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Information Technology Capabilities for Mathematics Education in High School: Conceptual Framework

Sivapoorani Krishnasamy, Lew Sook Ling and Tan Choo Kim
Faculty of Information Science and Technology, Multimedia University, 75450 Melaka, Malaysia

Abstract: Mathematics is considered as prerequisite knowledge in all areas. It is an essential subject for all levels of institutions. In spite of mathematics plays an important part in all aspects of our everyday life, degradation of mathematics performance has been reported among Malaysian students. The use of Information Technology (IT) tools is omnipresent for the reason of its capability. Undoubtedly, IT Capabilities (ITCs) facilitate teaching and learning mathematics. However, there were lacking of ITCs such as IT skills, IT resources and confidence to apply IT tools to integrate teaching and learning mathematics. Difficulties were faced by teachers and students to obtain ITCs. Therefore, the main objective of this study is to design an appropriate ITC framework for improving the performance of mathematics. From the findings, IT tools enable ITCs; ITCs contribute better learning experiences better learning experiences lead to improved mathematics performance. The following sections of this paper will initially discuss the status of mathematics performance among Malaysian students internationally. Subsequently, we present a summary of existing IT tools and finally propose an ITC framework for improving teaching and learning Mathematics.

Key words: Information Technology (IT), IT Capability (ITC), performance of mathematics, technology integration in teaching and learning, Malaysia

INTRODUCTION

Research background: The important role of mathematics grows in all areas such as analytical, science, engineering research development, finance medicine and computing science. Basic arithmetic and estimation is very important in education even in our daily life. For example, using algebra to study the symmetry in chemistry and calculus for molecular structure. Furthermore, mathematics also provide ability to interpret (logical reasoning) analyse information, simplify and solve problem (Laure, 2008; Nagasaki, 2015).

However, recently the performance of Malaysian students in Mathematics was degraded. This problem should be concerned and make a sense of urgency to improve the performance of students in Mathematics across our nation.

Statements of problems: The poor performance of Malaysian students was reported in Programme for International Student Assessment (PISA). PISA was started on 2000 by Organisation for Economic Co operation and Development (OECD). By using assessment, it evaluates international education systems by three major aspects, reading, mathematics and science. Malaysia participated PISA for the first time in 2010 and scored below average for all the participations: 55th among 74 countries with the average of 404 marks in 2010 and 52nd among 65 countries with the average of 421 marks (Amnah and Peters, 2015).

Furthermore, mathematics knowledge and skills among Malaysian students were degraded remarkably from “above average” to “below average” in Trends In International Mathematics and Science Study (TIMSS). TIMSS was established by International Association for the Evaluation of Educational Achievement (IEA) to evaluate the assessment of Mathematics and Science among standard 4 and form 2 students. Malaysia participated TIMSS for the first time in 1999 and scored “above average” (519 marks) (Amnah and Peters, 2015). However, However, the performance has been degraded to “average” (474 marks) in 2007 and subsequently, the performance was further degraded to “below average” (440 marks) in 2011 (Amnah and Peters, 2015).

Previous studies (Bingimlas, 2009; Filiz, 2013) showed lacking of integration of Information Technology (IT) in teaching although IT has been supported contributing positive impacts in education (Moeller and Reitzes, 2011; Tan *et al*., 2015; Varol, 2013). The major obstacles of integrating IT in education by teachers were the lacking

Corresponding Author: Sivapoorani Krishnasamy, Faculty of Information Science and Technology, Multimedia University, 75450 Melaka, Malaysia

of IT capabilities for teaching and learning such as lacking of IT skills, lacking of access to IT resources and lacking of confidence to utilise IT tools (Bingimlas, 2009; Ertmer and Ottenbreit-Leftwich, 2010). Furthermore, the teachers who were lacking of IT training in solving technical problems of IT tools reduced their confident level to integrate IT in teaching (Filiz, 2013). Furthermore, the teachers who were lacking of IT training in solving technical problems of IT tools reduced confident level of teachers to integrate IT in teaching (Filiz, 2013; Tan *et al*., 2015). The less confident teachers became anxious when they consider themselves were not skillful in utilising or integrating IT at classroom. These low level of confidence caused poor learning experiences among students (Bingimlas, 2009) in which good learning experiences can contribute to the improvement of academic performance (Shapley *et al*., 2010).

Objectives of study: The overall goal of this study is to determine the impact of Information Technology Capabilities (ITCs) on teaching and learning mathematics. Specifically, this objectives of this are to:

- Identify the common IT tools integrated in teaching and learning mathematics
- Determine the relationships between IT tools, IT Capabilities (ITCs) learning experiences and performance of teaching and learning mathematics
- Design an appropriate ITC framework in mathematics education of the current high school system

Significance of study: This study was mooted out from the poor performance of Malaysian students in Programmes such as PISA and TIMSS for international students.

The developed framework is aimed to improve the mathematics performance in Malaysian high school. This aim is in line with the aspiration of Malaysia Education Blueprint 2013-2015, particularly the Education National Key Results Areas (NKRA) in which is to improve student outcomes across Malaysia's school system and to enable access to quality education for all students.

The teaching and learning difficult mathematics lessons can be conducted effectively with the developed IT application that incorporated all the IT capabilities from the developed framework. While mathematics being a fundamental knowledge for all disciplines, improving student outcomes in mathematics could develop a more competitive workforce as Malaysia pushes towards becoming a developed nation by 2020.

Furthermore, using the developed IT application particularly in low performing schools can improve the mathematics performance in overall. This expected outcome is tied in closely with NKRA's aim which can reduce the number of Band 6 and 7 schools by 20% and increase the number of Band 1 and 2 schools by 8% in the course of the GTP.

Literature review: There are pervasive usage of Information Technology (IT) tools such as personal computer, internet (Web) mobile application, digital assistant, big data and cloud computing nowadays (Edutopia, 2007; Heather, 2006). These IT tools are growing continuously and new technologies are still on developing stages. This widely growing IT tools have changed education in a new teaching and learning environment compared to traditional classroom setting. Recent study has proven IT tools played essential portion in education system. IT tools enable IT Capabilities (ITCs) and the latter is a vital way in education. ITCs have changed the way of teaching and learning. Therefore, IT tools are mostly welcomed for its ITCs in teaching and learning mathematics.

MATERIALS AND METHODS

Past prominent studies were explored and reviewed using systematic literature review (Wen *et al*., 2012). A keyword index search of "information technology capability", "factors of poor performance in Mathematics", "technology integration in teaching and learning", "e-Learning", "performance of mathematics by integrating information technology capabilities" was conducted in online ProQuest central online database of Siti Hasmah Digital Library, Multimedia University on October 2015. There were 232,646 studies found. Among the studies, only 210 articles were related to the keyword with education and 52 articles have been filtered according to the scope of title. A google search was then conducted as a second method. The 26 articles were found closely related to the scope of this study. Research questions were identified as:

- What are the common IT tools integrated in teaching and learning mathematics
- Are there any significant relationships between IT tools, IT capabilities, learning experiences and performance of teaching and learning mathematics

Pilot study: Based on the review of literatures, a research questionnaire will be developed as instrument to answer the research questions. The 20 high school students and 5 of their mathematics teacher will be pilot tested using the developed questionnaire. This pilot survey aims to

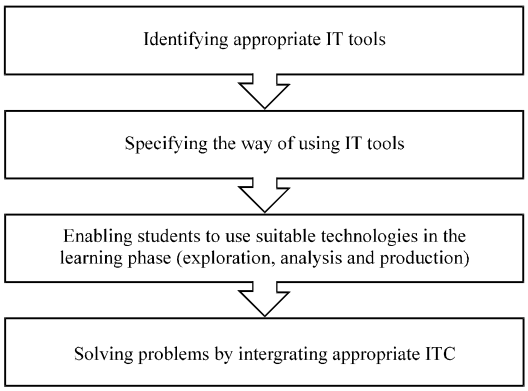

Fig. 1: Effective ITC integration (developed for this study)

ensure the face validity and reliability of the developed questionnaire. Assessment and analysis will be done on the suggestions and comments from this pilot study. Questionnaire will be amended based on the relevant suggestions and comments. The amended questionnaire will then be further reviewed by 5 information system and mathematics experts. These experts will be senior lecturers in academic institutions.

Actual survey: Focus group study will be conducted to identify key Information Technology Capabilities (ITCs) that influence mathematics performances of high school students, followed by a questionnaire survey of 250 teachers and 250 students to determine the relationship between ITCs (independent variable) and mathematics performance (dependent variable).

Based on this actual survey results, mathematics lessons will be delivered to 2 different groups of students "with" and "without" the IT application. Mathematics performances of both groups of students will be compared to verify the effectiveness of the proposed ITC framework and IT application in improving student's mathematics performances in high schools.

Data analysis techniques: While previous studies were explored and reviewed using systematic literature review (Wen *et al*., 2012) to design the research framework, multiple data analytical techniques including factor analysis, multiple linear regression, t-test, Analysis of Variance (ANOVA) and Bonferoni post hoc test for the collected primary data through survey questionnaire. The descriptive analysis will enable understanding of respondent's feedback using frequency, mean and standard deviation. In order to develop reliability and validity measurement for the variables, factor analysis will be carried out before subjecting the data to inferential analysis. Multiple linear regression will then be used to examine the relationship between independent and dependent variables. T-test and ANOVA will be used to understand the level of significant difference between variables especially the demographics, types of IT tools and its capabilities and the key constructs (Fig. 1).

RESULTS AND DISCUSSION

It tools in education: Before focusing on the effective IT tools for mathematics, a set of clear definitions of IT tools is essential. This study has identified eight types of common IT tools that integrated in education. The types of IT tools are defined in Table 1.

IT tools, IT Capabilities (ITCS), learning experiences and performance: Filiz (2013)'s framework was found effective in teaching and learning mathematics. It consists of four stages comprising identifying, specifying, enabling and solving problems using IT tools. With this notation, this study mimics Filiz (2013)'s framework and proposed a new ITC framework by incorporating ITC in the fourth stage for improving learning experiences and performance of teaching and learning mathematics; details as illustrated in Fig. 1. This ITC is a pre-condition and will be implemented as the very first step prior to Fig. 2.

Students can be more connected and scholastically successful when they use technology compared to traditional way in the classroom environment especially in some topics such as trigonometry and transformations (Nordstrom, 2013; Katherine *et al*., 2013). Hence, the following hypothesis:

- H_1: the higher the integration of IT in teaching mathematics, the better the student's performance of mathematics can be achieved

IT can improve student's proficiency by having better learning experiences. Shapley *et al*. (2010) pointed out the changes in students learning experiences can contribute to the improvement of academic performance. Specifically, learning experience of students is improved with the integration of IT.

Lacking of essential knowledge and skills was the main reason for the poor performance in mathematics. Essentially, this basic knowledge and skills had a significant portion for learning and understandings. However, most of the students did not have the exact idea on the essential theory of mathematics (Eng *et al*., 2010). Besides that, lacking of learning support, student's attitude and teaching experience also causes of poor performance. Students show less interest in mathematics when their confident level are too low (Eng *et al*., 2010;

Table 1: Integration of common information technology tools in education

IT tools	Definitions	Sources
Information technology (IT) tools	IT tools enable effective teaching and learning. Google Earth is an example of IT tool that enables students to have effective learning of geological processes. Virtual whiteboard of Live Binders enables teaching and learning geometry, algebra, graphing and etc	LiveBinders (2016)
Online learning and blended classrooms	Combination of both online and face-to-face teaching and learning.	Moeller and Reitzes (2011), Edutopia (2007)
Projects integrated with technology	Projects infused with technology such as power point slideshow, cloud, videos and etc	Edutopia (2007) and Nordstrom (2013)
Handheld devices for learning	Handheld devices such as mobile phones, tablets, iPad and etc	Moeller and Reitzes (2011) and Edutopia (2007)
Game-based learning	Integrating simulations and game-based learning activities into assessment of teaching	Moeller and Reitzes (2011), Edutopia (2007)
Interactive whiteboard	Using interactive whiteboard for multimedia presentation such as power point, videos and internet searching	Edutopia (2007) and Nordstrom (2013)
Web-based projects	Using online technology to conduct the project	Moeller and Reitzes (2011), Edutopia (2007)
Student-created Media	Media is created by students such aspodcast, videos, slideshow and etc	Edutopia (2007) and Nordstrom (2013)

Table 2: Summary of variables

Items	Variables	Sources
Independent (Information Technology Capabilities (ITCs))		
IV1	IV1: IT skills	Bingimlas (2009), Ertmer and Ottenbreit-Leftwich (2010)
	IV2: IT resources	(Bingimlas, 2009; Ertmer and Ottenbreit-Leftwich, 2010)
	IV3: Confidence level	
Learning experiences		
IV2	IV4: Attitude	Tang *et al.* (2015), Thembinkosi and Alfred (2012)
	IV5: Essential theory of mathematics	Bingimlas (2009), Ertmer and Ottenbreit-Leftwich (2010)
	IV6: Knowledge of technology	Varol (2013)
Dependent		
DV	DV1: Mathematics performance	Moeller and Reitzes (2011), Tan *et al.* (2015) and Varol (2013)

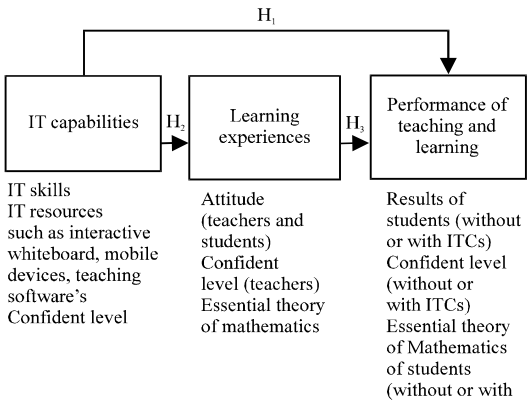

Fig. 2: Proposed research framework (developed for this study); H_1: the higher the integration of IT in teaching mathematics, the better the student's performance of mathematics can be achieved; H_2: the higher the integration of IT in teaching mathematics, the better the learning experiences of students; H_3: the better the learning experiences of students, the better the student's performance of mathematics can be achieved

Thembinkosi and Alfred, 2012). In addition, for effective technology integration, teachers should have a knowledge of technology and the way of handling (Ertmer and Ottenbreit-Leftwich, 2010). Hence, the following two hypotheses:

- H_2: the higher the integration of IT in teaching mathematics, the better the learning experiences of students
- H_3: the better the learning experiences of students, the better the student's performance of mathematics can be achieved

Information technology capability framework: Table 2 summarises the variables and sources. Based on previous studies (Filiz, 2013; Moeller and Reitzes, 2011; Edutopia, 2007; Nordstrom, 2013) IT tools enable IT Capabilities (ITCs). Therefore, this study was first to determine a set of effective IT tools before focusing on the relationships of the key constructs. As shown in Table 1, seven types of IT tools online learning and blended classrooms projects integrated with technology, handheld devices for learning, game-based learning, interactive whiteboard, web-based projects and student-created media. These findings were supported by Moeller and Reitzes (2011), Edutopia (2007) and Nordstrom (2013). Subsequently, ITCs were achieved by a flow of four stages that comprising identifying, specifying, enabling and solving problems using IT tools in mathematics education (Fig. 1) (Filiz, 2013).

The relationships between IT tools, ITCs, learning experiences and performance of teaching and learning mathematics were then determined as IT tools enable ITCs (Filiz, 2013; Moeller and Reitzes, 2011; Edutopia, 2007; Nordstrom, 2013). ITCs contribute better learning experiences (Bingimlas, 2009; Shapley *et al*., 2010) and better learning experiences lead to improved mathematics

performance (Eng *et al*., 2016; Thembinkosi and Alfred, 2012). Finally, this study proposed a research framework that comprises three levels and three hypotheses as illustrated in Fig. 2.

CONCLUSION

Knowledge of technology is one of the essential skills of integrating IT in teaching and learning. Yet, effective teaching with technology could not be achieved currently. Hence, appropriate IT tools were to be determined for effective teaching (Ertmer and Ottenbreit-Leftwich, 2010). The success is to be determined by an effective learning model (Katherine *et al*., 2013). It is hoped that the proposed framework will be effective in teaching and learning mathematics. Next, the proposed framework will be tested and confirmed empirically among teachers and students of high school in Malaysia.

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