ICT USE TO IMPROVE MATHEMATICS LEARNING IN SECONDARY SCHOOLS

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Abstract

Today’s students are expected to learn about and use digital-technology in mathematics to prepare them for their future, the work force and the challenges of everyday life. However, international studies show that secondary mathematics teachers are still not effectively integrating computer technology in their classroom. This paper presents the findings from a doctoral study on the extent to which mathematics teachers in government high schools in New South Wales, Australia have integrated computer technology into their teaching. The sample contained 114 mathematics teachers from 26 public secondary schools in New South Wales, Australia. A statistical model, logistic regression analysis was used to examine mathematics teachers’ beliefs, attitudes, knowledge (use of software packages; professional development experiences and needs in computer technology) and factors that encourage or hinder the use and not use of computers in the classroom. The findings of the study indicate that the strongest predictors that are positively associated with computer use are training on EXCEL and the need for ongoing support for the inclusion of technology in mathematics teaching. This paper concludes with recommendations as to how school leaders can support mathematics teachers to fully adopt computer technology use in teaching and learning.

INTRODUCTION

Mathematics education in the public secondary schools in New South Wales, Australia has been experiencing reforms directed toward the integration of technology in mathematics courses dating back to the late 1990’s. There is evidence that the mandated policy of Computer-Based Technologies in the Mathematics Key Learning Area of the New South Wales Department of Education and Training (1997) has not been fully embraced by schools in New South Wales (Vincent and Jones, 2008; Lyons, 2007).

Despite the mandate that accompanies this policy document that computer technology be integrated in the range of courses in the secondary mathematics key learning areas, there is evidence to suggest that computers are not widely integrated into Australian secondary mathematics classrooms (D’Souza, Sabita and Wood, 2003). Similarly, for teachers in the USA, where despite teachers’ increasing knowledge of and familiarity with technology and there being infrastructure to support it, many mathematics teachers are still not effectively integrating technology into their teaching (Foley and Ojeda, 2007). The international evidence suggests that one reason for the teachers not embracing technology is the fear that it might replace teachers in the school system (Li, 2007). Others attribute the ineffective integration of technology to the lack of adequate knowledge about when and how computers could be used in mathematics instruction, and lack of sufficient training (Jamieson-Proctor & Finger, 2008). This ineffective integration is disturbing given the benefits that are attributed to integrating technology into the classroom.

This paper examines the beliefs, attitudes and knowledge (professional development experience and needs) of mathematics teachers towards using computer technology and how this translates into
teachers using or not using computers in the classroom. In addition, the paper examines whether or not there were facilitating or inhibiting factors leading to embedding computer use in teaching mathematics, hence improving mathematics learning.

LITERATURE REVIEW

The literature reveals several ways of conceptualizing the way in which technology can impact on learning. These include: technology as a cognitive tool (Jonassen, Peck and Wilson, 1999), the computer as a mental and computational device (Tessmer and Jonassen, 1998), the computer as a tool for teaching students (Robleyer, 2008), the way that the computer acts in the acquisition of cognitive skills (Pappert, 1980) and the use of computers as a tool for enhancing student learning (Schoenfield, 1987).

In mathematics teaching and learning, teachers’ beliefs about mathematics learning with or without using technology are considered to be important because it could influence teaching and learning, and curriculum reform. For example, Schoenfeld (1987) argued that mathematics teacher’s beliefs can be thought of as individual perspectives on how one engages in mathematical tasks and pedagogical practices.

Just as teachers hold beliefs about mathematics that may influence how they teach or structure the learning environment, teachers also hold beliefs about the use of technology. For example, the studies conducted by Li (2007); Kynigos and Argyris (2004) on the nature of beliefs about technology use in the mathematics classroom portrayed some difficulties in the different aspects of learning situations in different ways, and the impact of using computers on their beliefs about teaching mathematics. Li's (2007) study reveals contrasting beliefs between students and teachers. For example, the students commented that they wanted to learn in a more effective, efficient and fun way, which suggests that technology, may help weak students by increasing their confidence levels. On the other hand, no teacher in the study considered the advantage of computer technology as an alternative to the traditional approach of teaching to improve weak students’ learning. Kynigos and Argyris (2004) study established the complexity of issues that play a pertinent role in forming beliefs and practices in the aspects of teacher intervention in the classroom, the emerging social roles and the possible influences of the school and the educational system. Their study also revealed that the type of intended innovation and the use of exploratory software played a major role in the kind of mathematical activity going on in the classroom.

Mathematics teachers are also faced with inhibiting factors or barriers to computer use. For this reason, there have been several studies specifically focused on secondary mathematics teaching. Manoucherhi (1999) in a US study concluded the lack of computer use is due to lack of experience and access to educational software; lack of adequate professional training and lack of professional support in the use of computers in mathematics instruction. In New Zealand and Australia, similar conclusions by D’Sousa, Sabita and Woods (2003); Palmer (2002) identified that the common barrier to technology use in the classroom was a lack of professional development and lack of access to computers.

One of the barriers that mathematics teachers identified in failing to adopt the use of computers in the classroom, is the lack of professional development in technology. To address this issue, several authors prescribed different types of professional development in the use of technology. This can be in the form of formal training in technology courses (Swan and Dixon, 2006); training of teachers in the use of software packages (Toumasis, 2006); instructional strategies (Sorkin et al., 2004); and lesson planning integrating technology in mathematics (Hardy, 2004). In line with the need for on-going professional development (Wells, 2007 and Sprague, 2007); further training in software use (Sorkin et al, 2004) and teachers’ preferences about who should provide training are some issues that should be looked at.

Based on the literature review, a research model is necessary to address the questions asked in this
inquiry. The design includes the method and instrument used, such as the questionnaire survey, sampling and selection of data.

RESEARCH DESIGN

Method and instrument used

A mixed-model approach prescribed by (Teddlie and Tashkkori, 2002) was used in this study. The instrument used in this study was a survey questionnaire developed and piloted by the researcher and mailed to secondary schools in the New South Wales Department of Education and Training. The questionnaire design is a closed-response with five open-ended questions. The design of the questionnaire includes: (1) six closed questions in Section 1 coded from 0 to 6 depending on the answers to be chosen by the respondents; (2) three multiple answers questions in Question 10, 11 and 12 using a 5-point Likert Scale coded from 1 to 5 as, SA (Strongly Agree) = 5; A (Agree) = 4; U (Undecided) = 3; D (Disagree) = 2; SD (Strongly Disagree) = 1 and (3) seven open-ended questions. The questionnaire survey is composed of three sections and the questions asked are presented below. However, the actual tables used in Question 10, 11 and 12 are not included due to restrictions in the number of pages allowed.

Section 1 – Professional Development for Using Technology in Mathematics

1. What is your school classification?
2. Position:
3. Number of years teaching mathematics
4. Number of years using computers in mathematics teaching?
5. What formal training have you had in computer technology?
6. What types of professional development or in-service programs have you participated in over the past three years to use computers in teaching?
7. What other software packages would you like your school to purchase and for what purpose would you use this?
8. Do you require any other ongoing support for your inclusion of computers into the teaching of mathematics?

Section 2: Your Belief/Conceptions in Mathematics Teaching and Learning and Using Technology (Computers)

1. This question or statement is about the sixteen beliefs about the nature of mathematics, mathematics teaching and learning with or without technology. The teachers were asked to tick the appropriate code which they identify as their beliefs. For example, they were asked about their belief if the use of computer technology in the classroom enhances student learning by putting a tick on the corresponding codes on the spaces provided.
2. In your own words teaching mathematics with computers is …
3. Describe your most successful use of computers in the teaching of mathematics.

Section 3: Technology Use and Instructional Practices

1. Who in your school fulfills the role of assisting you to integrate computer technology into mathematics teaching?
2. How is the integration of computer-based technology into the teaching of mathematics accomplished in your school?
3. Have you observed any successful outcomes as a result of integrating computer-based technology to your teaching?
4. Finally, are there any other challenges that need to be addressed in your school in order to have mathematics teachers integrate computer-based technology into teaching?
Sampling and selection of data

The site of the data gathering of this research is the NSW DET (New South Wales Department of Education and Training), Australia. This included public high schools sampled in seven large regions spread out across the state of New South Wales. The data gathering procedure that was used in the collection of data is ‘cluster sampling’. The sample population was selected from 100 high schools including central/community schools. The participating schools were sent letters through mail with prior approval on 4 March 2005 to conduct study from the NSWDET (New South Wales Department of Education and Training). A final response rate from 26 high schools comprised of 114 teachers including head teachers.

DATA ANALYSIS

A statistical model analysis, ‘logistic regression analysis’ was used to predict the use of computer in the mathematics classroom. The reason for using this model is that, it is the most effective and sound way of analyzing the data collected in this study considering the presence of multiple dependent variables. Therefore, an explanation of the logistic regression model is subsequently provided. A diagram of a model for predicting computer use in the classroom is presented in Figure 1.

Definition of logistic regression

Logistic regression is another approach to category prediction, which carries fewer assumptions than does discriminant analysis. When the dependent variable consists of only two categories, binary logistic regression is applicable; when there are three or more categories; multinomial logistic regression is the appropriate choice (Kinnear and Gray, 2008, 518-519).

Logistic regression analysis

In each of the section in Figure 1, the probability of using computers in the classroom for different values of the variable was determined by evaluating the formula:

\[ P(\text{Use}) = \frac{e^{\beta_0 + \beta_1 X + \beta_2 X + \ldots}}{1 + e^{\beta_0 + \beta_1 X + \beta_2 X + \ldots}} \]

A model for predicting computer use

A model for examining the relationships between teachers’ use of technology in the classroom and five classes of predictor variables was used and is illustrated in Figure 1.

Figure 1 Model for examining relationships between beliefs, barrier, professional
development choices and needs and computer use in the classroom

The analysis was completed in sections, reflecting relationships between the five components of the model, namely beliefs, barriers, professional development choices, professional development needs and ICT use in the classroom. The first four sections that follow explore the relationships between:

- beliefs and ICT use;
- perceived barriers and ICT use;
- professional development undertaken (choices and barriers) and ICT use; and
- perceived professional development needs and ICT use.

RESULTS

The following sections present the results and analysis of this study. They represent the associations between and among: teachers’ beliefs, perceived barriers claimed by teachers; professional development choices and barriers; teachers’ perceived professional needs for training (ongoing support); preferred sources of training; ongoing support; formal training; beliefs predicting professional development (training on software use); beliefs predicting professional development (wanting further training on software use); teachers’ reports of training on software packages, and computer use. Mediators to computer use were also investigated. The results were analysed using stepwise logistic regression.

Beliefs and ICT use

The sixteen dependent variables analysed were data from Section 2 of the survey: Your Belief/Conceptions in Mathematics Teaching and Learning and Using Technology (Computers). The sixteen items are composed of sub-headings of what teachers’ believe in the nature of mathematics and mathematics teaching and learning with or without technology. For example, item 1-mathematics is made up of individual components that incorporate the study and application of number, algebra, geometry, calculus, collection of data and graphs; and item 16-the use of computer software can make understanding clearer through graphs, presentations and simulations. The other items were not included in this paper due to restrictions on the number of pages.

The relationships between the beliefs about mathematics, teaching mathematics and technology and the likelihood of teachers’ use of computer technology in the classroom were analysed. The analysis shows that the three beliefs containing positive coefficients (mathematics is about life, concepts and resources) did not predict computer use. While somebody who endorsed the belief that mathematics is made up of individual components that incorporate the study and application of number, algebra, geometry, calculus, collection of data and graphs significantly predicted computer use in the classroom.

Perceived barriers and ICT use

Whether teachers used computers in the classroom, only the lack of lesson plans was found to be associated with computer use (p = .01). The non-users of computers were significantly more likely to indicate that a lack of lesson plans was a barrier to using computers than did the teachers who used computers in the classroom.

Professional development choices and barriers

Those who undertook departmental training were more likely to suggest the following barriers to using technology:

- lack of time to undergo training;
- need for technology support;
issues in relation to the compatibility of hardware and software;
• lack of confidence in using the software;
• lack of knowledge of teaching strategies using computers;
• inability to trouble - shoot problems with computers; and
• lack of lesson plans using computers in mathematics.

Teachers perceived professional needs for training (ongoing support) and ICT use

Continual support in professional development has been the major issue of many teachers in schools. The data reveals that teachers who used computers are more likely to require on-going support than those who do not use computers (p = .001). While 88% of those who *used computers* want an on-going support to use computers in mathematics, only 59% who *do not used computers* want on-going support.

Preferred sources of training

After examination of the sixteen beliefs of teachers about mathematics, mathematics teaching and learning, and technology use in the classroom, there is no significant association to the six preferred source of training, (a) Head teacher, (b) Computer Teacher, (c) Conference/seminars, (d) The Internet, (e) District Office and (f) Education Department Training Program to any of the teachers’ perceived beliefs. However, (1) the Internet is negatively associated with computer use and (2) the Head Teacher is positively associated with computer use.

Ongoing support

Of the sixteen beliefs of teachers about mathematics, mathematics teaching and learning, and technology use in the classroom, only one belief, *students need to be encouraged to enjoy learning* is positively associated with the need for ongoing support for the inclusion of computers in mathematics teaching ($\beta = 0.648$), and negatively associated with computer use ($\beta = -0.385$).

Formal training

After examination of the sixteen beliefs of teachers about mathematics, mathematics teaching and learning, and technology use in the classroom, only one belief, *the use of computer help students develop higher-order skills* is associated to ($\beta = 0.476$), teachers’ formal training but not to computer use.

Beliefs predicting professional development (training on software use)

Teacher who had training on software packages were more likely to hold beliefs about mathematics, mathematics teaching and learning, and technology use in the classroom. The software packages that are positively associated with beliefs are: Word, Access, EXCEL, Publisher, the Internet, Programming, Front Page, Power Point and Paint Shop. Only one of the software packages (LOGO) among the ten is not significantly associated with any of the sixteen beliefs perceived by teachers in mathematics teaching. However, EXCEL is the only software package that teachers have been trained at has a positive association to computer use ($\beta = 1.759$).

Beliefs predicting professional development (wanting further training on software use).

An examination of teachers who are wanting further training on software packages were more likely to hold beliefs about mathematics, mathematics teaching and learning, and technology use in the classroom. None of the items on wanting further training on software packages were significantly associated with the use of computers in the classroom.
Mediators to computer use (beliefs and perceived barriers to computer use)

When all the sixteen sub-items on beliefs were examined on the impact on teachers’ perceived barriers to computer use only one item on barriers, the lack of lesson plans using computers in Mathematics was associated to the belief on the use of computer technology enhances students learning that leads to the factor predicting computer use ($\rho = .02$). None of the other items predicted computer use.

Teachers’ reports of training on software packages

An examination as to the nature of the association between training in each of these packages and teachers use of the package in the classroom revealed that in every instance, an equal or greater percentage of teachers who had training used the specific package in the classroom when compared to teachers who did not have training on the package. The associations were significant for Word, Access, EXCEL, the Internet, and programming.

Using logistic regression analysis model to find out the associations between and among the variables, only ten emerged as significant: (1) conference workshops; (2) school-based staff development; (3) training on EXCEL; (4) lack of lesson plans using computers in mathematics; (5) need for ongoing support for the inclusion of technology in mathematics teaching; (6) head teacher; (7) the Internet; (8) mathematics is made up of individual components that incorporate the study and application of number, algebra, geometry, calculus, collection of data graphs; (9) the use of computer technology provides access to huge amount mathematics resources and (10) when teachers use computers in the classroom, they are able to spend more time on concepts rather than routine computational skills. These variables were entered in the final model for predicting computer use of mathematics teachers in the classroom.

Final model for predicting computer use

Figure 2 describes the final model for predicting computer use. Looking back at Figure 1 (the original model for predicting computer use), beliefs and PD (professional development) choices were eliminated from the results of the logistic regression analysis. This means that beliefs and PD (professional development) choices were not significant predictors to computer use. It shows that teachers’ beliefs about the nature of mathematics and mathematics learning with or without technology are not contributing factors to the adoption of computer use in mathematics teaching and learning.
When a final logistic regression analysis model was performed to predict computer use and not use in the classroom using ten independent variables, only four emerged as predictors to computer use in the classroom.

Figure 3 illustrates the four predictors of computer use and not use: (1) training on EXCEL, (2) the need for ongoing support, (3) lack of lesson plans and (4) the Internet.

The study’s findings indicates that (1) Training on EXCEL is positively associated with computer use with a $\rho$ value = .014; (2) Need for ongoing support for the inclusion of technology in Mathematics teaching is positively associated with computer use with a $\rho$ value = .003; (3) Lack of lesson plans using computers in Mathematics is negatively associated with computer use with a $\rho$ value = .003 and (4) The Internet is negatively associated with computer use with a $\rho$ value = .000. The strongest predictors of computer use are the need for Ongoing Support for the inclusion of technology in mathematics teaching and training on EXCEL program. The study suggests that an ongoing support for computer use in mathematics teaching such as training on hands-on use of EXCEL program is needed in assisting mathematics teachers to adopt the use of technology in the classroom.

The final formula to predict computer usage in the classroom is provided below:

$$P(\text{Use}) = \frac{e^{5.044 + 1.480 \text{Excel} + 2.415 \text{Support} - 1.038 \text{LessonPlan} - 0.984 \text{Internet}}}{1 + e^{5.044 + 1.480 \text{Excel} + 2.415 \text{Support} - 1.038 \text{LessonPlan} - 0.984 \text{Internet}}}$$

Using this equation we can determine that the probability of using computers in the classroom increased with teachers identifying the need for support in the inclusion of computers in mathematics teaching and having been trained in EXCEL($P(\text{Use}) = 0.999869$) and decreased if they requested professional development through the Internet and professional development in lesson planning that
incorporates the use of technology in mathematics teaching (P(Use) = 0.999147). However, the probabilities show that there is only a minute difference between them.

CONCLUSION

This paper specifically focused on the use of ICT to improve mathematics learning by encouraging teachers to adopt the use of technology in public secondary schools in the New South Wales Department of Education and Training. This paper is gleaned from a doctoral study conducted in 26 public secondary schools in 2005 to 2006. A summary of the separate regression analysis on the association among beliefs, barriers and professional development were examined. The results of the study show that training on EXCEL and the need for ongoing support for the inclusion of technology in mathematics teaching are positively associated with computer use. Lack of lesson plans using computers in mathematics teaching and the Internet are negatively associated with computer use. This means that a teacher who wants training in EXCEL, need [SIC] ongoing support for the inclusion of computer [SIC] in Mathematics teaching, preferred to be trained in the use of the Internet and welcome [SIC] lesson preparation with technology integration is more likely to adopt computer use in mathematics teaching and learning. The literature used in this study states that ‘teachers’ beliefs can influence their teaching practices’. However, the results of this study on the beliefs of teachers did not show any effect on teachers’ adoption of using and not using computers. Perhaps, the gap is methodologically and statistically bound. The present study rigorously used logistic regression analysis in the associations between/among the variables used.

These results indicate that past and current computer policies and professional development programs integrating the use of ICT in mathematics seem to be not effective in making teachers adopt the use of computer technology in their teaching practices. There should be a thorough monitoring technique or strategy that include implementation, feedback and evaluation of technology plans by the stakeholders of the secondary education sector. Possibly a more structured and ongoing professional development programs for mathematics teachers should be aligned to their needs and beliefs. Therefore, it is highly recommended that a leadership role of school executives should be a preference when implementing and encouraging teachers to use ICT in the mathematics classrooms.

REFERENCES


