/EJ873679.pdf

Wong, L.-H. (2012). A learner-centric view of mobile seamless learning. *British Journal of Educational Technology*, *43*(1), E19-E23. doi:10.1111/j.1467-8535.2011.01245.x

Zahadat, N., Blessner, P., Blackburn, T., & Olson, B. A. (2015). BYOD security engineering: A framework and its

analysis. *Computers & Security*, *55*, 81–99. doi:10.1016/j.cose.2015.06.011