Abstract: In Singapore, the revised junior college mathematics curriculum implemented in 2006 has specifically identified the graphic calculator as an important tool in the teaching and learning of advanced level mathematics topics (MOE, 2004). The study described here, which is part of my PhD thesis, investigates teacher change, in a time of transition from a classroom without graphic calculator use, to teaching in a classroom where graphic calculator has the potential to be an integral part of students’ learning of mathematics. This study carried out in 2006 specifically seeks to describe how the concerns of teachers, the teaching strategies of teachers and the roles of teachers change when they integrate graphic calculator into the junior college mathematics curriculum. The study also aims to identify important features among teachers who are successful in integrating graphic calculator into the curriculum. This study is anticipated to complete by end 2006. The contributions from this study will be discussed in anticipation to theme B on teachers and teaching.

Introduction

The graphic calculator is a powerful handheld device that is becoming increasingly affordable and accessible to students and teachers in the classroom. The capabilities of the graphic calculator include drawing of graphs and the execution of numerical, matrix and statistical calculations. There is a large amount of research supporting the use of calculators in teaching and learning of mathematics (Dunham & Dick, 1994; Heid, 1997; Husna, Munawir & Suraiya, 2005; Penglase & Arnold, 1996). The graphic calculator reduces the drudgery of applying arithmetic and algebraic procedures when these procedures are not the focus of the lesson. Students are free to spend more time on problem solving. The graphic calculator also makes it possible for students to visualize data in more than one way. With graphing calculators, students can switch between graphical and numerical representation of data (Waits & Demana, 2000).

The graphic calculator has brought about changes in the curriculum, the assessment mode and the way teachers teach mathematics in various parts of the world. In Singapore, with the revised mathematics curriculum in 2006, graphic calculator will form an integral part of the teaching and learning process in schools. The use of graphic calculators will be expected for all three Advanced
Level mathematics papers (H1, H2 and H3\(^1\)) offered at junior colleges (MOE, 2004). This provides a rare opportunity to investigate teacher change in a time of transition.

**Rationale and Purpose of the Study**

Since the 1980’s, many countries have realized the potential of graphic calculators and have integrated or have made recommendations for its integration into the mathematics curriculum. The availability of graphic calculators has resulted in the teaching of mathematics to be reexamined at both the secondary and collegiate levels (Dunham & Dick, 1994). The National Council of Teachers of Mathematics (NCTM) has long advocated the use of calculators at all levels of mathematics instruction, and graphic calculators are no exception (NCTM, 1989, 2000). In 1989, in the *Curriculum and Evaluation Standards for School Mathematics*, the National Council for Teachers of Mathematics (NCTM) made the following recommendations: “Scientific calculators with graphing capabilities will be available to all students at all times” (p.124). NCTM’s most recent standards document, *Principles and Standards for School Mathematics* (2000), placed greater emphasis on the implementation of technology in the teaching and learning of mathematics by making technology one of its main principles. This principle states: "Technology is essential in teaching and learning mathematics; it influences the mathematics that is taught and enhances students' learning" (NCTM, 2000, p. 24).

At present, there is much research being done on graphic calculator usage (Kor, 2004; Noraini, 2005). The majority of research on graphic calculators seems to fall into two categories; namely, student performance, and attitudes and beliefs. Most research studies on graphic calculators involve the investigation of the teaching of a certain mathematics topics using graphic calculator and report on its impact on student performance and understanding of concepts (Burrill, 2002). Authors of various reports have concluded that benefits in student achievement can be derived from appropriate graphic calculator use (Heid, 1997; Husna, Munawir & Suraiya, 2005). The other category of research investigates how teacher attitude, belief and conception of mathematics affect the use of graphic calculator in the classroom (Jost, 1992; Simmt, 1997; Tharp, Fitzsimmons & Ayers, 1997). So far, there is no study done to investigate how the concerns of teachers change as they integrate graphic calculator into mathematics curriculum at secondary or tertiary school levels. The revised mathematics curriculum in 2006 provides a rare opportunity for me to investigate teacher change.

\(^1\) H1 level: Half of H2 in breadth but similar to H2 in depth; H2 level: Equivalent to current ‘A’ level subjects; and H3 level: Allows for a greater range of learning and research options. Must offer subject at H2 level.
There is limited research on teaching strategies employed by teachers when they integrate graphic calculator into mathematics curriculum (Barton, 1995; Fox, 1997). The relationship between teachers’ knowledge and pedagogical strategies and their use of graphic calculator is largely unexamined (Doerr & Zangor, 2000). However, a recent study was conducted by Ball and Stacey (2005) to describe the teaching strategies that teachers can use to produce students who are judicious users of technology. The four teaching strategies mentioned are (a) to promote careful decision making and technology use, (b) to integrate technology into curriculum, (c) to tactically restrict the use of technology for a limited time, and (d) to promote habits of using algebraic insight for overview and monitoring. This study aims to describe and analyze how the teaching strategies of teachers change when they integrate graphic calculators into junior college mathematics curriculum.

There are a few studies which investigate the role of teachers teaching with graphic calculator in the classroom (Barton, 1995; Doerr & Zangor, 2000; Farrell, 1996; Simmt, 1997). Doerr and Zangor (2000) conducted a qualitative classroom-based research study on role, knowledge and beliefs of a precalculus teacher. Five patterns and modes of graphic calculator tool use were identified, supported by rich field notes. The results of the study suggested that nature of the mathematical task and the role, knowledge and belief of the teacher influenced the emergence of rich usage of the graphic calculator. The descriptions of various modes of graphic calculator use seem to illuminate certain roles of teachers like being an explainer and interpreter of results. Thus, this study aims to investigate how such roles of teachers change when they integrate graphic calculator into mathematics curriculum in junior colleges.

There is limited research on the factors that impact the integration of graphic calculator into the mathematics curriculum (Arvanis, 2003; Bynum, 2002). Arvanis (2003) investigated the extent Illinois high school Algebra I teachers used graphic calculators and what factors impacted this use. Algebra I teachers reported that the factors that most influenced their use were personal beliefs, ‘offers something different to do’, workshops and other teachers. The factors that limited their use of graphic calculators were emphasis on basics, cost, availability, not enough time, lack of training, and lack of materials. This study aims to further investigate factors that impact the successful integration of graphic calculator into the junior college mathematics curriculum.

Research questions

The purpose of this study is to pursue answers to the following research questions:
1. How do the concerns of teachers change when they integrate graphic calculator into the junior college mathematics curriculum?

2. How do teaching strategies of teachers change when they integrate graphic calculator into the junior college mathematics curriculum?

3. How do the roles of teachers change when they integrate graphic calculator into the junior college mathematics curriculum?

4. What features seem common among teachers who are successful in integrating graphic calculator into the junior college mathematics curriculum?

**Significance of the study**

This study aims to contribute findings and knowledge of change in teacher concerns, teaching strategies and teacher roles when they integrate graphic calculator in the junior college mathematics curriculum. From this research, the changes in teaching strategies and changes in roles of teachers identified will serve to inform the wider community of mathematics educators resulting in improved pedagogy and practice in the mathematics classrooms. Knowledge of teaching strategies and teacher roles can also be used as a base for meaningful pre-service and in-service programmes. Another significant contribution will be the development of a framework which describes factors identified from findings in the Singapore context that results in the successful integration of graphic calculator into junior college mathematics curriculum. The success factors identified will serve to inform policy makers what factors demand greater attention at various stages of implementation of new technology in mathematics curriculum.

**Research Methodology**

The methodology used is case-study approach. Following Merriam’s (1997) suggestions for case study research, data will be collected by means of classroom observations, interviews and document analysis.

**Subjects**

A formal letter will be drafted and sent to principals of junior colleges to request for mathematics teachers who would like to participate in this study. The mathematics teachers have to teach the revised syllabus mathematics (H1, H2) in 2006. A total of 9 subjects from 3 junior colleges agreed to participate in the study.

**Instrumentation**

Every subject in this study will be visited by me once a school term for three terms. Every school term consists of 10 weeks of study. The duration of study is from January 2006 to September 2006. During each visit, the sequence of events
will be lesson observation, administering Teacher Concern on Graphic Calculator Use (TCGCU) questionnaire and interview. Data collection will involve the following aspects: lesson observations, teacher self-reflection of other lessons, a Teacher Concern on Graphic Calculator Use (TCGCU) questionnaire and interviews.

A significant part of the data collection is by means of classroom lesson observations. Only lessons that involve teachers using graphic calculators as part of their instructional strategy will be observed. Every lesson observation will be audio-taped. Detailed field notes about how each lesson is conducted will also be made. The times at which activities change and the times at which significant classroom events occur will be noted in the lesson observation checklist. After checking the audiotape, a comprehensive set of observations about the lesson will be made, describing up to 20 characteristics of the lesson. Characteristics that are monitored include lesson preparation, lesson proper, teaching strategies, classroom management and technical issues. The teacher interactions with individual students and the whole class will be recorded. The teachers’ use and students’ use of graphic calculator will also be recorded. Thus the teaching strategies and roles of teachers are carefully monitored through examination of the types of instructional activities planned, their questioning techniques and how teachers explain concepts.

Based on three sources, a Teacher Concern on Graphic Calculator Use (TCGCU) questionnaire will be constructed: concerns of teachers found in the pilot study, concerns identified from relevant literature research and concerns found in Stages of Concern Questionnaire by Hall and Hord (2001). Care will be taken to attempt to fit concerns into seven different stages proposed by Hall and Hord. The seven stages are: Awareness, Informational, Personal, Management, Consequence, Collaboration and Refocusing. In each stage, the items which are statements of concern typical of that stage are obtained by adapting items from Stages of Concern questionnaire and writing as appropriate some new items to suit the local context. The Teacher Concern on Graphic Calculator Use (TCGCU) questionnaire will have a total of 35 statements of concern.

A preliminary version of the interview protocol has been developed based on review of selected literature (Simonsen & Dick, 1997). This interview protocol will be piloted by three mathematics teachers who have experience in teaching mathematics with graphic calculators and appropriate changes will be made. The final format of the interview protocol will be derived after additional input from two authorities in mathematics education research. The interview protocol contains primarily open-ended questions grouped into four areas comprising: (a) teacher concerns, (b) teaching strategies, (c) teacher roles, (d) success factors. Specifically, teachers in the interview will be asked twelve questions. Some of the questions are adopted from Simonsen and Dick (1997). For example, under teaching strategies,
the teacher will be interviewed on how the presence of graphic calculator has helped them teach the mathematics topic differently to illuminate students’ learning of mathematics. The teachers will also be interviewed if there are any specific functions in the graphic calculator that deliberately made them enthusiastic about their teaching.

Conclusion

This study carried out in 2006 specifically seeks to describe how the concerns of teachers, the teaching strategies of teachers and the roles of teachers change when they integrate graphic calculator into the junior college mathematics curriculum. The data collection is anticipated to complete by end 2006. The findings from this study will be discussed in anticipation to theme B on teachers and teaching. Being offered an opportunity to participate in the discussion will definitely be beneficial and enriching to me as a new researcher and as a PhD student.

References


