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Statistical analysis model predicting computer use in mathematics

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Abstract

This paper is a report of a doctoral thesis that investigated the factors that were associated with the use of computers in secondary mathematics teaching, the choices made by teachers and learning theories guiding their teaching. Mixed methods approaches were used to triangulate the results of the study. The study was divided into three stages, the first a questionnaire completed by 114 teachers, the second was examination of current accredited courses in teacher preparation for mathematics teaching to identify what learning theories were included in subjects, and the third were interviews with 8 teachers in training and 6 experienced teachers. Results of the inquiry revealed that the probability of a teacher using a computer was maximized when they strongly agreed with the statement that the lack of lesson plans was a barrier to using computers and with the belief mathematics is made up of individual components and responded highly undesirable in training conducted by the Internet or education department training programs and strongly disagreed with the belief that when teachers use computers in the classroom, they are able to spend more time on concepts. Overall, the teachers made choices to use computers when appropriate in their lesson preparation, teaching materials and teaching strategies with the use of learning theories.

Keywords

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Disciplines

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Statistical Analysis Model Predicting Computer Use in Mathematics

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Abstract: This paper is a report of a doctoral thesis that investigated the factors that were associated with the use of computers in secondary mathematics teaching, the choices made by teachers and learning theories guiding their teaching. Mixed methods approaches were used to triangulate the results of the study. The study was divided into three stages, the first a questionnaire completed by 114 teachers, the second was examination of current accredited courses in teacher preparation for mathematics teaching to identify what learning theories were included in subjects, and the third were interviews with 8 teachers in training and 6 experienced teachers. Results of the inquiry revealed that the probability of a teacher using a computer was maximized when they strongly agreed with the statement that the lack of lesson plans was a barrier to using computers and with the belief mathematics is made up of individual components and responded highly undesirable in training conducted by the Internet or education department training programs and strongly disagreed with the belief that when teachers use computers in the classroom, they are able to spend more time on concepts. Overall, the teachers made choices to use computers when appropriate in their lesson preparation, teaching materials and teaching strategies with the use of learning theories.

Introduction

The focus of this doctoral thesis was to examine the beliefs, attitudes and knowledge (professional development experience and needs) of mathematics teachers towards using computer technology and how this translated into their using, or not using, computers in the classroom. In addition the thesis examined whether or not there were facilitating or inhibiting factors leading to embedding computer use in mathematics teaching. In so doing "computer technology" has been used to refer to both hardware and software packages and to communication technologies such as the Internet, hypermedia, multimedia the use of interactive whiteboard (IWB), wireless Internet learning devices (handheld computers and small tablet notebook), WebQuest, social-learning facilities (wikis, blogs and twitter) and programming languages.

There is evidence to suggest that computers are not widely integrated into Australian secondary mathematics classrooms (D'Souza, Sabita and Woods, 2003) despite the evidence in numerous studies in the positive effect of computer use in student learning like, improved logical reasoning using spread sheets (Wu and Wong, 2007); enhanced learning through using cognitive skills and higher order learning (Schimidt et al, 2009), and improved teachers' skills such as: increased enthusiasm in the use of technology (Sorkin et al, 2004); broadened teachers' knowledge of technological resources and methods of teaching (Hardy, 2004); improved teaching methodology in the use of logical reasoning with the aid of Geometre's SketchPad (Toumasis, 2006). 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.

The Study

The study examined the extent to which mathematics teachers in Government High Schools and Catholic High Schools in New South Wales have integrated computer technology into their teaching. In the first study, the source of data and results describing the participating schools in the New South Wales Department of Education and Training were the schools who participated in the survey drawn from regional districts of the New South Wales Department of Education and Training Public Secondary Schools. During the time of the study, there were 365 government high schools, 65 of them were specialist secondary schools and the rest are comprehensive high schools. In 2005, 100 schools were selected randomly from the school classifications comprehensive high schools, rural/country schools, selective high schools and priority funding schools. The schools were invited and sent questionnaires to participate in the survey. There were 114 teachers who participated in the survey. The data gathering procedure that was used in the collection of data is 'multi-stage stratified cluster sampling.' The sample population was selected from all New South Wales Department of Education and Training public high schools including central/community schools. The first study focused on the question "What are the factors that contribute to the use or non use of computers in the classroom?" More specifically it addressed the questions:

1. Are individual teacher's belief in the nature of mathematics, mathematics teaching and learning, and mathematics teaching and learning using technology associated with computer use and not use?
2. What are the barriers faced by mathematics teachers in using technology in the classroom?
3. What knowledge (or professional development and training in technology use) mathematics teachers had prior to teaching and during their teaching career, and how it is associated with teacher use and not use of computers in the classroom?
4. Do teachers need on-going support for technology associated with computer use and not use in the classroom, and how is it associated with teacher use of computers in the classroom?

The second study involved the examination of current accredited courses in teacher preparation for mathematics teaching to identify what learning theories were included in subjects. This leads to the third study.

The third study was conducted to complement or supplement the first study. The interviews were undertaken as a means of triangulating the research by deepening the exploration of why and how teachers teach effectively in the use of technology in the classroom. The aim was to follow-up the unexplained areas. This was accomplished by exploring the role of learning theories in the use or non use of technology in teaching mathematics. In this study inexperienced (n = 8) and experienced teachers (n = 6) were interviewed with regard to their plans for teaching, and in particular how they prepared their lessons, the materials they used with or without technology and their use of teaching strategies and associated learning theories. When questioning as to their choices in teaching two specific questions were formulated:

1. When do teachers use and not technology in mathematics teaching?
2. In examining the choices made by teachers in teaching mathematics is their evidence as to the application of different learning theories?

Figure 1 illustrates the model for investigating the relationship between the four sets of independent variables beliefs, knowledge, needs and barriers and the dependent variable computer use. To better understand findings in the literature several other investigations were conducted to examine the mediating effects of the independent, specifically whether beliefs mediated knowledge, needs and barriers.

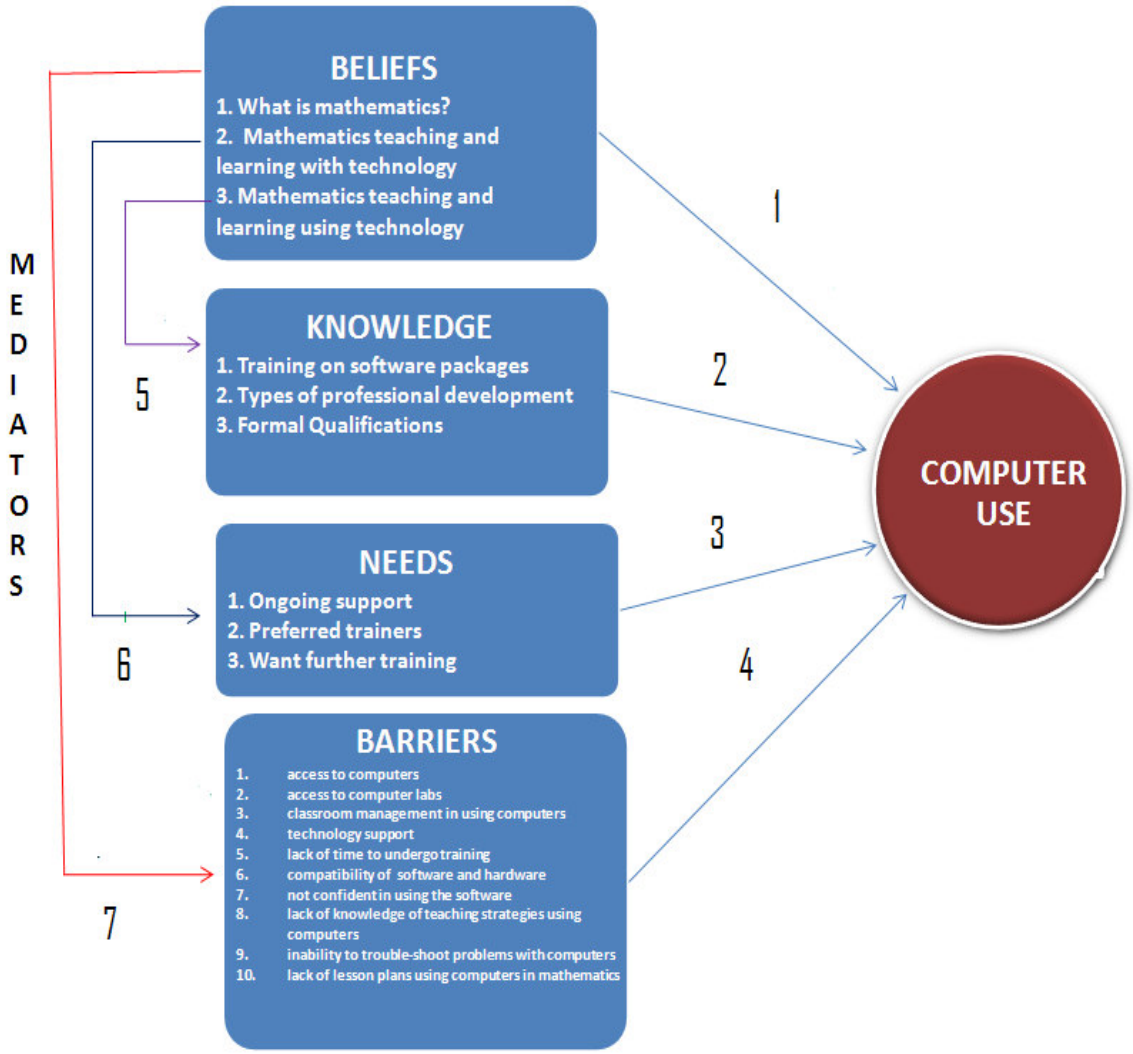

Figure 1 A Model for Predicting Computer Use

Findings

A logistic regression analysis (Tabacknick and Fidell, 2001) was used to predict the probability of computer use in the classroom. The formula for finding the probability of use is given by,

$$\hat{Y}_1 = \frac{e^{\alpha+B_1X_1+B_2X_2+B_3X_3+\ldots}}{1+e^{\alpha+B_1X_1+B_2X_2+B_3X_3+\ldots}}$$

where, X_1 are the significant variables.

These investigations involved examining the relationships (using regression analysis) between computer use (refer to Figure 1) and,

1. Beliefs
2. Knowledge
3. Needs
4. Barriers

1. Beliefs

A *stepwise logistic regression* was performed to ascertain the relationships between the 16 beliefs statements about mathematics, teaching mathematics and technology and the likelihood of teachers' use of computer technology in the classroom. The final model, containing only the statistically significant predictors of computer use, correctly classified 83% of all the cases ($\chi 2 = 31.598$, df = 4, p = .000). Only four beliefs made a significant contribution to the model. The probability of using technology was maximized for teachers who strongly agreed that *Mathematics is a way of life and a way of thinking, when teachers use computers in the classroom, they are able to spend more time on concepts rather than routine computational skills,* and *the use of computer technology provides access to huge amount of mathematics resources* and disagreed with the statement that *Mathematics is made up of individual components that incorporate the study and application of number, algebra, geometry, calculus, collection of data and graphs*.

2. Knowledge

2.1 PD training in software packages

Having completed professional development in the use of packages was interpreted as the intention to use computers in the classroom. A logistic regression predicting computer use with training on ten packages, Microsoft Word, Excel, Access, Front Page, PowerPoint, Desktop Publisher, Paint Shop, the Internet and programming was performed. The probability of using computers in the classroom was maximized for teachers who had training in *Microsoft Excel* ($\chi 2 = 15.062$, df = 1, p = .000).

2.2 Types of Professional Development

None of the types of professional development undertaken in the last three years, such as conferences, school based training, department sponsored training, or district sponsored training were significant.

2.3 Whether they had formal qualifications

Holding undergraduate or postgraduate qualifications was not significantly related to computer use.

3. Needs

3.1 Ongoing support

The probability of using computers in mathematics teacher was maximized for teachers who requested for ongoing support for the inclusion of computers into the teaching of Mathematics ($\chi 2 = 3.909$, df = 1, p = .048).

3.2 Preferred trainers

The probability of using computers in the classroom was maximized for teachers who endorsed training on *the Internet,* and through *Education Department Training Programs* as desirable ($\chi 2 = 20.687$, df = 2, p = .000). Provision of professional development by the Head Teacher, Computer Teacher, Conference/Seminars, and District Office were not significantly related to computer use.

3.3 Want further training

Teachers' indications that they wanted further training in the software packages on Microsoft Word, Excel, Access, FrontPage, PowerPoint, Desktop Publisher, Paint Shop, the Internet so that they can were not significant *(ns)* in predicting computer use.

4. Barriers (perceive barriers to computer use and actual use)

The probability of using computers in the classroom was maximized for teachers who agreed that " lack of lessons plans was a barrier to using computers in mathematics". ($\chi 2 = 6.426$, df = 1, p = .011). None of the remaining barriers (refer Figure 1) were significantly associated with the use of computers in the classroom. The number of teachers indicating a lack of lesson plans as a barrier was higher for teachers who do not use technology (78%) than teachers who do use technology in the classroom (60%). The differences for the other items were not significant.

All the beliefs, needs, knowledge and barriers found significant were then used as independent variables to model computer use. Table 1 shows the final predictors of computer use.

Table 1 Final model predicting of computer use through logistic regression

	Predictors (Independent Variables)		S.E.	Wald	df	P value
1	Mathematics is made up of individual **components** that incorporate the study and application of number, algebra, geometry, calculus, collection of data and graphs. (BELIEFS)	- 1.63	.85	3.66	1	.056
2	When teachers use computers in the classroom, they are able to spend more time on **concepts** rather than routine computational skills. (BELIEFS)	2.461	1.11	5.00	1	.026
3	The **Internet** (KNOWLEDGE-PD)	- 1.41	.74	3.64	1	.056
4	**Education Department Training Program** (KNOWLEDGE-PD)	-2.28	1.10	4.30	1	.038
5	**Lack of lesson plans** using computers in Mathematics (BARRIER)	-2.63	1.41	3.47	1	.062
	Constant	23.86	11.45	4.34	1	.037

Table 1 Final Model for Predicting Computer Use

The final model to predict computer usage in the classroom was:

$$P(Use) = \frac{e^{23.861 - 1.629Comp + 2.461Concepts - 1.405Internet - 2.280EDTP - 2.626LPan}}{1 + e^{23.861 - 1.629Comp + 2.461Concepts - 1.405Internet - 2.280EDTP - 2.626LPan}}$$

Using this equation the probability of using computers in the classroom was maximised when teachers strongly disagree (1) with the *lack of lesson plans* being a barrier to using computers in mathematics, liked to be trained by the *Education Department Training Program* (1), endorsed the *Internet* as the preferred trainer (1), strongly agreed (5) to the belief that when teachers use computers in the classroom, they are able to spend more time on *concepts* rather than routine computational skills, and strongly disagree (1) with 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. The maximum probability of use, P(Use in Classroom) = 1 (0.9996) and the minimum probability of use were the same variables were reversed. In this case the P(Use in the Classroom) = 0.000002. The final model, containing only the statistically significant predictors of computer use, correctly classified 92.3% of all the cases ($\chi 2 = 36.940$, df = 5, p = .000).

In the study, the relationship between beliefs and knowledge, needs and barriers were examined so as to begin the process of examining whether the relationships with computer use were mediated. Results show:

Beliefs predicting knowledge (5), refer to Figure 1

1. Training on software packages
    a. The belief that *Using computer technology, teachers reduce time in presenting lessons and can move through material more rapidly* is associated with having had training on Microsoft Word ($\chi 2 = 7.396$, df = 1, p = .007).
    b. The belief that *Mathematics is remembering facts, rules and learning by rote and when teachers use in the classroom, they are able to spend more time on concepts rather than routine computational skills* is associated with previous training on Microsoft Access ($\chi 2 = 9.612$, df = 1, p = .008).
    c. The belief that *When teachers use computers in the classroom, they are able to spend more time on concepts rather than routine computational skills* is associated with having had training on

Microsoft Excel($\chi 2 = 5.431$, df = 1, p = .020).

d. The belief that *The use of computer technology helps students develop higher-order skills* is associated with having had training on Microsoft Front Page ($\chi 2 = 10.223$, df = 1, p = .000);
e. The belief that *Computer technology use provides students with a greater motivation to solve problems* is associated with Microsoft PowerPoint ($\chi 2 = 4.4.81$, df = 1, p = .034).
f. The belief that Mathematics is describing the world in front of us, the use of computer technology provides huge amount of mathematics resources and students who have been exposed to computer technology in the classroom will do better on test than those who haven't are associated ($\chi 2 = 19.029$, df = 3, p = .000) with Microsoft Desktop Publisher.
g. The belief that *When teachers use computer in the classroom, they are able to spend more time on concepts rather than routine computational skills* is associated with having had training on the Internet ($\chi 2 = 6.647$, df = 1, p = .010).
h. The belief that *When teachers use computers in the classroom, they are able to spend more time on concepts rather than routine computational skills is associated* with having had training on programming languages such as HTML, DHTML, C++ and others ($\chi 2 = 4.353$, df = 1, p = .037) ;
i. The belief that *Mathematics is a way of life and a way of thinking* is associated with others like geometry software ($\chi 2 = 4.520$, df = 1, p = .043).

2. Types of professional development
   a. The belief that *Mathematics is describing the world in front of us is positively associated* with conference workshops ($\chi 2 = 4.610$, df = 1, p = .032).
   b. The belief that *Students who have been exposed to computer technology in the classroom will do better on test than those who haven't* is associated with department sponsored training ($\chi 2 = 8.19$, df = 1, p = .004).
   c. The belief that Mathematics is a way of life is associated with district sponsored training ($\chi 2 = 6.171$, df = 1, p = .013).
3. Formal qualifications

   None of the sixteen beliefs is associated with either possessing undergraduate or post graduate qualifications (ns).

Beliefs predicting needs (6), refer to Figure 1

1. Ongoing support

   The four beliefs, *Students need to be encouraged to enjoy learning; using computer technology, teachers reduce time in presenting lessons and can move through material more rapidly; the use of computer technology helps students develop higher-order skills,* and *the use of computer software can make understanding clearer through graphs, presentations and simulations* are associated with ongoing support for the inclusion of computer in mathematics teaching ($\chi 2 = 23.034$, df = 4, p = .004).

2. Preferred trainers

   None of the 16 beliefs is significantly associated with preferred sources of trainers such as: the Head Teacher, Computer Teacher, Conference/Seminars, the Internet, District Office and Education Department Training Programs.
3. Want further training
   a. The belief that *Students who have been exposed to computer technology in the classroom will do better on tests than those who haven't* is associated with Microsoft Access ($\chi 2 = 5.828$, df = 1, p = .016).
   b. The belief that *Mathematics is fun and when teachers use computer in the classroom,* and *they are able to spend more time on concepts rather than routine computational skills* are associated with wanting training on Microsoft Excel ($\chi 2 = 10.779$, df = 2, p = .005).
   c. The belief that *Students who have been exposed to computer technology in the classroom will do better on tests than those who haven't* and *using computer technology, teachers reduce time in presenting lessons and can move through material more rapidly* are associated with wanting training on Microsoft Front Page ($\chi 2 = 14.710$, df = 2, p = .002).
   d. The beliefs that *Students who have been exposed to computer technology in the classroom will do better on tests than those who haven't* and *using computer technology, teachers reduce time in presenting lessons and can move through material more rapidly* are associated with Microsoft Paint Shop ($\chi 2 = 9.113$, df = 2, p = .010).

e. The belief that *When teachers use computers in the classroom, they are able to spend more time on concepts rather than routine computational skills* is associated with wanting PD on programming languages such as HTML, DHTML, C++ and others($\chi 2 = 4.929$, df = 1, p = .026).

In the research interview, the inexperienced teachers explicitly talked about the learning theories they learned in their teacher training courses. These theories were the same theories covered in five subjects offered in the teacher preparation course examined. Most of the theories the practicing teachers studied in their teacher training course, 'constructivist theory', 'behaviourist theory' and 'information processing theory', were applied by them in the actual or practical teaching. However, the practicing teachers did not differentiate the use of these theories whether with or without the use of technology in regards to the choices they make in applying learning theories to teaching.

The teachers interviews suggest that teaching and learning mathematics incorporates the use of many learning theories. Theories in mathematics learning are intertwined with lesson preparation, choices of teaching materials and teaching strategies with or without the use of technology. The experienced teachers explicitly talked about the use of technology in terms emanating from the constructivist theory of learning (Vygotsky, 1934; Piaget, 1950; Biggs and Telfer, 1987; Schoenfeld, 1987; Jonassen et al, 1993; Krause et al, 2007), behaviourist theory of learning (Skinner, 1904 and Pavlov, 1926), and intelligence and multiple intelligences theory (Spearman, 1904; Thurnstone, 1938; Gardner, 1983; Sternberg, 1985).

Conclusions

The literature reviewed in this study found both similarities and dissimilarities to the present study. Researchers in the past simply identified the barriers to technology use using ranking and percentages of responses to items or questions. In the present study modelling whether teachers actually used computers or not through logistic regression analysis found that factors that contribute to computer use were often different to those where methodologies simply asked teacher what the barriers were. Only one barrier the lack of lesson plans was significantly related to whether or not teachers used computers in the classroom. Further, it was the teachers who used computers that indicated this was a barrier. In regards to the barriers of computer use, literature says that lack of access to computers (Forgasz, 2006) is the dominant barrier to computer use. Using logistic regression model in the present study, teachers believed that 'the lack of lesson plans using computers in mathematics' is the barrier to computer use in the classroom. The factors that predicted computer use in the classroom are the beliefs that Mathematics is made up of individual *components* that incorporate the study and application of number, algebra, geometry, calculus, and collection of data and graphs; the belief that when teachers use computers in the classroom they are able to spend more time on *concepts* rather than routine computational skills; the preferred/non-preferred sources of professional development via the *Internet*; *Education Department Training Program* and *lack of lesson plans using computers in the mathematics classroom* being a barrier to computer use.

The results of the third study revealed that inexperienced and experienced teachers' use of technology was embedded in their lesson preparation, teaching materials and teaching strategies. In the teachers' lesson preparation the use of technologies and software packages (such as: spreadsheets, Geometre's ScketchPad, PowerPoint presentations and online resources like: HotMaths, WebQuest and Geogebra) was at times a strategy and sometimes a teaching material. There were occasions they chose to use technology for classroom management purposes, and there were instances when visual and graphing representations of objects need a less demanding way of presenting the lesson to the students.

When learning theories were presented to the teachers how they apply them to the choices they make in teaching with or without technology, the responses were overwhelming because they are in alignment with the learning theories used in education. They are theories like behaviourism, constructivism, cognitivism, information processing theory, Vygotzky's zone of proximal development, and intelligence and multiple intelligences theory.

In summary, the choices teachers make in teaching with technology depends upon the topics taught and the circumstances they faced, like when the classes are in the first period of the day that is when students are receptive to learning. It is also the learning ability of the student that counts, when behaviourist learning theory and multiple intelligences theory were taken into consideration in the teaching and learning process. The statistical modelling technique used in the study, four factors beliefs, knowledge, needs and barriers predicted computer use in mathematics teaching.

Finally, Figure 2 shows a diagram of what choices teachers' make in using and not using technology in teaching mathematics: lesson preparation, teaching materials (used and not used of technology), teaching strategies, all linked to 'learning theories.'

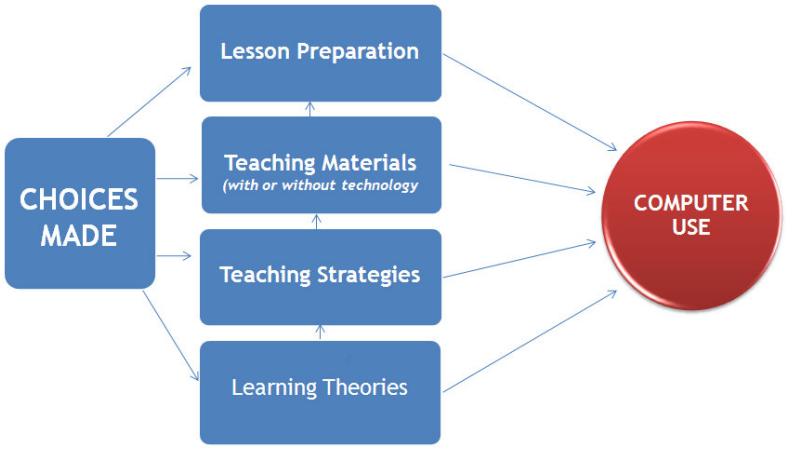

Figure 2 Teacher's choice of use and not use of technology in the classroom

The choices that teachers make in everyday teaching in preparing their lessons, teaching strategies they apply in the classroom, the materials they used (technology and not technology) and learning theories (refer to Figure 2) made a difference to why teachers used or not use computers in teaching.

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