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Effects of the handheld technology instructional approach on performances of students of different achievement levels

Choo-Kim Tan*, Choo-Peng Tan

Faculty of Information Science and Technology, Multimedia University, Jalan Ayer Keroh Lama, 75450 Bukit Beruang, Melaka, Malaysia

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ABSTRACT

The handheld technology selected and the ways it is implemented influences the way mathematics is taught and learnt, which in turn generates positive effects in the mathematics education. This study was conducted to examine the effects of handheld technology instructional approaches on performance of students of different achievement levels in Probability at a private higher learning institution in Malaysia. A quasi-experimental study with non-equivalent control group design with pre-test and post-test design was conducted on a sample of 65 students. The sample was divided into the experimental group and control group. The handheld technology instructional approaches, i.e. teaching and learning approaches using the graphing calculator (GC) as a teaching and learning tool and the GC instructional worksheets, were employed in the teaching and learning of probability in the experimental group. The conventional teaching approach was adopted in the control group. Quantitative and qualitative methods were employed to collect and analyse data. Quantitative data was collected using the Probability Achievement Test (PAT). PAT was administered to both groups at the beginning and end of the study. Qualitative data was collected using students' journals. The results show that students, the high, average and low achievers, gained benefits when the handheld technology instructional approaches were used in learning Probability, particularly random variable, poisson distribution, binomial distribution and normal distribution.

1. Introduction

Previous research found that technologies make mathematics richer and more experimental as students study new content of mathematics and pay greater attention to processes that are not feasible without technologies (Lee, 2004). Such technologies include the handheld technology, such as the graphing calculator (GC). Many research recommended and encouraged the integration and adoption of the handheld technologies into mathematics curriculum as the research produced positive results. The obvious evidence was the improvement in students' performance in topics such as algebra, statistics, geometry, trigonometry and calculus (Arnold, 2008; Horton, Storm, & Leonard, 2004; Nor'ain, Rohani, Wan Zah, & Mohd. Majid, 2011; Thompson & Senk, 2001; Waits & Demana, 1999b). However, there is apparently a lack of research, particularly in developing country such as Malaysia, which focuses on the effects of GC in Probability curriculum at the higher education institutions as there is limited adoption of the GC into the Malaysian curriculum and classrooms (Muhd Khairiltitov, 2003), i.e. the GC is a new instructional technology in Malaysia and its adoption in the Malaysian Mathematics education is still at the initial stages (Nor'ain et al., 2011). Moreover, studies on its effects on students' Probability performance among students of different achievement levels, particularly in the topics of random variable (RV), poisson distribution (PD), binomial distribution (BD) and normal distribution (ND), were found limited.

This research was thus conducted with the main objective to study the effects of the adoption of the handheld technology instructional approaches on students' Probability achievement in the topics of RV, PD, BD and ND among the high achievers (HA), average achievers (AA) and low achievers (LA). More specifically, the three research questions that guided this study are:

* Tel.: +60 6 2523427; fax: +60 6 2318840.
E-mail address: cktan@mmu.edu.my (C.-K. Tan).

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(1) Are there significant differences in the students' achievement in a) RV, b) PD, c) BD and d) ND between the HA in the experimental group (EG) and control group (CG) of the higher learning institution?
(2) Are there significant differences in the students' achievement in a) RV, b) PD, c) BD and d) ND between the AA in the EG and CG of the higher learning institution?
(3) Are there significant differences in the students' achievement in a) RV, b) PD, c) BD and d) ND between the LA in the EG and CG of the higher learning institution?

2. Literature review

2.1. Mathematics achievement

One of the challenges faced by mathematics educators around the world is to improve students' performance in mathematics. The reason behind is students could not achieved better performance in mathematics. Malaysian mathematics educators too could not be escaped from facing the same challenge. For instance, in Malaysia, mathematics performance is regarded as weak, despite various efforts employed by the Ministry of Education to improve mathematics education (Noraini, 2006a). TIMSS 2011 (TIMSS 2011 International Results in Mathematics, 2013) showed Malaysia's ranking in mathematics fell from 20th in 2007 to 26th in 2011 with the decrease of the average score from 474 in 2007 to 440 in 2011.

In Probability learning, it was found that Probability is perceived as an abstract field where most students may not be able to imagine the situations described in the problems. If students do not understand probability concepts well, they may face difficulties in interpreting the problems in probability. The probabilistic reasoning in Malaysia schools, as stated by Munisamy and Doraisamy (1998), is found to be a difficult skill to acquire by most students. Many students feel that probability learning is difficult (Honeycutt & Pierce, 2007; Kissane, 1997), and they tend to focus on the use of an algebra of probabilities, without being insightful, and with many misconceptions (Kissane, 1997). Misconceptions in mathematics and probability may result in mistakes made in calculations.

2.2. Outcomes of incorporation of handheld technology

The handheld technology was proved as a multidimensional tool such as graphing tool, visualization tool, exploratory tool, confirmatory tool, problem-solving tool and calculation tool in supporting students' learning (Ng, 2011). It was evident from previous studies that incorporating the GC into mathematics lessons (Ha, 2008; Noraini, 2006b; Serhan, 2006; Tan, 2012) helped students develop better understanding of mathematical concepts and hence improved mathematics performance. The reasons students showed improvement in mathematics achievement is the use of the GC helped them to use more sophisticated strategies to solve complicated problems (Brooks-Young, 2009) which enhanced their problem solving strategies and skills.

Schwarz and Hershkowitz (1999) noted that the use of the GC in an investigation-based approach improved students' knowledge of functions when appropriate use of model examples was promoted, which also led students to include more important ideas in justifying the answers. Students found that the use of the GC helped them to save the computational time and the "trouble" of memorizing mathematics and statistics formulae, removed the tedium of certain mathematical tasks and manipulative procedures as well as provided accurate answers in a shorter period of time (Daire, 2010; Tan, Madhubala, & Lau, 2011; Waits & Demana, 1999a).

The handheld technology enabled students to explore mathematics particularly calculus through the link of graphical, numerical and algebraic representations (Ng, 2011). Through the connection of these multiple representations, students were able to solve those mathematics equations that cannot be solved using normal algebraic methods or normal calculator easily (Sundram, 2008) as well as they were able to have better visualization in mathematics concepts and generalizations about mathematics properties (Ng, 2011), and hence increase their conceptual understanding, problem-solving skills (Ng, 2011) and thinking skills (Sundram, 2008).

Students' abilities in decision making, interpreting and concluding the results were also improved when the handheld technologies approaches were adopted in classrooms. Students need to decide on the information or data to be entered and the functions or operation to be used. Finally, they must interpret the answers and results and make conclusion (Nor'ain et al., 2011). Consequently, these skills make students gain better mathematics understanding and thus showed improved performance in mathematics.

Research conducted on particular groups of students also provided evidence that the handheld technology approaches yielded positive outcomes. Bouck (2009) highlights in his study that although students without disabilities achieved better results in the post-test, students with disabilities, those who are health impairment and emotional impairment, had also made gains from the pre-test to post-test. In addition, there was statistically significant difference in the average between the pre- and post-test in the achievements of the different ability groups and within each of the high, average and low ability groups (Acelajado, 2004a, 2004b). The higher achievements among the low ability students in the pre-calculus curriculum were reported in Harskamp, Suhre, and Van Streun (2000) as well as in Van Streun, Harskamp and Suhre's (2000) studies, which could be linked to an increased use of the graphical solution strategies.

Other positive effects of adopting the handheld technology approaches in mathematics classrooms are it fostered positive attitude among students, better interaction among themselves as well as between them and their teachers. With this approach, students had more opportunities to actively communicate, discuss and involve in classrooms (Ng, 2011; Nik Rafidah, Zarita, & Safian, 2008; Noraini, 2004; Tan et al., 2011; Waits & Demana, 1998a). They found that learning is fun and interesting (Tan et al., 2011).

3. Pedagogical design on GC instructional approach

This section discusses the pedagogical design on GCs instructional approach which based on the educational theory of mediated tools and scaffolding as well as the 'balance approach'.