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The impact of a Technology-based approach for the learning of Mathematics at secondary school level

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Abstract

The main purpose of this research project was to determine how technology helps students to engage in Mathematics learning at school. One hundred and forty-five students (girls & boys) of varying learning performances studied the topic fraction using technology-enhanced lessons. The scores of a summative test were compared with those students who had studied the topic using the traditional approach. Results confirmed that the mastery of higher order skills can be enhanced using technological tools. Gender bias was also investigated and the results showed that high performing boys benefitted more from the experiment. Regarding the affective domain of learning, students across all levels of performance were positively impacted and showed much interest in the new learning approach. A theoretical framework, the Technology Integration Model (TIM) evolved from this study and should serve as guiding framework for all major stakeholders involved in the process of empowering students with effective digital learning content.

KEYWORDS: Technology-enhanced lessons, Educational Technology, Mathematics.

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1. Introduction

The ubiquity of computers and their integration in the educational process are redirecting both teaching and learning. Numerous research document positive learning achievement in many subjects, including Mathematics. However, the integration process is still haphazard, loose and undefined, such that outcomes are often mitigated, if not controversial. At times there have been attempts to completely replace traditional methods, while in other cases technology has only been timidly and sparsely integrated. Integration can also be context-laden and can take different dimensions depending on the methodological approach. Finding the right balance between traditional practices and technological functionalities can be promising for both teachers and students. The purpose of this study is to investigate if technology-enhanced lessons can have any significant impact on the cognitive and affective domains of learning.

2. Literature Review

Students are an unavoidable partaker in any innovative learning approach. Learners nourish the hope to see their learning experience take a new turn, where independent and flexible learning supersede didactic and teacher-centered instruction. In a technologically-dominated society, instruction takes a new dimension to meet emerging learning needs, address learning disabilities, bridge the learning gap and engage students in ways that have previously not been possible. According to Hashmi et al. (2019), technology has great potential to increase learners' motivation, improve their learning, knowledge retention and understanding. Barnes, Marateo and Ferris (2007) mentioned that the Next Gen learn differently from their predecessors, being unique in that they are the first to grow up with digital and cyber technologies. They have out-of-school

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access to a wealth of materials from Open Learning Resources (OLR) and spend more hours at home on the computer than at school. Not only are they acculturated to the use of technology, they are saturated with it. This media saturation and ease of access to digital technologies is driving the next generation to think, communicate, and learn in distinctive ways (Carr, 2010). This acculturation with the functionalities of technology offers great propensities and affordances to transform teaching and learning. These out-of-school acquired technological skills can be translated into school settings to help students engage in constructive learning in an already friendly environment (Selwyn, Potter and Cranmer, 2009). Unfortunately, today there is a mismatch between demand and supply, and this is a fundamental cause in the decline of education. Our students have changed radically and today's students are no longer the people our educational system was designed to teach (Pierce and Ball, 2010). They come to the classroom with preconceived notions of how the world works (Bransford, Brown and Cocking, 1999). If these notions are not engaged, students may fail to grasp new concepts that they are taught. Pedagogy is defined as the interactive process by which a student's learning is mediated by teachers using a range of tools (Vygotsky, 1978, p 27). Therefore, the school-day cannot still be constructed as in the fifties, and technology is here to challenge this setting and allow more space for students to engage in formal off-premises and self-learning. By varying the range of tools with emerging technologies we can expect that what was not possible or difficult to explain in the past, can now be achieved.

In an attempt to redirect learning using computers, Mitra (2007) carried out an experiment in India and coined the concept of the "The child-driven education" where students can teach themselves using a computer provided they work in groups. In his project "The hole in the wall" he demonstrated how students in the most remote areas of India, learnt to teach each other how to use the computer and search the Internet and be creative, using a computer fixed in a wall. Capone (2018) also reported this peer tutoring effects whereby students serve as teachers for their weaker peers.

Probably the greatest asset of technology is the motivation, it elicits in young students to take control of their learning and become independent learners (Tubaishat & Lansari, 2011) In a meta-analysis which brought together 15 years of investigations on the effect of teaching and learning with technology on student cognitive and affective outcomes, Lee et al. (2013) found that in terms of magnitude and direction, the overall effect sizes for the two outcomes exhibited a positive effect. Moreover Capone (2018) found out that students showed a positive attitude to those teachers who use technology as a tool for teaching thus allowing the students to easily interact with the educator. Raja and Nagasubramani (2018) also added that teachers and learners can take advantage of technology in good light and eliminate the limitations that draw many students and schools back from achieving excellence.

On the other hand, Pate (2016) brings some precautionary notes to literature review. In her article entitled "*Technology implementation: impact on students' perception and mindset*", she analyzed the current negative impacts of implementing new technological "applications" which include over-reliance on computers to make all the difference, utilizing technology merely for substitution and convenience purposes, the habit of students to adopt a consumer mindset, and the increase in plagiarism.

From a gender bias point of view, research findings on differences among computer users have been inconsistent (Heemskerk, Volman & Admiraal, 2009; Sanders, 2005), at times related to the methods of data collection.

Research questions:

1. What is the impact of technology-enhanced lessons on the cognitive and affective domain of learning?
2. How does technology-enhanced learning (TEL) benefit students with varying academic performances?
3. Is there any gender disparity in the adoption of technology for learning?
4. What is the impact of TEL on the mastery of higher order and lower order skills?

3. Methodology

For the purpose of this study a mixed-method approach was adopted. A quasi-experimental design was adopted whereby 145 students comprising both boys and girls of mixed learning abilities participated in an experiment to learn a topic on Mathematics, namely fractions using the traditional approach complemented with technology-based lessons. The experiment lasted for two weeks in each of the four selected schools, after which a control MCQ (multiple-choice question) test of 30 items was administered to the participants. Control groups of matching learning abilities to the experimental groups in terms of gender, age and learning performance also participated in the test. The test scores of the experimental and control groups were then analyzed to identify any significant differences in learning performance caused by the intervention.

For the qualitative aspect of the research, observation of students was carried out using a rubric comprising of the following main themes derived from literature review, namely: ease of use, engagement and enjoyment, self-efficacy, group work and peer tutoring, video effectiveness, teacher's reaction, classroom management, reluctance to change. Unstructured personal interviews in the participants' mother tongue were also carried out with some students. The responses were recorded ad verbatim and translated into English and analysed using a thematic approach based on the above-mentioned themes.

Learning is a multilevel cognitive process which is best described by the six levels of Bloom's taxonomy (Anderson et al., 2001). There might be a tendency to believe that ICT (Information and Communication Technologies) is most effective with Lower Order Thinking (LOTS), but according to Lim (2007), ICT tools can also be used to engage students in higher-order type of thinking. Cox and Marshall (2007) observed that it is important to answer how ICT impacts simple and complex learning tasks. The fourth research question was to investigate if technology has varying impact on the level of skills to be acquired. Initially the MCQ test was devised to comprise items at the two levels of difficulty, namely HOT (Higher Order Thinking) and LOT. Comparison of test scores were then carried out for each level of difficulty.

Table 1 shows the profile of the four experimental groups, indicating that boys and girls of both good and average performing levels participated in the intervention.

Group	I	II	III	IV
Target	Good performers-boys	Good performers-girls	Average performers - boys	Average performers – girls
Maths CPE grade	A	A	C	C

Table 1 - Categories of the experimental groups.

Good performers were those who obtained a grade A in Mathematics at the end of primary school examinations (CPE-Certificate of Primary Education), while average performers were those who obtained a grade C. A number of high performers (those with a grade A^{+}) also participated in the experiment.

4. Data Analysis

One hundred and forty-five Form I students (boys 42.8%) were taught the topic fractions using tablets and slide presentations. The intervention lasted over two weeks and comprised six lessons of 75 minutes each.

Comparison of test scores between experimental and control groups.

To measure the impact of technology-based lessons on learning performance, test scores of the experimental and control groups were analysed and compared for any significant difference. Table 2 shows that high performers who benefitted from the intervention performed better than their counterparts from the control groups when all the 30 items of the test were considered. When these items were considered separately in terms of HOTs and LOTs, the difference in test scores between the two groups was significant only in the case of HOTs. Calculations for Cohen's d indicated high values, hence the high effect size. The intervention thus caused a significant difference in test scores; but more precisely for HOTs. In the case of LOTs, no significant difference in test scores was observed as students (high performers) did well with or without the intervention. To some extent these findings corroborate with those of Wenglinsky (1998) who arrived at the conclusion that the use of computers to teach higher-order thinking skills was positively related to academic achievement.

Items	**Group**	**N**	**Mean Rank**	**Cohen's *d***	***p***
All	Experimental	11	27.82	0.798	.043
	Control	31	19.26		
LOTS only	Experimental	11	26.59	0.509	.060
	Control	31	19.69		
HOTS only	Experimental	11	27.73	0.753	.044
	Control	31	19.29		

Table 2 - Comparison for High Performers.

Items	**Group**	**N**	**Mean Rank**	**Cohen's *d***	***p***
All	Experimental	62	98.52	0.630	.000
	Control	99	70.03		
LOTS only	Experimental	62	92.10	0.446	.015
	Control	99	74.05		
HOTS only	Experimental	62	99.77	0.672	.000
	Control	99	69.25		

Table 3 - Comparison for Good Performers.

For good performers, Table 3 shows that the intervention caused significant differences for both LOTs and HOTs. However, in-depth analysis gender wise (Table 4) revealed that for girls, the intervention caused no statistically significant difference in the case of LOTs whereas for boys the difference was statistically significant for both HOTs and LOTs.

So in general those already doing well in the subject scored significantly higher test scores especially at the HOTS level, after studying fractions using technology. This study confirms that the mastery of higher order skills can be enhanced using technological tools (Lim, 2007). In fact, Handal et al. (2011) wrote that teachers need to be reassured that technology can be useful for developing HOTs skills.

Items	Group	N	Mean Rank	Cohen's *d*	*p*
All	Experimental	23	43.50	0.917	.001
	Control	42	27.25		
LOTS only	Experimental	23	40.35	0.600	.018
	Control	42	28.98		
HOTS only	Experimental	23	44.28	1.014	.001
	Control	42	26.82		

Table 4 - Comparison for Good Performers (Boys).

Items	Group	N	Mean Rank	Cohen's *d*	*p*
All	Experimental	39	55.23	0.420	.049
	Control	57	43.89		
LOTS only	Experimental	39	52.29	0.327	.260
	Control	57	45.90		
HOTS only	Experimental	39	55.87	0.426	.031
	Control	57	43.46		

Table 5 - Comparison for Good Performers (Girls).

Similar analysis revealed that following the intervention, average students did not get higher test scores compared to the control groups. However, as pointed out by Livingstone (2012), notwithstanding the apparently moderate improvements in learning performance, the integration of ICT (Information and Communication Technologies) is still a valid enterprise and there is some merit to this position, as it elicits motivation and compensates for some forms of disadvantage. Karpati (2004) reported that when educational software was used to assist students who were behind, there were not beneficial effects for their students. There were two main causes which were picked up during class observation and interaction with these particular students. The first one was their low level of basic arithmetic skills, showing difficulties with multiplication tables, Highest Common Factor (H.C.F.) and Least Common Multiple (L.C.M.) The second cause was the language barrier, as all the e-learning materials were in English. For these students, class teachers reported using Creole and French frequently in their normal classes. Vygotsky (1978) argued that language is the main tool that promotes thinking, develops reasoning, and supports cultural activities. During the intervention, it was observed that students struggled with the medium of instruction and concept assimilation.

Moreover, the tablet experience warranted a significant level of independent work, whereby students spent significant time learning on their own. Figure 1 summarizes the main findings of this first data analysis and depicts clearly for whom and at which level technology enhanced learning had a significant impact.

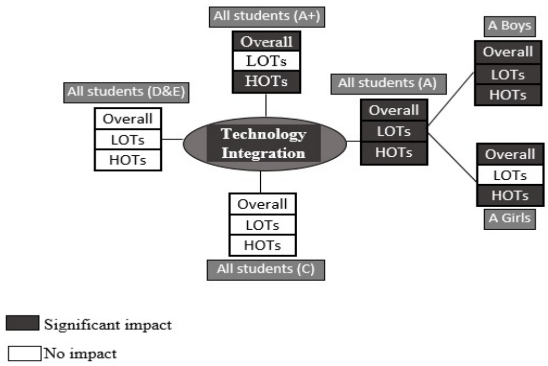

Figure 1 - Impact of TEL on learning.

4.1 Gender disparity

The Cohen's d values from Tables 5 and 6 show that boys benefitted more from the intervention than girls.

Analysis was also carried out to investigate if good performers from the experimental groups had comparable test scores with high performing girls of the control groups. Only the boys could match the latter's performance, confirming that boys benefitted more from technology-enhanced lessons. These findings concur with those of Christoph et al. (2015) who argued that computer-related activities are typically perceived as male-specific. On the other hand, Chinweoke (2016) found that when ICT was used to teach trigonometry, there was no gender disparity. So, further research is warranted in this area.

	Control Group	Experimental Group	Effect
CPE Math grade	A^+ (Girls) 27	A (Boys) 23	No sig. difference
	A^+(Girls) 27	A (Girls) 39	Sig. difference $A^+ > A$

Table 6 - Gender bias on technology adoption.

4.2 Impact on the affective domain of learners

Lipnevitch, Preckel and Krumm (2016) demonstrated that Mathematics attitudes contributed to students'

Mathematics achievement over and above personality and cognitive ability, and argue that attitudes may be more malleable than the later characteristics. Cox (2008) reported that the impact of IT (Information Technology) on learning goes beyond assessing increase in test scores, but learning gains can also be measured in terms of effects on pupils' generic and specific skills and knowledge, effects of group and collaborative learning, taking account of human–computer interfaces, the changing nature of knowledge presented and the role of the teacher. Lim, Lim and Koh (2012) also interviewed teachers who reported that ICT engaged their students and helped them to learn better, even if ICT could not increase their students' academic performance. Moreover, Mathematics anxiety, fear and math-dislike are common among many students, making learning a dreadful experience (Escalera-Chávez et al., 2017; Uchida and Mori, 2017). If technology can help overcome this fear and anxiety, breed excitement and enthusiasm, there will definitely be room for concepts to be learnt and practiced in an environment which is conducive and friendly. This qualitative aspect of learning is further analysed and reported in the following section.

4.3 Qualitative analysis of classroom observation and students' unstructured interviews

Both classroom observation and unstructured interviews with students were carried out to confront participants in their natural setting and this helped uncover unexpected issues and behaviours. The two approaches complemented each other. The findings have been organized around the following central themes: ease of use, engagement and enjoyment, self-efficacy, group work and peer tutoring, video effectiveness, teacher's reaction, classroom management, reluctance to change. In the Results section, simply state what you found, but do not interpret the results or discuss their implications.

Ease of use

Students demonstrated much ease working with the tablet. Adaptation was mostly smooth and easy-going for the majority of them who showed no difficulty in completing the tasks set on the tablet. This ease of use was voiced out by students during discussion with them. Some even dared to change the settings on the tablet, like the desktop picture. According to Prensky (2001), today's students are digital natives navigating in the technological world with disconcerting ease.

Engagement and enjoyment

People usually engage in what they enjoy. The most telling truth of this intervention is the level of engagement and positive attitude that it solicited among the majority of students. They were prompt to try the new learning approach and worked hard to successfully complete the e-exercises. Students hardly absented from school during the intervention, except in extreme cases, demonstrating their willingness not to miss the lessons and benefit from the experience. Teachers said students looked forward to the intervention and some even took their break time to enjoy the lesson.

It was fun for them, without their realizing that learning was taking place but in a different setting. Over the two-week intervention, some had developed a liking for the study of Mathematics. So, the approach and platform used to teach Mathematics can make a difference in students' attitude toward the subject.

They found the explanation clear and the class more interesting. One student said "*Our primary school teacher did not explain the concepts so clearly*". Another student said he did not like Mathematics before but now the tablet experience made the lesson very interesting. Another student commented "*this class is so cool, are we going to study other Mathematics topics using the tablet?*"

Most students interviewed had shared the tablet experience with their parents and siblings at home, hence indicating that the enjoyment and excitement crossed the school boundaries. Years of research have shown that intrinsic motivation (including enjoyment) leads to better persistence, performance and satisfaction in a variety of tasks (Baard, Deci and Ryan, 2004; Black and Deci, 2000). And this intervention clearly demonstrated technology's potential to breed enjoyment and foster engagement among students.

Self-efficacy

Jones (2007) suggested that technology is thought to be most effective when the learning focus shifts from the teacher to the student, with students' interests and abilities guiding the content, pace, and learning activities. One common element that cut across all the groups was the extent to which students enjoyed their independent learning, working at their own pace, selecting the exercises to do and receiving instant feedback for their answers. Students preferred to do the exercises that were on the tablet rather than the ones in their text book because they could get a feedback for their worked-out answers right away. Self-efficacy is acknowledged as a key element in successful learning (Azar & Mahmoudi, 2014), helping leaners to try harder to solve problems, be more accurate and show constancy in dealing with difficult issues. Self-directed learning motivated most of them, as they sought help from the teachers or assistants only in extreme cases.

Group work and peer tutoring

The interaction among the students who worked in pairs helped them to clarify the concepts explained. There were intense moments of learning through sharing, team work, promoting at times a healthy competition among the pairs of students. They shared the tablet and took turns to key in the answers, while the other one worked out the solution. They celebrated good answers as a team. When all the lessons of fractions had been taught, students eagerly attempted the 20-item quiz. All pairs worked hard to get the best score. Many requested for a second attempt to complete the quiz with the hope of improving their score. This activity promoted a healthy and productive competition, with each pair trying to achieve better.

Peer tutoring helped the slower partner to catch up, promoting at the same time collaboration and group work. When the software indicated a wrong answer, the partners did not give up, but continued the discussion to find the right solution. The classroom environment was very relaxing and team spirit promoted effective learning. Both group work and peer tutoring have been recognized as triggering factors that favour effective learning among learners (Tsuei, 2014) and this intervention has confirmed the contribution that technology can bring to these elements of learning.

VIDEO EFFECTIVENESS

The viewing sessions proved to be very effective especially after the whiteboard explanation. Students watched attentively and reacted promptly to the narrator's questions. The possibility to replay the videos or review the slide animations proved to be helpful where concepts were particularly difficult to assimilate. The researcher could pause the video and step in to clarify further and exemplify the concepts. Some comments about the videos include

"The videos are interesting because it's technology"

"They provide step by step procedures"

"Captions and animations make explanations easier"

High and good performers were the greater beneficiaries of the video viewing sessions as they mastered the English language better and demonstrated higher maths skills. Average performers still enjoyed the experience but often struggled to assimilate new concepts given their restricted prior knowledge.

TEACHERS' REACTION

This intervention confirmed the need for a transition in the teacher's role from the sage on the stage to the guide on the side as purported by Domingo and Garganté (2016). Technology-enhanced strategies saved much teaching time, allowing the teacher to care more for the slow learners, while others worked independently. Thus, individual needs were met more efficiently.

It was noted that the female teachers took a greater interest in the intervention and even tried the e-exercises themselves. However, apprehension was there too. One lady teacher was worried about her job – "*There won't be work for us in the future*". This intervention showed that although there was a general positive attitude towards the integration of technology in the teaching and learning process, apprehension and doubts still prevailed as to how would this integration be implemented if teachers were not adequately empowered to use these tools. This mix feeling has been widely reported in numerous research (Uluyol & Sahin, 2016; Gul, 2015; Handal et al., 2011; Hargreaves, 2005). Two teachers even cautioned that the enthusiasm of the intervention may have been associated with the presence of newcomers in the classroom (the researcher and his assistants), and partly with the new tool, and wondered if the same enthusiasm could be maintained in the event the intervention was to be extended for a longer period.

CLASSROOM MANAGEMENT AND DISCIPLINE

During the e-lessons, classroom discipline was much better as the students were always busy watching the videos, listening to slide presentations or still doing the e-exercises. Ghavifekr and Rosdy (2015) reported that teachers agreed that ICT helps to improve classroom management as students are well-behaved and more focused. One teacher commented: "*At least when given classwork, all are interested and get down to work whereas in traditional classes, some would not even start the work*". Figg and Jaipal-Jamani (2011) pointed out the need for teachers to know the specific classroom management techniques for teaching with technology.

RELUCTANCE TO CHANGE

It was not uncommon to find some students holding firm to their traditional practices, still longing for the teacher's whiteboard explanation, with the lesson notes well documented in the explanation copybook, and a record of completed exercises and mistakes highlighted, and all meant for revision purposes before tests and exams. This concept of learning to the test still prevailed in the mind of some students. Moreover, some students saw e-learning more as an optional or supplementary component to traditional learning. In some cases, the reluctance to change was associated with Mathematic learning difficulties, whereby basic arithmetic skills were missing and students struggled with multiplication tables, H.C.F and L.C.M.

Some wished the interface could provide a working space to avoid doing calculations in their exercise books. One student proposed that the whiteboard be maintained for explanation and the tablet for practice. He commented that "*just tablets would not be enough and some might end up only playing*". Another one added, "*I prefer the copybook. I like to go over the pages to see what I have written before. But the tablet is faster for data entry and to verify the answer*".

TECHNO-LEARNING CONCEPTUAL FRAMEWORK

The Techno-Learning Model (TLM) conceptual framework (Figure 2) has been formulated to summarize the implications, prerequisites and outcomes of the intervention. It describes the implementation of the intervention from the students' perspectives and depicts its effectiveness on learning outcomes. While a major component of the instruction comprised the traditional whiteboard explanation and the technology-enhanced lessons, the intervention made provision for students to maximize on learner autonomy and take control of their learning. In fact, learner autonomy was a consistent observed practice during the intervention and according to Chen (2014), it is affected by both intrinsic and extrinsic factors like learning motivation, learning anxiety, learning strategies, learning style and learning environment. From this study, it was observed that learner autonomy was directed by three main contributors namely, motivation, mastery of basic Mathematics skills and the English language. The greater the motivation and the ability to interact with the learning content, the more students enjoyed the experience and benefitted from it. The TLM relied significantly on learner autonomy for a smooth integration and its success.

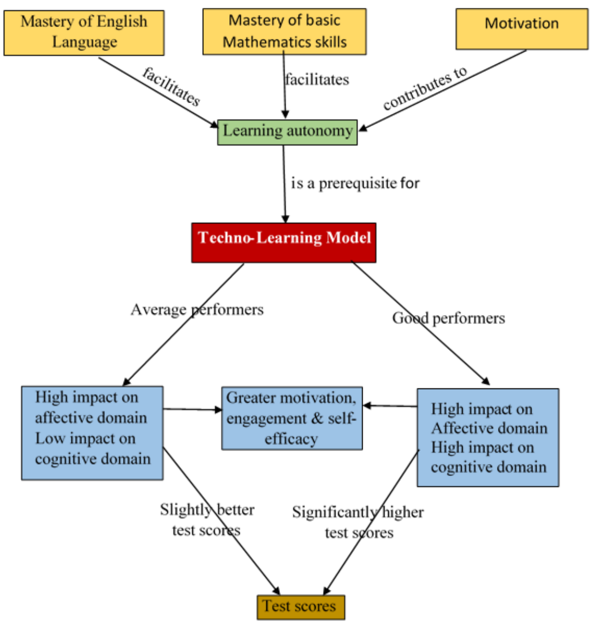

Figure 2 - Techno- Learning Conceptual Framework.

At the grass root level, the intervention created a high impact on the affective domain of learning with greater motivation, sustained engagement and increased self-efficacy for all students, independent of their learning performance. The impact on the cognitive domain differed for average and good achievers with the latter benefitting from the intervention to significantly increase their test scores. The reason is that good performers demonstrated a better level of learner autonomy facilitated by a good mastery of English language and basic arithmetic skills. On one hand, the average students showed difficulties with technical reading skills, trying to grasp concepts, understand instructions properly, and on the other hand they had to struggle with their basic arithmetic skills.

The TLM framework pictures how technology can have a positive impact on Mathematics learning performance. Future research will certainly review the outcomes of this intervention by modifying a few components and adding new ones to the model which with time, will go through many iterations before an accepted one is carved. The TLM has thus laid the foundation on which future works can be modelled.

6. Conclusion

Students who were already doing well in Mathematics, benefitted from technology-enhanced lessons, as they scored significantly higher scores than their counterparts who studied the traditional method. However, this study showed that average students, did not perform any better in terms of test scores as compared to their counterparts who studied the traditional way. We therefore conclude that technology enhanced learning benefitted high and good performers more as they already mastered basic prior knowledge. Data analyses revealed that high and good performers also had good grades in English and were therefore better poised to benefit from this experiment which was mostly English-based. For the average students, the medium of instruction, English, did pose some problems. Many did not understand words like "compare" two fractions or "equivalent fractions".

This study also showed that technology-enhanced lessons were a convenient way to introduce differential learning. Brighter students progressed faster in their learning and tried new exercises and subtopics, while the slower ones took their time to complete the exercises. Some bright students dared to work other exercises for which explanation had not yet been given. The treatment had thus triggered the Mathematics enjoyment that can be vital for boosting learning performance.

For average students, the learning of new concepts is simply additional cognitive overload, when basic Mathematics skills like H.C.F, L.C.M. and multiplication tables have not yet been mastered. Hence, they cannot assimilate the curriculum within the same time period as high achievers and therefore lag behind a bit more with every semester that goes by.

The observations and the interviews showed that there was no gender bias in acceptance and attitude toward the new learning paradigm, in terms of ease of use of the tablet, and the motivation it generated.

When integrating technology in the classroom, it is imperative to determine which learning activities are best facilitated by ICT, as some of them might still be best mediated by traditional means, like introduction of the topic with real life objects, class interaction around the application of mathematical concept, correcting exercises involving drawings or complex workings and identifying simple arithmetic flaws when working out solutions.

Technology must be incrementally integrated to provide a smooth change over from the traditional mode of teaching. Students still have to adapt to the tool as a learning vehicle despite their familiarity with it. This transition can be long, complicated and even painful as both teachers and students struggled to revisit their teaching and learning in a technology-mediated environment. Teachers on their side were not reluctant but hesitant for fear of getting it wrong. Teachers need to be made aware of their changing role and responsibilities in the midst of technology-driven education.

The intervention relegated the use of copybooks, and both teachers and students showed concern for that, especially with regards to proof and documentation of work completed by them and also for revision purposes before exams. Students therefore have to be introduced to innovative ways of revising as they maximize on technological affordances where whole lessons can be previewed again using the videos and the interactive slide presentations. Moreover, e-exercises are always at hand for practice with answers and solutions.

In a nut shell, this study has revealed that technology-enhanced lessons can benefit all students. However, we need to ensure that a second digital divide is not created and this means empowering the less abled with necessary basic skills, so that the learning of new concepts does not become additional cognitive burden. There is definitely much to gain with TEL (Technology enhanced lessons) if the implementation is not haphazard and hasty, but rather properly planned with pedagogical insights as partially provided by the findings of this research.

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