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Graphing Calculator Exposure of Mathematics Learning in a Partially Technology Incorporated Environment

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ABSTRACT

Integrating technology in the mathematics curriculum has become a necessary task for curriculum developers as well as mathematics practitioners across the world and time. In general research studies seeking a better understanding of how best to integrate mathematics analysis tools with mathematics subject matter normally observe mathematics lessons taught exclusively in a technology enriched environment or computer lab. In some universities where paper and pencil examination is the major assessment tool, undergraduate mathematics courses are still taught in a traditional manner that takes care of the algorithmic and procedural steps. This paper relates a study that embarks on the technology exposure claiming that human action is mediated by technological setting. Situated in a traditional classroom setting where there is more teaching and less hands-on, it reports foundation students' acceptance of technology-in-mathematics interaction in a typical course enriched with graphing calculator (GC) deliberated in the worksheets with printed GC commands alongside each question. Data was collected from students' worksheets and also questionnaire that measures attitudes towards technology in mathematics from a class of 763 pre-university students. The results may enlighten mathematics practitioners about the feasibility of taking full advantage of technology to teach mathematics in a partially technology incorporated mathematics course.

Keywords: technology exposure, graphing calculator, technology incorporated environment

INTRODUCTION

There is a plethora of handheld calculator with computer software program for instance and readily available for teaching higher level mathematics. In our study, we focus on a specific technology application, named Ti-84 graphing calculator (GC), because this type of handheld package is the most widely used in university mathematics education. These GC handhelds operate on specific command language and can be executed via the 'mathematics analysis tools' such as computer or other graphics calculator (Pierce, Stacey & Barkatsas, 2007).

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State of the literature

- GC is widely used in distance learning and in higher education, where the number of students in lecture's room is much bigger than in school classroom and assessments require even more resources. GC is also being used for comparative assessment between sex, course taken, school and institution. Still, GC hardly made it into the classroom as a teacher's daily tool. There are several reasons for that (Chalmers & McAusland, 2002):
- Various approaches have been proposed to allow for free text assessment of writings such as the Project Essay Grade or the Intelligent Essay Assessor (Foltz et. al. 2004). A detail description of such approaches can be found for instance, in Whittington and Hunt, 1999.
- In the context of math education, there have been some approaches to adapt the 'fill in the blanks' metaphor to mathematics. An example for such an approach represents (Patel et. al. 1998).
- There are various approaches to utilize GC for math assessment in a Web environment (e.g. Larson et. al., 2007: Texas Instrument Incorporated, 2010). In general, the integration of GC corresponds to the integration of inference techniques in assessment, and typically this is being used to allow specifying possible solutions in a more general and more abstract way.

Contribution of this paper to the literature

- We need a 'theory' of smart assessment in mathematics education, which describes categories of mistakes in general and in special mathematical fields like algebra or geometry. A similar classification is necessary for process skills.
- This theory needs to be extended to the level where processes are divided into discrete steps. This involves, for instance a distinction of stages in the solution process, such as generating solutions, evaluating and selecting the appropriate strategy, planning and then undertaking an activity that solves the problem (Thomas et. al., 2004). For specific solution processes a further split-up to individual solution steps is necessary as in the case of solving linear systems of equations.
- The single problem solving steps have to be related to mechanisms for identifying possible errors. A somehow general approach would be the description of extended solution spaces that could be exploited using automatic theorem proving or unit tests.
- Error classes and patterns have to be identified on this discrete step level. If possible, these error classes should be independent of the specific subject and problems. This implies that we need a meta-description of semantic events. It remains an open question, however whether we can identify problem solving strategies across different subjects.

Notwithstanding, in some universities where paper and pencil examination is the major assessment tool, mathematics is taught traditionally concentrating more on instrumental learning and less hands-on with technology. Due to limited time to complete the course syllabus most lecturers generally will treat the use of mathematics analysis tool as an add-on technology.

TECHNOLOGY EXPOSURE

With an emphasis on student learning process and their achievement, the purpose of this research is to investigate the impact of technology exposure on mathematics achievement. Should graphing calculator (GC) be employed in classrooms to recover student learning process in mathematics traditionally? Common sense expresses instructors technology use in the classroom augments and recovers student learning process. Many researchers define that learning mathematics is a time consuming and difficult subject (Dewdney, 1993; Dehaene, 2011; Resnikoff, H. L., & Wells Jr, R. O., 2015). As a pre-requisite, all pre-university level students have to take even though they think that mathematics is not important and not related to their future career. Thus, some kind of students feels they do not have to work or perform up to their potential. In other case, students are often to refuse and reluctant to participate in the mathematics lesson. Alternatively, with technology, not only to help students understand the lessons, but also make them feel like a part of the lessons even though they are not majoring in mathematics. This is because underperforming students should be categorized, in general as missing or obscuring inspiration to be academically effective. In short, technology will help and offers a variety of possible ways to merge mathematics education (Kaput, 1992; Olive et al., 2010; Goldenberg, 1999).

TECHNOLOGY-ENRICHED MATHEMATICS COURSE

Cretchley's (2007) research into learning in a technology-enriched undergraduate mathematics course, recounted that technology confidence did not associate to score on course tasks nor to technical level or frequency of use of technology but associate discreetly with attitudes mathematics and technology. She also found that societal perception of benefits of technology skills and experience with professional software motivates students to engage heftily in technology task. Similarly, Gomez and Heins (2008) found that technology confidence correlates positively with computer-mathematics interaction, a construct employed by Galbraith and Haines (1998) to study the attitude towards use of technology for learning mathematics. Also, Barkatsas, Kasimatis and Gialamas (2009) found that Year 9 and Year 10 students with high level of mathematics confidence possess optimistic attitude towards mathematics with technology. Interestingly they also found that students with negative attitudes towards mathematics, short in mathematics confidence established confidence in using technology and positive attitude towards mathematics and technology.

ATTITUDE TOWARDS TECHNOLOGY

In a technology enriched environment, students are trained to be resourceful to engage different tools in their learning and doing mathematics. Kor (2005) found that students with positive attitudes towards using mathematical analysis tools (graphics calculator) faced technical difficulty initially due to unfamiliarity with the calculator commands when engaging the tool but overcome the obstacle shortly. Pierce and Stacey (2004) observe that negative attitudes towards technology lead to attempted avoidance of the tool. In addition, Cretchley (2007) noted that beginner undergraduate students in mathematics with low level of computer confidence are particularly vulnerable to the pressure of additional technology load in the enforced use of software.

Meanwhile, the order or sequence of delivering a technology integrated lesson similarly also calls for attention. Chapman (2013) studied the influence of technology skills to learning mathematical concepts experimented that students with a low level of technology understanding and skill benefit from strategy that begins with technology skills followed by learning mathematical concepts. In any case, Gary and Gary (2005) alert that instructional material that imposes too much extraneous load may increase a learner's cognitive load and hence, exceed one's learning capacity. As a result student may fail to progress satisfactory plan for the material and subsequently may not improve an accepting of the course content. Sutherland et al. (2004) pointed out that knowing how to use technology alone is not sufficient to impact learning and teachers will need to creatively exploit readily available software to transform learning in schools.

Seemingly many research on technology integrated mathematics lessons focused on mathematics taught exclusively in a technology enriched environment. Most of the research also employed the strategy of giving the participants a short training session on how to use the tool before the actual lesson with tool engagement. Due to the paucity of pre-university level research outlined above, we designed a study to investigate the exposure of technology use together with the factors that influence its integration into pre-university mathematics achievement.

METHODOLOGY AND PRELIMINARY RESULTS

We decided to implement a national comparative approach in order to comprehend more completely different teaching traditions and subject related conceptions (Norjoharuddeen M.N., 2004; Noraini I., 2004 and Arjunan V., 2009) at the university level. Research is conducted as a following plan:

a) Create an Expose Group (EG) and Control Group (CG) for science based students who are registered or passed their Math 1 and Math 2.
b) Workshops are conducted using a traditional teaching method for CG and new technology method (GC exposure) is given to EG. Students are reviewed on related graphing function topics.
c) All respondents are occupied a Post Test which is included Math 1 and Math 2 topic.
d) Lastly, students are asked to answer a set of questionnaire related to their views and perception on graphing topic before and after using GC.
e) A Post Test answer booklet is compiled thoroughly with questionnaire collected and the answer is checked by experience teachers.

Figure 1. A Correlation framework between technology exposure and mathematics achievement

The hypothesis model explored examines whether the relationships between student's technological exposure (Group) and mathematics score (mathematics achievement with GC-aided) is significant or not (refer to **Figure 1**).

This section of the study indicates the statistical procedures that were used to test the hypothesis. The association between the level of measurement and the appropriateness of data analysis is important to make sure the existence of technical and conceptual interaction. Students are started an instrumental genesis when they try to use a new technology device for the first time. A simple regression test is used to assess whether there is a statistically significant difference between the group performances. Each participant was occupied a specific mathematics course test named Math 1 and Math 2 before entering a workshop and sit for post-test to assess achievement. Is there a statistically significant gain in achievement from control group score to expose group scores?

HYPOTHESIS TEST

H_0: the observed variable fits the normal distribution

H_a: the observed variable does not fit the normal distribution

Initially, dependent variable, mathematics score with GC aided (MSGA) was continuous observed variable. By using a normality test, data distribution of this study is substantially negatively skewed for MSGA (see Appendix A). Based on Shapiro-Wilks[1] statistical test, dependent variable (MSGA) in this study was not normally distributed because of value is not close to 0 and significant value is less than 0.05.

Then, the data is needed to be transformed into a Standardized Zscore by using a transformation method (Tabachnick and Fidell, 2007 and Howell et al, 2009) to assume for normality. A new dependent variable name called Standardized Mathematics Achievement With GC-Aided or SMAWGA (zscore) was introduced for the next analysis.

A simple regression analysis was conducted to investigate how well technology exposure predicts standardized math score with GC-aided. The direction of the correlation was positive (0.834), which means that students who have exposed to graphing calculator tend to have higher math scores and vice versa (see **Figure 2** and **Table 1 & 2**). The results were statistically significant ($F = 1738.618$, $p < 0.05$) and r^2 indicates that approximately 69.6% of the

[1] For tests on samples of n = 3 to 2000 use Shapiro-Wilks; for those of n > 2000 use Kolmogorov-Smirnov

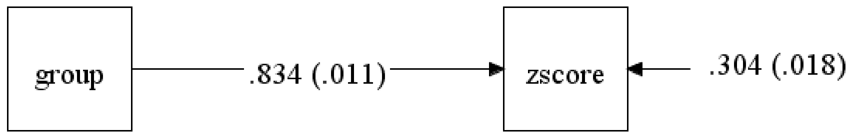

Figure 2. A correlation test result between technology exposure and SMAWGA

Table 1. A simple Regression Test between Technology Exposure and SMAWGA

STDYX Standardization		Estimate	S.E.	Two-Tailed Est./S.E.	P-Value
ZSCORE ON					
	GROUP	0.834	0.011	75.669	0.000
INTERCEPTS					
	ZSCORE	-2.505	0.056	-44.969	0.000
RESIDUAL VARIANCE					
	ZSCORE	0.304	0.018	16.560	0.000
R-SQUARE					
	ZSCORE	0.696	0.018	37.834	0.000

Table 2. ANOVA Test between Technology Exposure and SMAWGA

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	530.011	1	530.011	1738.614	.000[b]
	Residual	231.989	761	.305		
	Total	762.000	762			

a. Dependent Variable: Zscore: Total test mark

b. Predictors: (Constant), Group

variance in SMAWGA (zscore) can be predicted from technology exposure. As a result, technology exposure had a positive relationship towards SMAWGA (O'Dwyer et al, 2005).

CONCLUSION & DISCUSSION

This paper reported an initial exploratory study on technology exposure and mathematics achievement in a pre-university level mathematics course partially integrated with technology. Although it encountered limitation due to small sample size, the findings provide useful insights for preliminary study into effective design of technology-based learning materials for use in mathematics course with limited hours in workshop practice. This paper has made known that in a partially technology enriched environment, under-prepared for technology students need not be burdened with the extra attitude of learning the unfamiliar technology language in doing or learning mathematics. What is more important is they get the hands-on opportunity to experience the power of technology in helping them to solve real-world context mathematics problems where paper and pencil method might fail to do so.

This study has shown that the use of GC improvised math achievement and subsequently promotes positive attitudes towards technology (GC) in doing and learning mathematics. The fact that students were able to complete the problem in worksheet with GC-emulator even though they had not gone through a proper training session on GC was encouraging. Seemingly this paper supports that it is feasible to incorporate technology in learning mathematics using the improvised GC exposure approach for under-prepared students in technology. In other words students in an exam-oriented environment or in institutions where there is a shortage of computer lab, time constraint, lack of resources or infrastructure to receive proper training can still benefit richly from the use of mathematics analysis tools (graphics calculator) complemented with proper design of instructional materials.

It is hoped that this study could be expanded to a larger population in the future to afford a generalized results in the quantitative study. Prospective researchers may consider measuring the attitude towards technology quantitatively. Qualitative data from interviews and students' work are needed to justify the results of the study. Typically, technology is here to enliven and to facilitate the learning of mathematics. We believe that there are ways in which we can incorporate technology in mathematics effectively that neither harm the learners by overloading their learning capacities nor offset the conventional institutional culture. We definitely need a more in-depth study using bigger sample and employing a variety of mathematics analysis tools to fortify the result of this preliminary study.

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DECLARATION OF CONFLICTING INTERESTS

We confirm that there is no conflict of interest with any financial organization concerning the material discussed in the manuscript.

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STATEMENT OF ETHICAL GUIDELINE

The research participants are able to resolve on the questionnaire if they wish to be recognized or remain anonymous in the research. As quantitative research, it should be assumed that all participants wish to be anonymous, or that there are any benefits to the participants for remaining anonymous. Clearly, the students that agree to participate in this study will be anonymous and their identities will be private.

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APPENDICES

Appendix A

The result of Normality Test for Selected Variables

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
SMAWGA	.143	763	.000	.938	763	.000

a. Lilliefors Significance Correction