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Impact of Integrating IT in Mathematics Teaching Strategies on Undergraduate Foundation Students at the Bahrain Polytechnic

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Abstract: The current trend in tertiary education is to integrate IT into teaching and learning strategies to enhance the students' learning experiences. Faculty is therefore encouraged to make use of available IT infrastructure and applications as a platform to provide online access to the study materials as well as additional online module activities aimed at enhancing student learning. This paper reports on a study conducted on learners and faculty to investigate whether IT-integrated strategies utilized by faculty has impacted students' academic experiences and goals. Data collected in this study contrasted the influence of technology-driven lessons on students' performance before and after integrating IT into teaching and learning strategies. The study focused specifically on Foundation Mathematics students at the Bahrain Polytechnic by comparing data from pre and post IT-integrated teaching. Quantitative data collected, was analysed, statistically, using t-Test and Regression analysis. The results indicated that the students' overall grades in the Mathematics courses were affected, especially in their performance in interpreting results and that students tend to be more focused on understanding the implications of solutions to mathematical problems and expanding their knowledge beyond the subject boundaries, in contrast to focusing on only solving mathematical problems. Furthermore, the qualitative data collected via students/tutors focus group discussions strongly supports the data obtained from the statistical analysis and emphasizes on the positive effect of how integrating technology in teaching and learning enhances students' learning experiences.

Keywords: Foundation, Mathematics, Information Technology, Integration

1. Introduction

Technological advancement over the past fifty years or so, has led to the development of worldwide digital communities. Many countries, therefore have embarked upon the exploration of information technology (IT) as a tool for the enhancement of teaching and learning strategies in their educational systems (from Primary schools to tertiary institutions). Huge investments have been made by governments in several countries, over the past decade, towards this venture of incorporating IT structures into their educational systems to remain abreast with the age of technological advancement.

Integrating IT, therefore, into curricula of educational institutions, has been a top priority for most governments worldwide since it has been established to raise the standards of education (Khambari et al, 2010) by enhancing the technological knowledge and skills of both educators and learners. Embedding IT into the educational systems worldwide, therefore remains a major concern for educationalists. The Kingdom of Bahrain has, over the past decade, progressed steadily in infusing technology into its educational system since it is believed that integrating technology in teaching and learning potentially raises academic standards (The Report, 2016). The current changing landscape in Higher Education (HE), coupled with the fast-paced technological development is contributing immensely to the increased use of Technology-driven teaching and learning strategies in HE (Walker, Voce, & Ahmed, 2012). The traditional era of face-to-face contact with learners is no longer the exclusive teaching methodology, since there is increasing use of technology to enhance learners' experiences. This has resulted in a reduction of face-to-face contacts with learners, leading to independent learning and long-distance courses. A survey in the UK on the need for Technology-enhanced teaching and learning in HE institutions indicated that technology enhances the quality of learning and teaching, meets students' expectations and improves access to learning for students off campus (Walker, Voce, & Ahmed, 2012).

For the past 10 years, Bahrain has partnered with IT sectors, like Microsoft, to sign its first Education Transformation Agreement (ETA) in 2004 and then in

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2015 to create a central e-learning portal to train teaching corps and to team up with the Ministry of Education (MoE) to run IT programmes in schools (The Report, 2016). The initiatives involved equipping schools with IT resources, encouraging innovations and provision of IT training and certification to enhance employability skills. By 2010, classrooms in Bahrain were equipped with high-speed internets, availability of IT suites, development of e-learning environments in local schools, development of a central portal for online teaching materials and training. IT technology in education significantly assists educators to interact with learners individually and monitor their progress. In addition, the interactive nature of IT helps to foster creativity among leaners and permits parents to monitor their children's' academic progress. Moving forward, Bahrain intends to develop a series of 'smart cities', working in collaboration with the National Broadband Network (NBBN) to network more schools to foster a 21st Century learning environment (Walker, Voce, & Ahmed, 2012).

Successful implementation of IT in teaching and learning strategies requires educators to be more skillful in operating IT facilities as well as delivering IT-based lessons (Noraini et al., 2006). Adequate training programmes are therefore put in place to enhance their teaching skills and knowledge in IT. As a result, learners who go through the educational system show tremendous growth and development, especially in IT.

This study aimed at investigating the impact of integrating IT in the teaching and learning strategies of Foundation Mathematics on leaners' academic and professional goals, at the Bahrain Polytechnic. Bahrain Polytechnic is of the two main government-owned tertiary (HE) institutions in the Kingdom of Bahrain. It was established by a Royal Decree in 2008 as a key initiative for the Education and Training Development Committee as part of a project under the Bahrain Vision 2030 master plan. Bahrain Polytechnic offers degree level programmes in applied learning, technical education, skills-based and occupational training.

Available data shows that the traditional method of applying instructional strategies in teaching Mathematics is devoid of IT technology, in most cases, has shown the lack of motivation on the part of learners to the reception of instructions from educators, since instructions carried out were considered to be outdated, repetitive, superficial and mechanical approaches (Sadovsky, 2007). The author, as a result, suggested the need to rethink the strategies of teaching and learning of mathematics by helping learners develop judgements on what they are learning and linking their acquired knowledge to practical applications in real life situations.

Data obtained from previous studies clearly indicate that learners generally encounter challenges in assimilating mathematical concepts which culminate in learners' poor grades. Most of these challenges may be attributed to learners' attitudes towards the subject like devoting little time in revision and sometimes the notion that they are incapable of solving mathematical problems successfully (especially worded problems) (Bzuneck, 2001). The author in this study, hypothesizes/believes that the lack of motivation on the part of learners, could be related to certain factors like the environmental conditions that are directly related to the cultural background of learners and the location of the institution's physical facilities and structures. Interestingly, these factors outlined, lead to multifaceted interplay among learners' attitudes and contextual factors. In addition, the roles of educators during teaching and learning impinge on the outcomes as well. Learners' engagements, therefore, during instructional strategies are dependent on measures put in place by educationists as well as adequate infrastructure that help to enhance different teaching and learning strategies.

In addition, the effects on social life advanced by IT represent an extraordinary prospect for the development of education, as these inspire and give significant learning through technological resources. Endorsing this assertion, Butterworth (2002) indicated that the mathematical capacities are genetically engraved in our mindset and suggested that giving instructions in mathematics can be effective by applying models that incorporate natural thinking, manipulating materials and activities. Along these lines, one of the conceivable approaches to endeavor to facilitate the present circumstance is to urge educators and institutions to incorporate in mathematics lessons greater intuitiveness and energizing IT innovations, as well as, to explore digital resources such as simulations, educational games, related software and hardware, video games and pictures, to support the teaching and learning of mathematics and related subjects.

One of the current major concerns in terms of employability, worldwide, is the low number of qualified professionals in STEM (Science, Technology, Engineering and Mathematics) related jobs. The nature of these STEM experts and their presence are key elements for the economic development of nations and their ability to develop since we are living in an undeniably technologically advanced era.

In developing nations, however, it has been increasingly difficult to inculcate IT infrastructure into teaching and learning because of lack of IT resources in the institutions of learning. In this case, mobile devices such as smartphones and tablets can be a great alternative to use in the development of projects to integrate IT into the educational environment. This has the added advantage of cutting down on cost drastically (Unesco, 2015).

Taking cognizance of the factors discussed, this study aims to present a clear distinction between the impact of IT usage on learners academic and professional goals compared to non-IT integrated T&L approaches and to emphasize the essence of integrating IT into institutions' teaching and learning strategies, especially at the foundation level. A study has reported that the challenges faced by learners in assimilating mathematical concepts has a direct consequence on their lack of engagement in other mathematically related subjects (such as Physics and Chemistry) involving calculations that are essential in science and technology-related careers (Nicolette et al, 2017). This accounts for the low number of professionals in these areas of expertise. It is therefore essential that mathematics education, at the foundation level in tertiary institutions, be enhanced to combat the high dropout rate and sustain the interest of learners to pursue mathematically-related degree programmes. This therefore calls for measures such as equipping institutions with the appropriate IT infrastructure and developing and applying T & L methodologies that incorporate IT. This has been indicated as the exploitation of IT resources as auxiliary resources used to support the construction of concepts and motivation for learners (Tajra, 2011)

Society today is undergoing technological advancement at a rapid rate and it calls for the individuals, especially young people who are engaged in education to stay afloat with the rapid change in technology to enable them to become adequately prepared for this 21st Century job market. Devices like the tablets and mobile computers have become part of today's culture and an everyday reality and it feels like we cannot do without them, a clear indication that technology must occupy an important role in today's educational system at all levels. In this new era, it is imperative to develop T & L strategies in schools and colleges that embed IT technology and infrastructure to harness the full potential of learners by improving their learning and professional/academic goals.

2. INTEGRATING IT INTO MATHEMATICS T&L

Embedding IT in the teaching of Mathematics transforms the dynamics in Mathematics lessons. It enables Mathematics lessons to be integrated with practice and provides resources that assist in securing content and approach of theory with everyday life situations. IT has become a valuable T & L tool with a high potential in education and can produce significant changes in T & L methodologies by influencing learners' capabilities in accessing and interacting with mathematical knowledge (Hofmann, 2006).

One of the innovative ways of incorporating IT technology in T & L is the use of mobile devices, referred to as Mobile learning. This term, also known as mLearning is a concept associated with the use of mobile technology in T & L, which is considered as the intersection of "mobile computing" and "eLearning" to produce an educational experience anywhere and anytime (Hofmann, 2006), in a broad context of resource utilization (Welsh, Wanberg, Brown, & Simmering, 2003). m-Learning has, therefore, become an integral part of T & L processes and it is becoming increasingly common among learners. They are digital devices with powerful and affordable hardware, easily portable, easy interaction and access to the Internet, running many actions, including multimedia (Unesco, 2015). m-Learning is among the current trends that is transforming T & L processes (Johnson et al, 2014; Johnson et al, 2015, Unesco, 2015). The flexibility of the devices enables learners to learn anytime and anywhere, making formal and informal approach to learning, building new dynamic and stimulating environments for learners (INEP/MEC, 2013a). The ability to be constantly connected, ease of communication and content sharing, and easy location information enables these devices to perform different learning-related functions and explore a vast majority of resources available on the World Wide Web (www).

An UNESCO report (2015) indicated that the use of IT technologies is having tremendous influence on educational opportunities and that their use is also justified by the increasing usage of mobile devices by learners and teachers, making T & L processes simple and ubiquitous. However, the popularization and advantages of hand-held devices (mobile technologies) does not rule out desktop and laptop computers. Currently there is the tendency to use blended learning scenarios, where blended learning combines different forms of learning by integrating various ways of access to content (Goh, 2009). Some learning contents, for example, can be best used on larger screen devices, such as desktops and smart boards, since these offer better opportunities to display and create larger pieces of content (Goh, 2009).

Embedding IT technologies into T & L curricula should be done as interfaces that mediate teaching processes, since instructors bring different strategies to the T & L processes. However, in cases where lack of technological infrastructure prevents instructors from innovating, mobile devices offer new and exciting ways to improve the T & L experience of learners, enabling digital inclusion in the poorest and most remote places. Studies show that mobile technology is the most pervasive technology and the most quickly adaptable to the environment (Unesco, 2015) and is very common, even in areas where schools, books and computers are rare. According to Batista, Behar and Passerino (2010), IT applications used for teaching and learning Mathematics favour interactivity, learning in real contexts and collaborative practices. Furthermore, Barbosa and Fonseca (2013) believe that the use of IT devices and applications, such as games, increase learners' interest in math classes. In the light of this, Pereira and Rodrigues (2013) presented a series of initiatives for the use of IT devices in mathematics teaching. Malaysia, India and China, among others, have encouraged the use of IT technology, especially mobile devices, in T & L. However, the process of integrating IT requires efforts to train instructors, to make them capable of embedding IT technology, in general, in T & L strategies.

3. METHODOLOGY

The data obtained in this study is based on learners in Foundation Mathematics. Learners were instructed on the following Mathematics topics that include Geometry, Algebra, Trigonometry and Statistics. The methodology used in this study focused on learners' responses to classroom teaching and learning (T & L) strategies used by the tutor as well as a comparative analysis of the assessment grades of learners before and after the integration of IT into T & L strategies.

In this study, the researchers adopted a comprehensive methodology to test the effectiveness of integrating technology into teaching and learning in Foundation Mathematics at the Bahrain Polytechnic. The IT resources and applications that were mostly integrated into the teaching and learning of Mathematics included: Moodle (VLE), Mymaths, Kahoot, EDPuzzle, Quizziz, ActiveInspire and other mobile applications. The methodology used in the study consisted of two major elements:

1. Comparing students' performance in formative/summative assessments (referring to their tests data) in order to identify any statistically significant changes. To achieve this objective, researchers extracted a random sample of 100 students' assessment data based on three categories namely: performing calculations (how students do their calculations), how they interpret their answers to test questions and their abilities to link different knowledges to solve problems. The data was analysed using statistical analysis tools which included the following:
   - Descriptive statistics was used to explore the overall nature of the data and enabled researchers to select a suitable t-test to do further comparative analysis of the data.
   - Hypothesis testing, assuming equal variance (t-test for two samples) was used to test the significance of the differences among the average of learners' performance in the three areas (performing calculations, interpretation of results & linking different knowledges) as mentioned above, at 95% level of confidence.
   - Linear regression analysis was used to construct a suitable model that expresses the relationship between the learners' overall performances in the Mathematics course (considered as the endogenous variable) and the students' performance in the three categories mentioned above (considered as exogenous variables).

2. Conducting structured interviews of learners and tutors to obtain feedback on the effectiveness of the use of technology in teaching Mathematics at Foundation level. At this stage, learners were constituted into groups of 5 (focused groups), from each of the Foundation Mathematics courses (Mathematics 1, Mathematics 2 General and Mathematics 2 Technical) classes. Five tutors were involved in this study and each tutor interviewed/interacted with three focused groups by allowing them to respond to a structured questionnaire (see appendix). Students' feedback was recorded and later transcribed.

The researchers similarly, interviewed three tutors who represented three categories of Mathematics tutors in the Foundation programme. Category A tutor represented teachers who are specialized in Mathematics and are also specialized in IT infrastructure and applications; the second category, B, represented teachers who are specialized in Mathematics, but have a fair knowledge about IT; and the third, category C represented those who had very little or no previous knowledge and experience about IT usage in Mathematics teaching and learning. Again, their feedback in response to a structured questionnaire was recorded and transcribed.

4. EMPIRICAL FINDINGS

A. Analysis of Assessment data

A summary of the quantitative data obtained from students' assessment records were analyzed, presented as tables and discussed below.

B. Descriptive Statistics

The descriptive statistics of the data highlights the Measures of Central Tendency and Measures of spread of the data obtained before integrating IT (pre-IT) and after integrating IT (post-IT) into teaching and learning.

TABLE 1A. Descriptive statistics of data indicating the measures of central tendency (mean, median, mode) and measures of variation (standard deviation, range) of the three categories of learners' data before integrating IT (Pre-IT) into T & L.

Pre-IT integration					
Calculation		***Interpretation***		***Linking information***	
Mean	71.21452	*Mean*	65.60204	*Mean*	67.2551
Standard Error	1.683765	*Standard Error*	1.639748	*Standard Error*	1.591207
Median	56	*Median*	56	*Median*	56
Mode	55	*Mode*	55	*Mode*	52
Standard Deviation	16.66842	*Standard Deviation*	16.23268	*Standard Deviation*	15.75215
Sample Variance	277.8363	*Sample Variance*	263.4998	*Sample Variance*	248.1301
Kurtosis	-0.05964	*Kurtosis*	0.065063	*Kurtosis*	0.195174
Skewness	-0.2963	*Skewness*	-0.28277	*Skewness*	-0.19744
Range	68	*Range*	68	*Range*	68
Minimum	22	*Minimum*	22	*Minimum*	22
Maximum	90	*Maximum*	90	*Maximum*	90
Sum	5464	*Sum*	5547	*Sum*	5611
Count	100	*Count*	100	*Count*	100

TABLE 1B. Descriptive statistics of data indicating the measures of central tendency (mean, median, mode) and measures of variation (standard deviation, range) of the three of learners' data after integrating IT (Post-IT) into T&L

Post-IT integration					
Calculation		***Interpretation***		***Linking information***	
Mean	81.14286	*Mean*	81.2551	*Mean*	81.55102
Standard Error	1.384596	*Standard Error*	1.391667	*Standard Error*	1.356513
Median	86	*Median*	86	*Median*	86
Mode	86	*Mode*	86	*Mode*	86
Standard Deviation	13.7068	*Standard Deviation*	13.7768	*Standard Deviation*	13.42879
Sample Variance	187.8763	*Sample Variance*	189.8002	*Sample Variance*	180.3324
Kurtosis	0.387991	*Kurtosis*	0.1162	*Kurtosis*	0.15831
Skewness	-0.92504	*Skewness*	-0.87346	*Skewness*	-0.85612
Range	54	*Range*	54	*Range*	54
Minimum	45	*Minimum*	45	*Minimum*	45
Maximum	99	*Maximum*	99	*Maximum*	99
Sum	7952	*Sum*	7963	*Sum*	7992
Count	98	*Count*	98	*Count*	98

Tables 1a shows that the average mark for students in the sample in 'performing calculation' prior to integrating IT was 71 and this increased significantly to 81 after integrating IT (Table 1b). The case is similar for both "interpreting answers" and "linking information" where the average mark increased by 24% and 21%

respectively. This gives an indication that integrating technology in teaching Mathematics in foundation tremendously improved students' performances at their different levels of understanding.

Furthermore, the standard deviation in both cases, Pre (before integrating IT) and Post (after integrating IT) is small, suggesting a high impact of the change on most of the students. however, this did not create significantly extreme situations (accounting for their learning differences). Again, the consistent value of standard deviation for the Pre and Post integration of technology in each of the three areas suggested that "t-test assuming equal variances" could be used further to statistically analyse the data

C. *Hypotheses tests:*

Hypothesis tests (t-test assuming equal variances) was performed on the data, as indicated in the last paragraph.

T-test assuming equal variances:

As explained in the previous section, the significance of the differences in the averages of students' performances in the three areas was tested using the t-test, assuming equal variances, at 95% level of confidence in MS-Excel.

I) Ability to 'perform calculations':

The hypothesis tested was: the mean value of learners' results (based on their ability to perform calculations) is equal for both Pre-IT (before IT-integrated lessons) and Post-IT (after IT-integrated lessons). That is, the Null hypothesis (H_0) can be stated as:

$$H_0: \mu_{pre} = \mu_{post}$$

where μ_{pre} is mean value of learner's data based on their ability to perform calculations Pre-IT integration; and μ_{post} is mean value of learner's data based on their ability to perform calculations post-IT.

Table 2 shows that the p-value for the 2-tailed t-test is lower than the significant level (0.05) suggesting that the Null hypothesis is rejected and therefore the average (mean value) of the students' results is unequal as hypothesized. With reference to Table 1, it can be observed that the average mark has increased by 24%, suggesting that there is a statistically significant improvement in students' performance due to integrating technology into teaching and learning.

TABLE 2: Table shows the p-value obtained after performing t-test on learners' 'Calculation' data.

t-Test: Two-Sample Assuming Equal Variances		
Calculation		
	Calculation	Calculation
Mean	55.75510204	81.14285714
Variance	277.8363139	187.8762887
Observations	100	100
Pooled Variance	232.8563013	
Hypothesized Mean Difference	0	
df	194	
t Stat	-11.64604176	
P(T<=t) one-tail	2.06209E-24	
t Critical one-tail	1.652745977	
P(T<=t) two-tail	4.12419E-24	
t Critical two-tail	1.972267533	

II) Ability to "interpret questions' answers":

The hypothesis tested is: the mean value of learners' results (ability to interpret data) is equal for both Pre-IT (before IT-integrated lessons) and post-IT (after IT-integrated lessons). That is, the Null hypothesis (H_0) can be stated as:

$$H_0: \mu_{pre} = \mu_{post}$$

where μ_{pre} is mean value of learner's data based on their ability to interpret data, pre-IT integration; and μ_{post} is the mean value of learners' data based on their ability to interpret data, post-IT.

TABLE 3. Table shows the p-value obtained after performing t-test on learners' abilities to "Interpret data"

t-Test: Two-Sample Assuming Equal Variances		
Interpretation		
	Interpretation	Interpretation
Mean	56.60204082	81.25510204
Variance	263.4997896	189.8002314
Observations	100	100
Pooled Variance	226.6500105	
Hypothesized Mean Difference	0	
df	194	
t Stat	-11.46280812	
P(T<=t) one-tail	7.29355E-24	
t Critical one-tail	1.652745977	
P(T<=t) two-tail	1.45871E-23	
t Critical two-tail	1.972267533	

Table 3 shows that the p-value from the 2-tailed t-test is lower than the significant level (0.05) suggesting that the Null hypothesis is rejected and therefore the average of the students' results is unequal. Again, by referring to Table 1, it can be observed that the average mark has increased by 14%, suggesting that there is tremendous improvement in students' performances due to integrating technology in teaching and this is statistically significant.

III) Ability to "link different information to build up a conclusion":

Following the same methodology, the hypothesis that was tested is: the mean value of learners' results (ability to link information) is equal for both pre-IT (before IT-integrated lessons) and post-IT (after IT-integrated lessons). That is:

$$H_0: \mu_{pre} = \mu_{post}$$

where μ_{pre} is mean value of learner's data based on their ability to link information pre-IT integration; and μ_{post} is mean value of learner's data based on their ability to link information post-IT.

D. Regression Analysis:

The quantitative data was further subjected to regression analysis in order to predict the effect of IT-integrated teaching and learning strategies on students' overall grades. The Regression data is presented in tables 5 and 6.

Table 4 shows that the p-value for the 2-tailed t-test is lower than the significant level (0.05) suggesting that the Null hypothesis was rejected and therefore the average of the students' results is unequal.

With reference to Table 1, it is observed that the average mark/grade increased by 21%, suggesting that there is tremendous improvement in students' performance (which is statistically significant) due to integrating technology into T & L.

Table 5, below, represents a summary of the analysis of the data obtained after using the Linear Regression model to interpret the quantitative data for pre-integrating technology in teaching Mathematics at Foundation level. It also shows a comparison among all the three categories of learners' data obtained in the Foundation Mathematics courses.

TABLE 4. Table shows the p-value obtained after performing t-test on test learners' ability to "Link Information" data

t-Test: Two-Sample Assuming Equal Variances		
Linking information		
	Linking information	Linking information
Mean	57.25510204	81.55102041
Variance	248.1301283	180.3324216
Observations	100	100
Pooled Variance	214.231275	
Hypothesized Mean Difference	0	
df	194	
t Stat	-11.61956644	
P(T<=t) one-tail	2.47554E-24	
t Critical one-tail	1.652745977	
P(T<=t) two-tail	4.95109E-24	
t Critical two-tail	1.972267533	

TABLE 5. Summary output of Regression analysis data obtained on all three variables presented in learners' data before IT was integrated into T & L methodologies (pre-IT). Table shows Regression Statistics (which includes ANOVA data and Regression Coefficients).

Regression Statistics	
Multiple R	0.250278
R Square	0.062639
Adjusted R Square	0.032723
Standard Error	11.72008
Observations	100

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	3	862.8344	287.6115	2.093849	0.106258863
Residual	94	12911.86	137.3602		
Total	97	13774.69			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	47.63435	7.21212	6.604765	2.36E-09	33.3145225	61.95418749
Calculation	0.08288	0.071409	1.160641	0.248727	-0.058904027	0.224664418
Interpretation	0.028116	0.073312	0.383505	0.702212	-0.117447616	0.173678789
Linking information	0.163076	0.075566	2.158058	0.033471	0.013037739	0.313113986

The regression model is represented by the expression:

$$y_{pre} = \beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} + \beta_3 x_{3i} \quad (1)$$

where:

y_{pre}: Learners' overall grade for 'pre-integrating' technology into T & L

$\beta_0, \beta_1, \beta_2$ and β_3: are constants

x_{1i}: Ability to perform calculations

x_{2i}: Ability to interpret questions

x_{3i}: Ability to link different information to build up a conclusion.

The analysed data presented in Table 5 suggests that the linear regression model explains 56.3% of the data variation and it is statistically significant as the p-value for the t-test is below 5%. Therefore, this model appropriately predicts learners' overall grade based on their three abilities represented by the variables: x_{1i}, x_{2i} and x_{3i}.

The overall grade prior to integrating IT is expressed as:

$$(y) = 47.60 + 0.08x_1 + 0.03x_2 + 0.16x_3 \quad (2)$$

This model therefore suggests that the student's overall grade in the Mathematics course is affected mostly by his/her performance in calculations, and this effect is about 2 times more than when the student is interpreting results and linking information. This strongly suggests that students are more focused on how to solve mathematical problems, than understanding the implications of their solutions and/or expanding their knowledge beyond the subject boundaries, in the pre-integrating IT era.

TABLE 6. Summary output of Regression analysis data obtained on all three variables present in learners' data after IT was integrated into T & L methodologies (post-IT). Table shows Regression Statistics (which includes ANOVA data and Regression Coefficients).

Regression Statistics	
Multiple R	0.133919
R Square	0.017934
Adjusted R Square	-0.01341
Standard Error	15.40758
Observations	100

ANOVA

	df	SS	MS	F	Significance F
Regression	3	862.8344	287.6115	2.093849	0.106258863
Residual	94	12911.86	137.3602		
Total	97	13774.69			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	47.63435	7.21212	6.604765	2.36E-09	33.3145225	61.95418749
Calculation	0.08288	0.071409	1.160641	0.248727	-0.058904027	0.224664418
Interpretation	0.028116	0.073312	0.383505	0.702212	-0.117447616	0.173678789
Linking information	0.163076	0.075566	2.158058	0.033471	0.013037739	0.313113986

Table 6 above represents analysed data obtained after using the linear regression model to interpret the quantitative data for post integrating technology into teaching Mathematics at Foundation level. It also shows a comparison among all the three categories of learners' data obtained in the Foundation Mathematics courses. The regression model is represented by the expression:

$$y_{post} = \beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} + \beta_3 x_{3i} \qquad (3)$$

where:

y_{post}: Learners' overall grade after 'post-integrating' technology into T & L

$\beta_0, \beta_1, \beta_2$ and β_3: are constants

x_{1i}: Ability to perform calculations

x_{2i}: Ability to interpret questions

x_{3i}: Ability to link different information to build up a conclusion

The analysed data which is presented in Table 6 suggests that the above linear regression model explains 61.8% of the data variation and it is statistically significant as the p-value for the f-test is below 5%. Therefore, this model predicts the students overall grade based on the three abilities x_{1i}, x_{2i} and x_{3i}.
Overall grade for post-IT era is:

$$(y) = 53.70 + 0.09x_1 + 1.62x_2 + 1.02x_3 \qquad (4).$$

The model suggests that learners' overall grades in the Mathematics courses were affected mostly by learners' performance in 'Interpreting results'. This model also shows that the effect of 'Calculations' became the lowest after 'embedding technology' in the course. This gives a clear indication that the effect of integrating IT into teaching and learning enables learners to become more focused on understanding the implications of their solutions to Mathematics problems, thereby expanding their knowledge beyond the subject boundaries, which is in contrast with their abilities to solve mathematical problems (related to the pre-IT era).

5. FOCUSED GROUP DISCUSSIONS

A) *Instructors' feedback*

A summary of the qualitative data we obtained from students and tutors through focused-group discussions are summarized in the sections below.

Question 1:

The first question tutors responded to was related to whether learners were more engaged when using technology in teaching Mathematics. Instructor A, who is the IT specialist, indicated that learners were much more engaged. That learners were technologically active and that whenever technology was integrated into T & L or IT-related activities were integrated into teaching, learners appeared to be more engaged. Teachers from both Categories B and C agreed that from their observations, learners appear to be very attentive whenever T & L is technology-oriented. That learners are more attracted to technology applications – software (like Kahoot, Quizziz, etc.) and therefore become more engaged.

Question 2:

In responding to the question as to whether leaners' assessment results were impacted by integrated technology in T & L, in comparison to the traditional method of teaching (with little or no IT component), Category A tutor emphatically mentioned the affirmative and cited the use of a VLEs (like Moodle) in institutions. The tutor mentioned that the availability of all T & L materials online (on VLEs such as Moodle), enables a more organized T & L process to occur. In contrast, the tutor indicated that the traditional method relies mainly on printouts and books and other resources that are scattered all over. Hence, she concluded that technology makes T & L much easier.

Category B teacher, in response to the question, mentioned that when comparing the two systems, memorizing mathematical expressions and formulae in the traditional method is non-existent in the IT era. For example, using statistical tools in Excel to solve a problem in statistics does not involve memorizing a statistical formal, but involves following steps in the application to solve the problem. Students are therefore happier using software applications to solve problems. The tutor therefore indicated that the use of technology enhances the understanding of the practical applications of the Mathematical concepts that learners are exposed to. For example, the e-Lessons which are prepared and uploaded on the VLE platforms (Moodle) enhance students' understanding of the practical applications of subjects/topics.

In response to students' use of e-Lessons & Flip classes prior to attending lessons, the teacher's response was that maximum participation in e-Lessons was about 60%, due to lack of time. The tutor however, asserted that e-Lessons and Flip classes uploaded in Moodle tend to enhance learners' levels of understanding in Mathematics topics and that learners should be encouraged to review them prior to attending lessons. In responding to implications of learners not making time to cover the Flip classes, the tutor mentioned the challenges involved in ensuring/monitoring students who attempt them; and that if Flip classes/e-Lessons are assessed/graded, learners will attempt to work through them.

The Category C teacher responded that since learners used a lot of technology (online resources) in their Statistics projects, they are able to utilize various statistical tools to do their problem-based learning (PBL) projects. Students acknowledged, in their reflection, how their usage of technology had impacted their research projects.

With regards to teaching with and without technology, Category C teacher mentioned that students were able to use technology easily to work out out/solve problems compared to the traditional method. With regards to Flip classes and e-Lessons, Category C tutor tends to agree with Category B's assertions that e-Lessons and Flip classes should be assessed to motivate students to pay attention to them.

Question 3:

In responding to the question: "Do you have easy access to resources as a tutor?", tutor A mentioned the affirmative and that there is easy access to online and databases whereby "we need anything we can get it". Category B's response agreed with that of A's and that there are no difficulties associated with accessing online resources, except for the intermittent hardware or system failures. Tutor A further mentioned that there should be contingency plans in place to mitigate any difficulties that may arise during usage. Tutor C agreed with A and added that there were no difficulties associated with accessing online resources. In response to how to deal with hardware failure while delivering a lesson, the category C tutor mentioned that she always had contingency plans (like hard copies of lesson outlines, worksheets, etc.) in place to mitigate such occurrences.

Question 4:

With respect to the responses to the question on the general impact of IT on teaching, Category A tutor stated that learners were more engaged and interested in the subject; that tutors' abilities to spontaneously introduce IT activities, like games, in teaching, tends to get learners more interested in the subject of mathematics. Learners have more fun using their smart phones to participate in the quizzes and other related activities, thereby getting them more and more engaged in the subject, thus creating a positive effect on students' learning. The Categories B and C tutors also indicated that learners were more focused during technology-driven lessons and this eventually enhances learners' understanding with a positive impact on their learning as well as on their assessment results.

Question 5:

On the question: 'Is it true that IT-embedded T&L processes make students lazier?', Category A tutor answered that it doesn't make them lazy; that instead the traditional method made learners lazier since it is often not interactive as the technology-driven one, from experience. Categories B and C tutors stated that they did not support the idea that it makes students lazy, and that it rather enhances their learning.

Question 6:

One of the key questions was: What are the challenges of using Technology in Teaching and Learning? Responding to this question, Categories A, B and C tutors responded that the concern was mostly about hardware malfunction and failure as opposed to software and applications. Tutor A further indicated that training must be provided to equip tutors in using applications and that teachers should be up to speed with new technologies whenever they are introduced. Tutor A further made an important point that teachers/instructors should continuously develop their T & L strategies in conformity with the upsurge of new technologies.

Question 7:

On the question as to whether teachers can suggest ways of improving IT infrastructure in teaching Mathematics, Category A tutor responded that an excellent infrastructure, so far, exists in the institution; that a lot of interesting software and applications are available online to download. The institution's VLE platform (Moodle) is excellent, and it is constantly updated with add-ins, applications, internet resources apps like Kahoot, Quizziz, Plickers, and many others. Category B tutor mentioned that instructors should make use of the different kinds of technology available in T&L in their teaching; that different kinds of technology are available. Currently, a lot of applications and software

are available for use in facilitating mathematics lessons to create effective lessons. Learners have confirmed, from institution surveys, that many well-organized materials are available on the VLE platform.

Category C tutor agreed with both respondents and further suggested that materials on Moodle pages should be classified into levels from Basic to Advanced. In reaction to overload of information, tutors confirmed that they always try to overload students with more information than less.

Question 8:

In response to the question on learners' participation in Flipped Classrooms and e-Lessons, Categories A, B and C tutors mentioned that students show enthusiasm in going through e-Lessons and Flipped classrooms; however, all learners should be encouraged to work through more e-lessons and flipped classrooms on all topics prior to coming to lessons. Otherwise, only the more responsible ones who will do it. They cautioned, however, that it was not necessary to enforce learners to work through the online pre-class activities before lessons, but rather to encourage learners to prepare for classes.

Question 9:

In responding to the question: Will you support the idea of a Mathematics application? Category A tutor supported the idea that although creating a Mathematics application will enhance dissemination of information, there are a lot of applications already available (EdPuzzle, Kahoot, Quizizz, etc). Therefore, a Mathematics application may not be necessary, since a lot of free apps are readily available online. The tutor however, indicated that the need for a Mathematics application could still be explored and that applications may be good if they help to differentiate materials. Category B tutor strongly supported the idea of introducing a Mathematics application that can highlight assignments, homework, and notifications; so that learners would not be able to give excuses for not completing their assignments. Category C tutor was not too sure how beneficial a Mathematics application would be for learners; since, smaller screens of their hand-held devices, such as smart phones, may not be able to display contents of Mathematics assignments, like equations and graphs. Tutor C, however, agreed with the essence of sharing notifications with learners via apps.

***B)** Learners' feedback*

Below is a summary of the learners' responses to seven key questions concerning the impact of integrating IT in T & L in their learning experiences. The groups of learners were selected from the three different Mathematics courses on offer at the institution, designated as Mathematics 1, Mathematics 2 (General) and Mathematics 2 (Technical).

*Question 1: As a student, are you more engaged in IT-embedded Mathematics lessons***?**

50% of the learners agreed that they are more engaged in IT-embedded Mathematics lessons; while 40% of the learners agreed that IT-embedded lessons make learning easier. However, 10% of the learners disagreed that they prefer to work through and solve problems manually instead of obtaining quick solutions from IT infrastructure.

Question 2: What is the effect of introducing technology in teaching and learning in Mathematics, in general?

50% of the learners agreed that it has positive effect on their learning experiences, since most students use technology a lot these days; 40% of them indicated that the effect depends on the subject although it is more effective in Mathematics compared to other subjects, since it accelerates learning of Mathematical concepts. Again, 10% of the learners mentioned that it was good in the sense that it accelerates learning and it's bad because sometimes the technology fails.

Question 3: Do available IT materials enhance your learning? / Do your personal IT skills and knowledge impact your learning as a student?

All the learners agreed that available IT materials enhance their learning experiences and that their personal IT skills and knowledge impact their learning as well.

Question 5: Can you suggest any ways of improving IT infrastructure here at BP?

50% of the learners suggested that constant maintenance of infrastructure was necessary; while, 40% agreed that good, faster, effective computers and internet connectivity must be available, especially during examinations period. 10% of the learners suggested that IT seminars and workshops should be run to update both faculty and students on new applications.

Question 6: What challenges do you face when you are exposed to IT in teaching and learning Mathematics?

All the learners agreed that they lacked access to spontaneous feedback, especially during examinations, since they would prefer to know their areas of weakness after taking online assessments.

Question 7: Will you support the idea of having a Mathematics application on your phone?

80% of the learners did not support the idea of having a Mathematics application on their phones because of the small-sized screens of the hand-held devices; also because phones are not meant for 'serious academic stuff', and that they wouldn't want to study or do revision on a phone. 20%, however, agreed that applications will facilitate quick revision when preparing for an assessment.

6. CONCLUSIONS:

The data obtained clearly demonstrates that integrating IT into T& L strategies tremendously enhances learners' academic experiences and performances. Statistically analysed quantitative data has shown significant differences between the two scenarios, namely pre-IT and post-IT eras. The qualitative data obtained from both learners and teachers via focused-group interviews indicates the positive impact that IT-integrated lessons in Mathematics have had on learners' learning experiences. From student's interviews, the differences in opinions, however, was only evidenced in their responses to two questions relating to the use of technology in Mathematics teaching in general: nearly half of the respondents agreed that technology has a positive effect on Mathematics teaching and learning; while, the other half indicated that it depends on the subject even though it appears to be more effective in Mathematics teaching. With regards to whether learners supported a Mathematics application on their hand-held devices, surprisingly, more than half of the respondents did not support the idea. They opined that a Mathematics app on a hand-held device removes the element of seriousness about the subject.

This study however, did not address the impact of integrating IT into other Mathematics-related subjects like Physics and Chemistry. Data from a study that examines or analyses the impact of IT integration on Mathematics related subjects will further indicate how IT-integration has impacted or otherwise Applied Mathematics courses.

7. LIMITATIONS:

Some of the limitations to the study may be due to the sample size of secondary data obtained, and therefore it will be helpful to increase the size in subsequent study. Furthermore, the number of faculty members on the focused group discussion may also be increased to include more faculty members in order to obtain more divergent responses (qualitative data) on the questions addressed in the study.

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