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Perceptions of Tech-Augmented Learning in Basic Mathematics among University Students: A Case of Matrix Algebra Tools

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Abstract:

This study adopted Survey research design.The Tech-Augmented Learning Questionnaire (TALQ) was used as the instrument for data collection from sixty (60) first-year students enrolled on the course at a Federal University in North Central Nigeria. The results of the study indicate a high positive perception of the technology augmentation with an overall mean of 4.19, which was reasonably above the TALQ metric benchmark of 3.0. The students expressed that they liked the tech-augmented learning activities, felt a high sense of satisfaction and achievement, and had a high expectation for their personal academic performance as a result of the tech-augmented learning activities. The students accepted that the approach used in the course improved their computational skills and allowed them to work at their own speed to achieve learning objectives. Based on the findings of the study, it was recommended that classroom instruction should be planned around available technological tools to enrich students learning experience, particularly in Mathematics education.

Key Words: *Mathematics education; Technology augmented learning; Matrix apps; Technology integration models; Basic mathematics*

Introduction:

Many students had negative perspective of the difficulty of mathematics as a school subject, and this misconception compounded by the deployment of instructional strategies that do not enhance mathematics proficiency among learners (Iji, Abah & Anyor, 2017). This source of concern among mathematics educators has driven the quest for technologically augmented solutions for instructional delivery. Mathematics requires the development and mastery of problem solving procedures. Such procedures involved skillful manipulations of equations, a sense of logic and the careful approach to ensure accuracy (Iji, Abah & Uka, 2013). This fact is a clear indication that in order to build favourable outcomes in mathematics education, effective delivery strategies are required. The delivery of such effective instructional strategies may be supported by education technology. Demystifying mathematics may involve classroom instruction that allows students to choose how they approach their studies, with the teacher acting as a guide, rather than a director.

Both the educational system and the educational process must adapt to the pressures on time. This calls for a fundamental transformation of education in terms of content, methods and outcomes. Educator now seek to inculcate skills that are aimed at accelerating technological change, rapidly accumulating knowledge, increasing global competition and raising workforce capabilities (Partnership for 21st Century Skills, 2002). School must equip students who will ultimately spend their adult lives in a multitasking, multifaceted, technology-driven, diverse and vibrant world. As a result university education has to be more strategic, aggressive and effective in preparing students to succeed and prosper (Innovation Unit, 2014). Such preparedness requires the utilization of emerging technologies to provide more learning opportunities, and suggests a change in the very meaning and nature of mathematics education (Italiano, 2014).

Specifically, the use of technology to support learning has come to be known as Technology Enhanced Learning (TEL). Kirkwood and Price (2014) report that although most TEL projects are relatively small-scale and context-specific, the cumulative lessons learned from a number of similar interventions can provide a useful indication of benefits that might be achieved. Apart from improving existing processes and outcomes, TEL ensures existing processes are carried out in a more cost-effective, time-effective, sustainable or scalable manner. TEL often refers to the use of technology such as computers, mobile devices like smart phones and tablets, digital cameras, social media platforms and networks, software applications and the internet in daily classroom practices.

Successful technology integration is achieved when the use of technology is routine and transparent, accessible and readily available for the task at hand, supporting the curricular goals and helping students to effectively achieve their goals (Edutopia, 2007). Tech-augmented learning seeks to deploy technological tools that are a seamless part of the learning process, almost a second nature to ordinary classroom activities. When tech tools are readily available to learners and efficiently blended into instructional activities, the outcome is often active engagement of learners and the provisions of the opportunity to build a deeper understanding of content.

This particular study chooses to augment mathematics instruction delivery with matrix algebra tools. The tools considered by this study are freely downloadable software applications that are tailored towards step by step presentations of solutions to problems arising in matrix algebra. The approach derives from the ubiquity of smart phones among the student population (Anyor & Abah, 2014) and the ease of using such apps. Students develop mathematical proficiency by using apps to confirm rigorous mathematical computations and to correct errors in highly tasking routines such as resolving a system of linear equations in three or more variables. The objective of technological augmentation is to integrate elements of conceptual understanding, procedural fluency, strategic competence, adaptive reasoning and productive disposition into the teaching and learning process (Kilpatrick & Findell, 2001).

Foundations of Tech-Augmented Learning:

The use of technology to support education is rooted in several constructivist viewpoints. Jean Piaget's cognitive development theory and Lev Vygotsky's social development theory are considered foundational in explaining learning as an active process of constructing rather than acquiring knowledge. Knowledge itself is not just a mental state, rather, it is an experienced relation of some things and it has no meaning outside of such relations (Hung, 2001). The constructivist orientation informs instructors to create learning environments that provides opportunities for students to create or construct knowledge (Bucci, Copenhaver, Lehman & O'Brien, 2003).

A more recent theoretical support for tech-augmented learning is found in Experiential Learning Theory. Experiential learning emerged out of the work of David E. Kolb and colleagues towards the close of the 20th century. The theory emphasizes the central role experience plays in the learning process. Kolb sees learning as the process where knowledge is created through the transformation of experience. Knowledge results from the combination of grasping and transforming experience. Specifically, Kolb, Boyatzis and Mainemelis (2000) maintain that in grasping experience, people perceive new information through experiencing the concrete, tangible felt qualities of the world, relying on their senses and immersing themselves in concrete reality. Similarly, in transforming or processing experience, some people tend to carefully watch others who are involved in the experience and reflect on what happens, while others choose to jump right in and start doing things. According to Kolb and his colleagues, the watchers favour reflective observation, while the doers favour active experimentation.

The realities of the present era are adequately explained by the experiential learning theory which encourages learning through active experimentation on elements that are concrete to the learner. Considering the ubiquity of digital technologies, particularly the penetration of smart phones among the new generation of learners in Nigeria, instructional strategies that maximize available tools are often recommended (Anyor & Abah, 2014). Tech-augmented learning not only leverage on the availability of digital tools, but also derive from the techno-cultural trend and lifestyle of the 21st century to develop students' critical reasoning, problem solving and life sustenance skills. This perspective of learning and teaching assumes that the mind naturally seeks meaning in context, that is, in relation to the person's current environment, and that it does so by searching for relationships that make sense and appear useful (CORD, 1999).

Several models of technology integration in classrooms are now available for the mathematics teacher to adopt and adapt based on existing classroom situations. Edutopia (2007) identifies the two commonly used models as SAMR and TPACK. The SAMR (Substitution, Augmentation, Modification, and

Redefinition) model was developed by Dr. Ruben R. Puentedura in 2012. The SAMR is intended to guide the process of using technology to enhance and transform teaching and learning. The substitution phase of the model emphasizes the use of technology as a direct tool substitute, with no functional change, while the augmentation phase presents technology as direct tool substitute, with functional improvement. As shown in Figure 1, the purpose of these first two phases is the enhancement of the instruction al process. The remaining two phases are targeted at the transformation of the teaching and learning process. Modification allows for significant task redesign while redefinition allows for the creation of new tasks previously inconceivable (Puentedura, 2012).

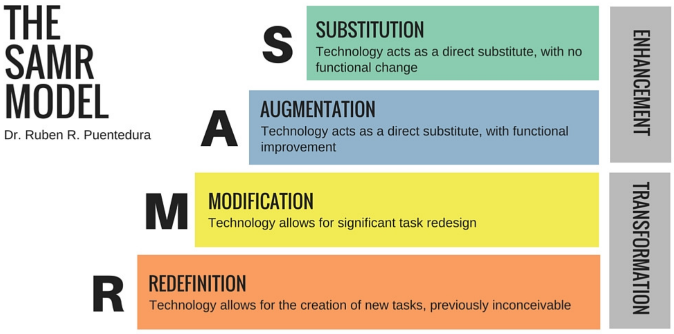

Figure 1: The SAMR Model (*Source: Wikiversity.Org*)

The Technological pedagogical Content Knowledge (TPACK) is a framework that identifies the knowledge teachers need to teach effectively with technology (Tpack.Org, 2016). The developers of the framework hold that effective technology integration for pedagogy around specific subject matter such as mathematics requires developing sensitivity to the dynamic, transactional relationship between the components of knowledge situated in unique contexts. The emphasis of TPACK (Figure 2) is that no single combination of content, technology and pedagogy will apply for every course, or every view of teaching.

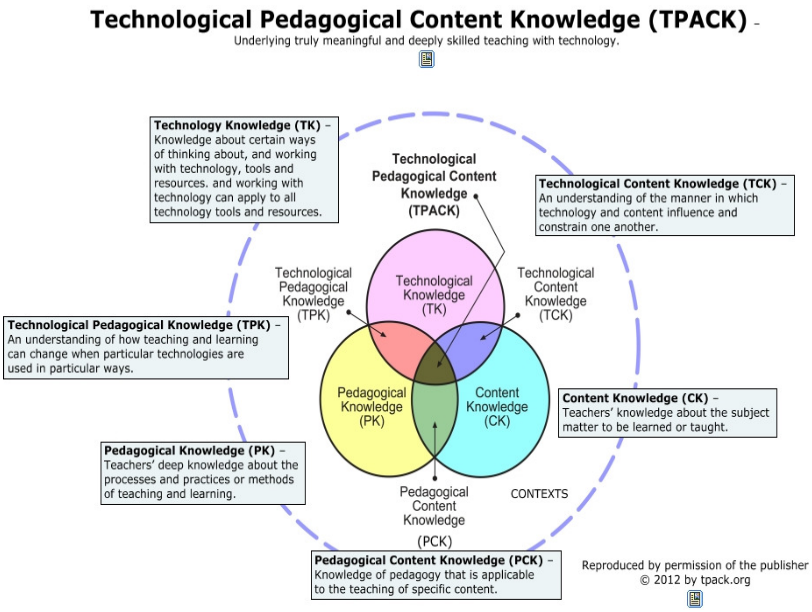

Figure 2: The TPACK Model (*Source: TPACK.Org*)

Another dimension to tech-augmented learning is the need for choice of specific tools that are relevant to content and acceptable to majority of users. In this regard, many theoretical models have been proposed to give explanations to end users acceptance behaviour with the most common among them being the Unified Theory of Adoption and Use of Technology (UTAUT) by Venkatesh, Morris, Davis, and Davis (2003). According to a brief review by Iji and Abah (2016), the UTAUT theorizes that four constructs will play a significant role as direct determinants of user acceptance and usage behaviour, namely, performance expectancy, effort expectancy, social influence and facilitating conditions. These determinants are in turn influenced by key moderators such as gender, age, voluntariness and experience. Thus the degree to which a technological tool helps both teachers and students of mathematics attain gains in performance, the ease associated with the tool, the availability of organizational and technical support, and the social benefits that are derivable, all contributed to the appeal of the tool.

Given these theoretical footings, this study sought to augment the teaching of a Basic Mathematics course for first-year university students with matrix algebra apps. The acceptability of the approach was based on the ease of access to the apps and the fact that smartphones are readily available among the students. The ages of the students, and their experience in navigating apps on their digital devices, meant that the adoption of tech-augmented learning was second nature to the students and readily integrated into the instruction process.

Empirical Studies:

Higher education teachers and researchers in mathematics education often seek ways to enhance the learning of mathematics through technological innovations. Technology provides an enormous spectrum of possibilities for new approaches to teaching and hence for learning across all levels of education. Much research and professional literature suggests that new approaches such as the use of software tools for augmenting mathematics instruction may enhance learning through cognitive, metacognitive and affective channels.

Studies highlighted here represent a small proportion of a larger body of empirical research into tech-augmented learning. A meta-analysis by Li and Ma (2010) examined the impact of computer technology (CT) on mathematics education in K-12 classrooms. The review of 85 independent effect sizes arising from CT deployment extracted from 46 primary studies involving a total of 36,793 learners indicated statistically significant positive effects of CT on mathematics achievement. The weighted least squares univariate and multiple regression analysis used by Li and Ma indicated that mathematics achievement could partly be explained by use of specific technologies in the classroom.

Similarly, an Iranian study by Taleb, Ahmadi and Musavi (2015) sought the views of the effect of mobile learning from 329 mathematics teachers from 2352 secondary schools from 19 districts of Tehran, using a descriptive-field method. The results revealed that in the opinion of participating teachers, mobile learning has a positive effect on motivating the students towards mathematics. Also, there is a positive and significant relation between using mobile learning and student participation in mathematics. These findings corroborates an earlier study by Anyor and Abah (2014) which revealed that students find the use of mobile learning in a blended collaborative learning framework to be very engaging and motivational.

In another study to examine whether the use of technology in university classes impact upon student behavior and student perceptions of instructional quality, Lavrin, Korte and Davis (2010) observed that adding technological components to courses where it is not currently used is likely to have a positive impact on students perception of instruction. There is also a resultant meaningful impact on student preparation for class, attentiveness, quality of notes taken, students' participation in class, student learning and desire to take additional courses in tech-augmented settings. Similarly, an analysis of 5 large scale studies of education technology , reveals that students with access to computer assisted instruction, integrated learning systems technology, simulations and software that teaches higher order thinking, collaborative networked technologies or design and programming technologies, show positive gains in achievement on researcher constructed tests, standardized tests, and national tests (Schacter, 1999).

In the same vein, Calder and Campbell (2016) report on a research project that examined the beliefs and attitudes of reluctant 16–18 year old learners when using apps in their numeracy and literacy programmes. The study uses an interpretive research methodology with a mixed-method approach. The report was concerned with the student engagement and cognitive aspects of the numeracy section of the study. The outcome of the study indicate that the use of apps enhanced student engagement with the numeracy tasks and transformed their attitudes towards mathematics from generally negative dispositions to positive and frequently enthusiastic ones. The visual and dynamic affordances of the apps influenced the nature of the student engagement. While there were greater than expected gains in mathematical understanding, this was conditional on the apps used and the pedagogical processes undertaken. In this case, Calder and Campbell (2016) deployed specific mathematical apps suitable for the students including *King of Maths, Math Blaster, Match the Fraction* and *Slide 1000*. The methodology of Calder and Campbell (2016) underpins a key pedagogical reality about tech-augmented learning, as the researchers strongly demonstrate that:

> Learning is mediated by language and the use of tools. Not only does the dialogue of the teacher and the learners in the classroom act as a mediator, the app itself acts as a mediating tool. The learner's preconceptions of the pedagogical media, in conjunction with the opportunities and constraints offered by the media themselves, promote distinct pathways in the learning process. That is, mathematical activity is inseparable from the pedagogical means, derived as they are from a particular understanding of social organization. Hence, the device will inevitably influence the mathematical ideas developed and is more than an environment. It is imbued with a complexity of relationships evoked by the users and the influence of underlying discourses. (p. 56-57).

Calder and Campbell (2016) reported that today's learners are engaged in and generally engrossed by digital media and can use them effectively to communicate, investigate and process ideas and personal questions. Mathematical apps, if used appropriately as part of a classroom programme, add variety and can enhance mathematical thinking and understanding.

Some other researchers have affirmed that there is already a wide range of existing digital technologies which are readily used by schools all over the world. Clark-Wilson, Oldknow and Sutherland (2011) listed deployment of innovation-based tools such as dynamic graphing tools, dynamic geometry schools, algorithmic programming languages, spread sheets and computer algebra systems (CAS). CAS such as Mathematica, Maple, MuPAD, Derive and Maxima have potential to facilitate an approach to learning which allows students to become involved in discovery and consolidate their own knowledge (Kumar & Kumaresan, 2008). Abari (2014) observed sustained interest and improved achievement after augmenting instruction in senior secondary school mathematics with Geogebra. Similarly, dynamic geometry systems like the Geometer's Sketchpad (GSP) seem to lend new dimensions to school geometry, with a clear invitation to experiment and explore geometrical constructions and connections (Age, 2016).

This research follows the direction of the aforementioned empirical studies and aims to investigate first-year student perceptions of using specific Matrix Algebra apps to augment learning in a Basic Mathematics class. Recognizing the great diversity of behaviours among learners, it is not assumed that the participants of this study will necessarily conform to the patterns reported in prevailing literature. The pattern of classroom interactions among students while using the matrix algebra tools and their views of expected outcomes are, therefore, also of key interest to this study.

Research Questions:

The following questions guided this study.

i. What are the categories of most frequently used digital devices among first-year university students?
ii. What are first-year university students' perceptions of tech-augmented learning in Basic Mathematics?

Methodology:

This study adopts a questionnaire survey to gauge the perceptions of first-year university students when a Basic Mathematics class was augmented with Matrix Algebra tools. The participants are drawn from 100 level students of B.Sc.(Ed.) Integrated Science programme enrolled for Basic Mathematics II, a core course in the second semester of the 2015/2016 academic session hosted by the department of Science Education of the University of Agriculture, Makurdi, Nigeria. The number of first-year students' enrolment on the course is 78.

The procedure for course delivery in this study entails the instructor (researcher) initially teaching Matrix Algebra in the usual conventional approach, and later introducing the use of Matrix Algebra apps to confirm computational routines. Three specific android-based matrix algebra apps were recommended for the students having smartphones to freely download from app stores. The apps are:

i. Matrix Calculator (Version: 3.05 ©Alexander Skokov): The developer description for the app indicates that the application is an absolutely free mathematical calculator that supports all matrix operations involving integers, decimal fractions, common fractions and complex numbers.
ii. Matrix Calculator (Version 5.1 ©Karpatil): This is a simple, open source and free matrix calculator, which supports some simple operations with matrices. This app works only with the real numbers.
iii. Matrix Operations (Version 2.5 ©GK Apps): This app has a simple interface for creating and computing the determinant of a matrix, inverse of a matrix, kernel of a matrix, rank of a matrix, eigenvalues and eigenvectors of a matrix.

These apps were recommended by the instructor for their ease of deployment, efficient device memory utilization, and robust interfaces that displayed computation steps as well as eventual solutions. They were all tested and affirmed appropriate by the instructor. The apps and others like them are freely downloadable from various app stores and on the Web. Students were permitted to freely select their preferred matrix algebra app. Those with laptops and other hand held devices were directed to search for and use any matrix tool that they felt comfortable with.

During classroom interaction, the few students who failed to come with any digital device were allowed to share with those with active devices. To avoid distractions from phone calls and notifications, all smartphones were switched to airplane mode in the course of classroom interactions thereby supporting the integration of digital devices with the instructional process.

Matrix Algebra was one of three key topics delivered by the instructor. This was covered during a six-week period with 2 hours of classroom discussions taking place each week. The students were given much class works and take-home assignments to be conducted with the matrix algebra apps. However, mastering manual computations was emphasized since current university examination policy does not support the use of third-party apps for assessment purpose.

The instrument for data collection for this study was the Tech-Augmented Learning Questionnaire (TALQ) which was adapted from items of Larsen (2012) Blended Learning Student Questionnaire, Version 2. Larsen (2012) reported a Cronbach alpha reliability coefficient of 0.94, indicating a high degree of internal consistency of the instrument. The TALQ comprises 23 items structured on a five point likert-type scale ranging from strongly disagree = 1 to strongly agree = 5. The main inspiration for this approach is the work of Chang and Fisher (2003) who developed their Web-based Learning Environment Instrument (WEBLEI) by building upon the work of Tobin and Fraser (1998). The cronbach alpha measure of internal consistency for the TALQ is 0.83.

Data from the study were collected directly by the researcher at the end of classroom sessions on Matrix Algebra. Participants were adequately informed of right to decline from the study and not to complete the TALQ, were assured that no credits (marks) are attached to this exercise. The TALQ did not include any personal details and returns were made through a student course representative. A total of 60 questionnaires were returned.

The data obtained from the TALQ was analyzed using simple percentages, a pie chart, mean and standard deviation. The benchmark for acceptance of statements on the TALQ was set at 3.00. This represented the mid-Likert point of neither agreeing nor disagreeing with statements. Likewise, a one sample t-test was carried out on each item of the TALQ, using 3.00 as the benchmark mean.

The matrix algebra tools used in this study are deployed as Open Educational Resources (OERs) and available as such from the developers. The apps continue to remain the copyrighted products of the respective developers.

Results and Discussions:

The results of this study are presented according to the research questions.

Research Question One:

What are the categories of most frequently used digital devices among first-year university students?

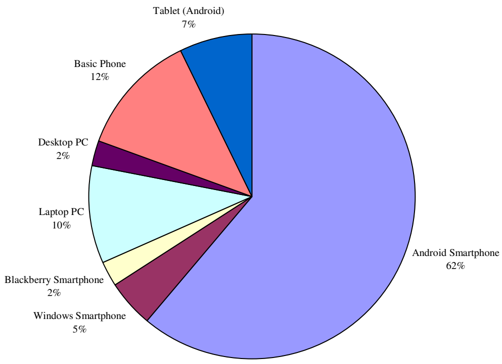

Figure 3: Categories of Digital Devices

The results displayed in Figure 3 indicate that a large percentage of first-year students use Android smart phones (62%). Likewise, 10% of the students own Laptop PC.

Research Question Two:

What are first-year university students' perceptions of tech-augmented learning in Basic Mathematics?

Table 1: First-year University Students' Perceptions of Tech-Augmented Learning

S/N	Items	Mean	SD	p-Value
1	I like the tech-augmented learning activities	4.13	0.83	0.0001*
2	The tech-augmented learning activities helped me to learn matrix algebra	4.23	0.70	0.0001*
3	This course has improved my computational skills in matrix algebra	4.18	0.87	0.0001*
4	There was a good balance between use of matrix apps and classroom activities	4.18	0.81	0.0001*
5	The use of matrix apps and classroom activities worked well together	3.92	1.11	0.0001*
6	I got the technical support I needed during this course	3.92	1.11	0.0001*
7	I understand why this course mixed the use of matrix apps and classroom activities	4.00	0.92	0.0001*
8	I will like my other courses to be taught like this course	4.23	0.89	0.0001*
9	My teacher seemed like he liked to teach this class	4.43	0.67	0.0001*
10	The use of the matrix apps allowed me to work at my own speed to achieve learning objectives	4.27	0.66	0.0001*
11	The activities of the tech-augmented classroom allows me to explore my own areas of interest	4.03	0.84	0.0001*
12	In this course, I have freedom to ask other students what I do not understand	4.50	0.75	0.0001*
13	I enjoy learning in this tech-augmented classroom environment	4.12	0.64	0.0001*
14	In the tech-augmented classroom, the organization of each lesson is easy to follow	3.92	0.93	0.0001*
15	The teacher encourages me to learn in different ways	4.60	0.62	0.0001*
16	The teacher encourages students to work together and help each other	4.73	0.45	0.0001*
17	I am regularly asked to evaluate my own work	4.10	1.02	0.0001*
18	My classmates and I regularly evaluate each other's work	3.70	1.07	0.0001*
19	I was supported by a positive attitude from my classmates	4.08	0.83	0.0001*
20	I felt sense of satisfaction and achievement about the tech-augmented learning activities	3.72	0.87	0.0001*
21	The tech-augmented learning activities held my interest throughout the course	3.98	0.73	0.0001*
22	The teacher is prepared and available to answer my questions	4.53	0.57	0.0001*
23	The teacher expects me to do my best	4.77	0.43	0.0001*
	Overall Mean	**4.19**		

**significant at $\alpha = 0.05$*

The results in Table 1 indicate a widespread agreement with the items of the TALQ instrument, yielding a grand mean of 4.19 which is far above the benchmark of 3.00. The associated p-values were all significant at 0.05 level of significance. Specifically, the results imply that first-year university students positively perceived the augmentation of the Basic Mathematics class with Matrix Algebra Tools. The students expressed likeness of the tech-augmented activities, felt a high sense of satisfaction and achievement, and held a high expectation of their personal academic performance as a result of the tech-augmented activities.

The findings of this study have supported the fact that there is increasing technology penetration among young learners. The percentage distribution of digital devices available among first year students conforms to the findings of Anyor and Abah (2014) who maintained that a great number of students (70%) deploy smart phones for mobile learning. This spread of computer devices also agrees with Iji et al (2017) who observed that most mathematics education students (49%) often access online cloud services using smart phones, a pointer to the changing technological landscape which is rapidly enabling the ability to learn on-the-go. It was obvious that the Matrix Algebra apps affords physical, technical and functional components which provides more psychological comfort for the users (Kenny *et al.*, 2009)

The responses of first-year students to the TALQ as shown in Table 1 affirm a positive perception of the augmentation of Basic Mathematics with Matrix Algebra tools. The students accepted that the activities of the tech-augmented classroom allow them to explore their own areas of interest. Similarly, it was accepted that the use of Matrix Algebra tools to augment the instructional process improved first-year students' computational skills in matrix algebra. The students were supported by a positive attitude from one another as allowed by the activities and interactions of the technology augmentation. These outcomes support the findings of Reed, Drijvers and Kirschner (2009) who observed that promoting learning with computer tools needs to take several factors into account, including improving students' attitudes, encouraging learning behaviors and giving sufficient opportunity for constructing new mathematical knowledge within mathematical discourse. In line with Lavin, Korte and Davies (2010), this study has strengthened the notion that the use of technological solutions in university classes has a positive impact on student perception of instruction and desire to take additional courses in tech-augmented settings.

The engagement in learning activities observed in this study points to the general benefit of effective use of digital technology in the classroom being confirmed in the reports of diverse studies. The results show that the use of apps shaped the learning experience in ways that differed from students' prior experiences and engendered confidence and differentiation of the individual engagement (Calder & Campbell, 2016). This observation agrees with Mango (2015) who presented research results indicating that iPad tools played a significant role in student learning engagement thus promoting active learning in the classroom and paving way for student success. Similarly, Anyor and Abah (2014) reported that 72.5% of students are motivated in their study of mathematics after very engaging learning experience in a blended collaborative framework. Generally, engagement in mathematics refers to students' psychological investment in an effort directed toward learning, understanding, or mastering the knowledge, skills, or crafts that academic work is intended to promote (Santos & Barnby, 2010). In the mathematics classroom, engaged students are actively participating, genuinely valuing, and reflectively involved in deep understanding of mathematical concepts and applications, and expertise (Attard, 2012). Affective engagement is students' own interest and enjoyment of mathematics as well as reactions to external incentives (Organization for Economic Co-operation and Development - OECD, 2004). Subject motivation is often regarded as the driving force behind learning. Interest in and enjoyment of mathematics is a relatively stable orientation that affects the intensity and continuity of engagement in learning situations, the selection of strategies and the depth of understanding. Students are active participants in the learning process, constructing meaning in ways shaped by their own prior knowledge and new experiences (Iji, Abah & Anyor, 2017). Behavioural engagement in mathematics refers to students' disposition to manage their own learning by choosing appropriate learning goals, using their existing knowledge and skills in mathematics to direct their learning, and selecting learning strategies appropriate to the task in hand (OECD, 2004). To do this they must be able to establish goals, persevere, monitor their progress, adjust their learning strategies as necessary, and overcome difficulties in learning. According to Abd-Wahid and Shahrill (2014), behavioural engagement is expressed in dimensions such as attentiveness, diligence, time spent on task and non-assigned time spent on task. Behavioural engagement draws on the idea of participation and includes involvement in academic, social, or extracurricular activities and is considered crucial of achieving positive academic outcomes and preventing dropping out (Fredricks & McColskey, 2012). These dimensions are all appropriately reflected in the results of this study as shown in Table 1.

The outcomes observed in this study strengthens the assertion that the academic environment is currently changing more than it has done at any time in the past and current trends demand augmentation to face-to-face lecture (Buchanan, MacFarlane & Ludwiniak, 2011). The use of digital technology like Smartphone apps is improving access to education and promoting new learning (Valk, Rashid & Elder, 2010), and most students found the smartphone apps presentation and the associated classroom activities to be useful, to the extent that they would suggest offering the activity in other classes (Rodis, Aungst, Brown, Cui & Tam, 2016). The pattern of perception observed in this study supports the earlier findings of Koh *et al.* (2014) who established that there is a high uptake and usage of smart devices and medical apps amongst first year clinical medical students with positive perceptions towards their use and impact on clinical practice. This pattern, according to Rung, Warnke and Mattheos (2014) might present an opportunity for educators to design educational methods, activities, and material that are suitable for smart phones and allow students to use this technology, thereby accommodating students' current diverse learning approaches.

Conclusion:

Most first-year students in Nigerian Universities came from a basic education background (secondary schools) that generally discourages the use of personal digital devices in the school environment. This study reports first-year students' reactions to the augmentation of a Basic Mathematics course with Matrix Algebra apps. The results indicate a widespread distribution of smartphones among the students and high positive perception of technology augmentation. The tech-augmented learning activities led to the students' sustained interest, active engagement and high expectation of performance in Basic Mathematics. The perspective of the findings of this study is that instruction planned around available technological tools can result in enriched learning experience for students, particularly in Mathematics Education.

References:

Abari, M.T. (2014). *Effect of Geogebra on senior secondary school students' interest and achievement in statistics in Makurdi Local Government Area of Benue State*. An unpublished M.Ed Thesis submitted to the Department of Science Education, University of Agriculture, Makurdi, Nigeria. pp 1-170.

Abd-Wahid, N. & Shahrill, M. (2014). Pre-university students' engagement towards the learning of mathematics. *Proceeding of the Social Sciences Research ICSSR*, 379-388.

Age, J.T. (2016). *The effect of Geometer's Sketch Pad on senior secondary school students' interest and achievement in geometry in Gboko Metropolis*. An unpublished M.Ed Thesis submitted to the Department of Science Education, University of Agriculture, Makurdi, Nigeria. pp 1-160

Anyor, J. W. & Abah, J. A. (2014). Students' perception of mobile learning in a blended collaborative learning framework in mathematics. *Benue Journal of Mathematics and Mathematics Education,* 1(3), 20-27. Retrieved on 3rd February, 2017 from https://files.osf.io/v1/resources/myvuh/providers/osfstorage/57ea881ab83f6901f194a75d?direct=true&action=download

Attard, C. (2012). Engagement with mathematics: What does it mean and what does it look like? *Australian Primary Mathematics Classroom- APMC, Professional Journal of the Australian Association of Mathematics Teachers Inc.,* 17(1), 9-13.

Bucci, T.T., Copenhaver, L.J., Lehman, B. & O'Brien, T. (2003). Technology integration: Connection to educational theories. *Contemporary Issues in Technology and Teacher Education, 3 (1)*, 26-42.

Buchanan, B., MacFarlane, R. & Ludwiniak, R. (2011). *Student perception of on-line lectures within a blended learning environment for computing students*. Retrieved on 4th June, 2017 from https://core.ac.uk/download/pdf/29592074.pdf

Calder, N. & Campbell, A. (2016). Using mathematical apps with reluctant learners. *Digital Experiences in Mathematics Education, 2(1)*, 50-69. DOI:10.1007/s40751-016-0011-y. Retrieved on 4th June, 2016 from https://link.springer.com/content/pdf/10.1007%2Fs40751-016-0011-y.pdf

Chang, V., & Fisher, D. (2003). The validation and application of a new learning environment instrument for online learning in higher education. In M. S. Khine & D. Fisher (Eds.), *Technology-rich learning environments: A future perspective* (pp. 1-20). Singapore: World Scientific Publishing Co. Pte. Ltd. Available from http://www.aare.edu.au/data/publications/2001/cha01098.pdf

CORD (1999). *Teaching mathematics contextually: The cornerstone of tech prep*. Waco, TX: CORD Communications, Inc. pp 1-60.

Edutopia (2007). *What is successful technology integration?* Retrieved on 15th November, 2016 from http://www.edutopia.org/technology-integration-guide-description

Fredricks, J. A. & McColskey, W. (2012). The measurement of student engagement: A comparative analysis of various methods and student self-report instruments. In S. L. Christenson (Ed.) *Handbook of Research on Student Engagement,* 763-782.

Hung, D. (2001). Theories of learning and computer-mediated instructional technologies. *EMI Online Learning Design, 38(4)*, 281-287.

Iji, C.O. & Abah, J.A. (2016). Prospects of cloud computing as a safe haven for improving mathematics education in Nigeria. In A. Aderoumu & A. Sodiya (Eds.), *Information Technology for National Safety and Security*, Proceedings of the 26th National Conference of the Nigeria Computer Society held July 19-21, 2016, at Abuja, Nigeria. pp 106-114. Retrieved on 2nd August, 2016, from http://www.ncs.org.ng/wp-content/uploads/2016/07/NCS-Conference-2016-Proceedings-Information-Technology-for-National-Safety-Security.pdf

Iji, C. O., Abah, J. A. & Uka, N. K. (2013). Attaining the Millenium Development Goals (MDGs) through Effective Mathematics Education. *Proceedings of the 54th Annual Conference of Science Teachers Association of Nigeria,* 99-107.

Iji, C.O., Abah, J.A. & Anyor, J.W. (2017). Impact of cloud services on students' attitude towards mathematics education in public universities in Benue State, Nigeria. *International Journal of Research in Education and Science (IJRES), 3(1)*, 228-244. Retrieved on 3rd February, 2017 from http://dergipark.ulakbim.gov.tr/ijres/article/download/5000202010/5000179858

Innovation Unit (2014). *21st century learning.* Retrieved on 18th March, 2014 from http://www.innovationunit.org/knowledge/our-ideas/21st-century-learning

Italiano, E. (2014). *Community, contemplation, and computers: The role of technology in education.* Retrieved on 18th March, 2014 from http://www.thepublicdiscourse.com/2014/02/11789/

Kenny, R. F., Park, C., Van Neste-Kenny, J. M. C., Burton, P. A. & Meiers, J. (2009). Using mobile learning to enhance the quality of nursing practice education. In M. Ally (Ed.) *Mobile Learning: Transforming the Delivery of Education and Training*. Edmonton: AU Press. pp 75-98

Kilpatrick, J. & Findell, B (2001). *Adding it up: Helping children learn mathematics*. Washinton, D. C. National Academy Press

Kirkwood, A. & Price, L. (2014). Technology-enhanced learning and teaching in higher education: What is "enhanced" and how do we know? A critical literature review. *Learning, Media and Technology, 39(1)*, 6-36.

Koh, K. C., Wan, J. K., Selvanathan, S., Vivekanada, C., Lee, G. Y. & Ng, C. T. (2014). Medical students' perception regarding the impact of mobile medical application on their clinical practice. Journal of Mobile Technology in Medicine, 3(1), 46-53. Retrieved on 4th June, 2017 from http://articles.journalmtm.com/jmtm.3.1.7.pdf

Kolb, D.A., Boyatzis, R.E. & Mainemelis, C. (2000). Experiential learning theory: Previous research and new directions. In R.J. Sternbery & L.F. Zhang (Eds.), *Perspectives on Cognitive, Learning, and Thinking Styles*. New Jersey: Lawrence Erlbaum.

Kumar, A. & Kumaresan, S. (2008). Use of mathematical software for teaching and learning mathematics. *ICME 11 Proceedings*, 373-388.

Larsen, L.J.E. (2012). Teacher and student perspectives on a blended learning intensive English program writing course. *Graduate Thesis and Dissertations*. Paper 12375. pp 1-252.

Lavin, A.M., Korte, L. & Davies, T.L. (2010). The impact of classroom technology on student behaviour. *Journal of Technology Research*, 2, 1-13.

Li, Q. & Ma, X. (2010). A meta-analysis of the effects of computer technology on school students' mathematical learning. *Educational Psychology Review, 22(3)*, 215-243. DOI: 10.1007/s10648-010-9125-8

Mango, O. (2015). iPad use and student engagement in the classroom. *The Turkish Online Journal of Education Technology, 14(1)*, 53-57. Retrieved on 4th June, 2017 from http://tojet.net/articles/v14i1/1417.pdf

Organization for Economic Co-operation and Development -OECD (2004). *Learning for tomorrow's world*. Retrieved on 20th July, 2015 from http://www.oecd-ilibrary.org/education/learning-for-tomorrow-s-world-9789264006416-en

Partnership for 21st Century Skills (2002). *Learning for the 21st century: A report and mile guide for 21st century skills.* Washington: Partnership for 21st Century Skills, 1-5.

Puentedura, R.R. (2012). *The SAMR model: Background and examplars*. Retrieved on 15th November, 2016 from http://www.hippasus.com/rrpweblog/archives/2012/08/23/SAMR_BackgroundExamplars.pdf

Reed, H. C., Drijvers, P. & Kirschner, P. A. (2009). *Effects of attitudes and behaviours on learning mathematics with computer tools.* Amsterdam: Faculty of Psychology and Education, VU University Amsterdam, 1-54.

Rodis, J., Aungst, T. D., Brown, N. V., Cui, Y. & Tam, L. (2016). Enhancing Pharmacy Student Learning and Perceptions of Medical Apps. *JMIR Mhealth Uhealth*, *4(2)*, e55. doi: 10.2196/mhealth.4843. Retrieved on 4th June, 2017 from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4882412/

Rung, A., Warnke, F. & Mattheos, N. (2014). Investigating the use of smartphones for learning purposes by Australian students. *JMIR mHealth uHealth, 2(2)*, e20 doi:10.2196/mhealth.3120

Santos, S. & Barmby, P. (2010). Enrichment and engagement in mathematics. In M. Joubert & P. Andrews (Eds.), *Proceedings of the British Congress for Mathematics Education,* 199-206.

Schacter, J. (1999). *The impact of education technology on student achievement: What the most current research has to say*. Santa Monica, CA: The Milken Family Foundation. pp 1-12.

Taleb, Z., Ahmadi, A. & Musavi, M. (2015). The effect of m-learning on mathematics learning. *Precedia – Social and Behavioural Science, 171*, 83-89.

Tobin, K. & Fraser, B.J. (1998). Qualitative and quantitative landscape of classroom learning environments. In B.J. Fraser & K.G. Tobin (Eds.), International Handbook of Science Education. Dordrecht: Kluwer Academic Publishers. pp 623-640.

Tpack.Org (2016). *What is TPACK?* Retrieved on 15th November, 2016 from http://www.tpack.org

Valk, J.-H., Rashid, A. T. & Elder, L. (2010). Using mobile phones to improve educational outcomes: An analysis of evidence from Asia. *The International Review of Open and Distributed Learning, 11(1)*. Retrieved on 4th June, 2017 from http://www.irrodl.org/index.php/irrodl/article/view/794/1487

Venkatesh, V., Morris, M.G., Davies, G.B. & Davies, F.D. (2003). User acceptance of information technology: Toward a unified view. *MIS Quartely, 27(3)*, 425-478.
