Research Proposal

A comparative study of online facilitated instruction in mathematics

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Introduction/ Overview

The use of online facilitated instruction is expanding rapidly in the Technical and Further Education (TAFE) sector of Victoria. Online learning is being promoted on a global scale and new learning environments such as TAFE Virtual Campus are being created to offer flexible delivery of vocational education and training courses (Mitchell J. & Bluer R. 1997; Wheeler 1996; Kemp, D. 2000).

The use of online environments in teaching and learning can be placed in two distinct categories - one where the content of a course is fully online and students have little or no face to face contact with the teacher and second, courses where online environment is integrated into classroom teaching. This study is concerned with the second (hybrid) model of online learning in a mathematics course and aims to explore its impact on students' achievement and attitude towards mathematics.

The case of using technology in mathematics education and its resulting effect on students' achievement and attitude towards mathematics has been studied by various researchers over a long period of time. Many of these studies indicate a positive effect on achievement and students’ attitude. However, the use of online learning environments in classroom settings to teach mathematics is a relatively new phenomenon and anecdotal evidence suggests that students respond positively to online environments.

The use of computer technology in mathematics classrooms has been favoured by a number of policy documents (AEC, 1990; NCTM, 1998) and studies have reported that computers in classroom create a more interactive and democratic classroom (Harasim et. al., 1995; Thomas et.al., 1996). It is assumed that computer facilitated mathematics learning is likely to provide the kinds of experiences predicted by educational theory to lead to learning (McCoy, 1996). Despite these recommendations and rich possibilities, the use of computer facilitated mathematics instruction has not shown consistently superior results compared with traditional instruction. Findings concerning the efficacy of computer facilitated instruction have been mixed (McCoy, 1996).

On the one hand there are studies that show clear improvement in performance as a result of computer use (French, 1997; O'Callaghan, 1998) there are others indicating that there is no significant difference in the performance (Hollar & Norwood, 1999). It appears that individual
constructs of each setting plays a key role in the resulting performance and more elaborate studies are required to identify these individual constructs.

Computer based online learning environments offer a new set of parameters and resources. Online facilitation offers flexible and collaborative learning opportunities that have the potential to align closely with the principles of constructivist theory (Jonassen, 1996). Although studies by Freeman (1997), Gilliver et.al (1998), Gerber et.al (1998) and Oliver & Omari (1999) show a positive response by students in terms of their attitude towards online learning, several studies comparing students achievement have found no significant difference between the traditional methods and online based teaching (Jones, 1999; Schmeeckle, 2000). However, in one study (Schmeeckle, 2000) it was found that the online facilitated instruction was more efficient than the traditional teaching and took half the time. There is a lack of research on online learning in mathematics and as a result there is no clear mandate on the effectiveness of online instruction in mathematics in either totally online or mixed mode (hybrid) settings.

This lack of clarity about the efficacy of computer based online facilitation in mathematics can only be resolved by further research in a range of settings where mathematics is being taught either in a mixed or totally online mode. The proposed study tests the efficacy of online facilitation at a specific level of instruction and contributes to the collective body of research in online mathematics instruction. The thesis being tested is that the carefully planned implementation of online facilitated instruction will result in better performance and more positive attitudes towards mathematics among TAFE business and marketing students.

Recent developments in Java based programming have enabled creation of realistic and highly interactive online learning environments. The development of Maths Connections for Adults (MCA Online) website [1] at the Victoria University offers a unique learning environment for mathematics. The author of this proposal has played a key role in the development of this online learning environment and has extensive experience in online teaching and learning. The MCA online website offers learning units on twelve selected topics on mathematics ranging from simple mathematics lessons on decimals, fractions and numbers to more sophisticated topics on trigonometry, statistics and algebra. The website makes extensive use of interactive online resources available from key worldwide mathematics sites. Another useful feature of this website is its communication platform, which allows students to form communities of learners for collaborative learning. It also offers access to archives of answers to mathematics problems.
posted by students on most mathematics topics at Dr Math Archive [2]. The MCA online website will serve as an anchor for the online facilitation of mathematics instruction during this study.

The proposed study is significant from the point of view that it adds to the rapidly evolving body of research concerning the application and effectiveness of specialist online learning environments in mathematics instruction at the vocational education and training level. Considerable state and national funds have been invested in developing and promoting online learning environments and flexible learning is being promoted as a strategy to improve access and participation in vocational education and training. Anecdotal evidence suggests that many teachers are sceptical about the effectiveness of computers and online technologies. This study uses both quantitative and qualitative data to document the effect of online facilitation in mathematics instruction.

**Contribution to knowledge**

The proposed study contributes to the research on computer facilitated mathematics instruction by adding new knowledge about the efficacy of online learning environments in mathematics instruction. Most of the previous experimental studies in computer facilitated instruction of mathematics have been limited to the use of specialist mathematics software applications. Use of specially developed online learning environments to support mathematics instruction has not been studied so far. Furthermore, the previous studies have been limited by addressing mostly the technology elements and not focusing on the qualitative aspects of learning. This is the first systematic study of online facilitated mathematics instruction at a vocational education and training setting in Australia. This comparative study which uses both a quantitative and qualitative methods will show how the use of an online learning environment in mathematics instruction affects TAFE students’ attitude and performance in mathematics. The study will also contribute towards building a better understanding of teachers’ and students’ use of online environments in mathematics learning.
Summary of Significance

This study is significant for several reasons:

1. The State and National educational agencies have allocated a significant amount of resources and funding in developing and promoting online learning. At the same time, many educators and community members are skeptical about the efficacy of online learning environments. It is therefore important to conduct systematic studies of the effect of online learning environments on students’ performance and attitude, and assist in informed educational policy making.

2. The study has the potential to demonstrate that online facilitated instruction leads to better educational outcomes and attitudes towards learning. Both students and teachers are likely to benefit from the findings by developing an informed understanding and acceptance of online learning environments in teaching and learning contexts.

3. The qualitative measures of the study are likely to identify factors that influence students’ participation and success in online leaning. These findings are likely to be a useful guide for teachers and content developers in future implementation of online facilitated instruction.

Literature Review

Theoretical Framework

The present study is being undertaken from a theoretical perspective based on cognitive and constructivist theories of learning. Both these perspectives are discussed here briefly:

Cognitive theories of learning have revealed a number of strategies that suggest how people think and learn. Schank and Cleary (1995) suggest that human reasoning is case-based, rather than rule based and we build generalisations, or knowledge structures, by drawing on our rich case-base. From a cognitive science perspective, the learning theory that seems most relevant to this study is that of anchored instruction. Developed by the Cognition and Technology group at Vanderbilt (CTGV, 1993) anchored instruction provides learning opportunities that are based on authentic tasks and environments, and includes opportunities for reflection and application. Instructional activities are designed around an anchor that is case or problem based and learning
materials allow exploration by the learner. For example application of this theory in online learning environment enables learners to use selected websites as anchors.

Dunn and Dunn's (1978) cognitive theory of learning styles is also relevant for the current study. This theory suggests that students have particular learning styles, can recognise their own learning style, and will perform better if taught in a manner consistent with their preferred style. Dunn (1996) points out that accommodating different learning styles is essential for multicultural education. She suggests that learners with particular learning styles respond well to computer facilitated instruction.

Constructivist theories refer to the idea that individuals actively construct knowledge by interacting with the environment. This environment could be the learning content, their peers or the teacher. According to this theory knowledge construction is a process of thinking about and interpreting experience (Vygotsky, 1978). Constructivism places a special emphasis on social context. Vygotsky (1978) developed a notion of zone of proximal development (ZPD), which he described as the zone between what a learner can do on his own and what the learner is capable of doing with an expert help. In a teaching situation, if a teacher is able to identify learners' ZPD then instruction can be structured to improve learners' cognitive development within this zone.

The work of Von Glasersfeld (1995) extends the notion of constructivism to assert that the individual learner is not the recipient of knowledge passed into his consciousness by the teacher. He argues that each learner builds up his or her own knowledge subjectively and a consensus may be achieved about certain beliefs or concepts, but he points out that this consensus can not be considered to genuinely represent any external reality. Von Glasersfeld stresses that it is wrong to assume that other individuals construct cognitive structures that in any way resemble our own. Therefore, teachers can not assume that the understandings arrived by their learners resemble their own.

Dengate (1998) carried out an extensive review of Constructivist paradigm for mathematics teaching and offers that constructivist teaching of mathematics should be guided by:

- the posing or problems/open tasks and encouragement of reflection;
- the staging of situations which evoke, sustain and modify elements of mathematical thinking;
- emphasis on independent, but interactive mathematical activity;
- adoption of a facilitatory role; and
- the promotion of discussion in the classroom.
Constructivist conceptions of education have dominated the development of educational computing methods in the recent times specifically because opportunities offered by computer and online technologies blend well with the constructivist ideals (Kahn & Friedman, 1998, Jonassen, D., 1996, McCoy, 1996, Schank, R.C. & Cleary, C, 1995).

McCoy (1996) points out that the application of constructivist theory to the realm of mathematics learning produces a perspective wherein students are understood to learn best by means of "active involvement with mathematical models that allow them to internally construct their own understandings and concepts" (p.438). Computer facilitated learning is ideal for this purpose because computers and computer facilitated instructional programs "provide a rich experience that allow students to be actively involved with mathematics" (p.438).

The Maths Connections for Adults (MCA Online) as an instructional website allows for active and collaborative learning consistent with constructivist paradigm. Its interactive learning units are designed to encourage students to explore mathematical meaning at their own pace. Students are able to input their own data for questions and follow its solution step-by-step. MCA online is designed to be used in conjunction with classroom teaching and allows teachers to build realistic problem based tasks for learning. The range of communication and interactive learning features available at MCA Online make this website a good online learning environment from the point of view of anchored instruction and constructivist theories [See Appendix 1, 1b, 1c, 1d & 1e for screen shots]. Research studies being proposed here will enable us to find how these theoretical underpinnings translate into a meaningful reality.

In a brief literature review of current research on the topic proposed under this study I will draw from three categories of research:

a. use of computer facilitated learning in mathematics classrooms;
b. use of online learning environments in mixed mode delivery of curriculum content from a range of disciplines; and
c. use of online learning environment in mixed mode delivery of mathematical content.

It is not in the scope of this study to review the literature on online learning applications for distance education and off-campus mode delivery. Such online programs are not directly relevant to campus-based delivery of mathematics courses offered by mainstream vocational and educational settings.
Computer Facilitated Learning

McCoy (1996) offers a substantial review of current research concerning computer-facilitated learning in mathematics classrooms. McCoy divides these studies into three categories: computer programming as a means of mathematics development, computer facilitated direct instruction in mathematics and the use of mathematics tools applications. The review of research on computer facilitated mathematics instruction is of direct relevance to this study.

In computer-facilitated instruction McCoy (1996) found that those programs using creation of a micro-world schema to teach arithmetic and geometric concepts produced consistently favourable results. Other software programs not using micro-world concept were quite varied in their design and included drill and practice exercises as well as mathematical concept development. Research on these applications produced varied results (p.448). McCoy found that most computer-facilitated instruction yielded favourable results, a few produced results showing no significant difference and none was found to be favouring traditional instruction. In all these studies concerning computer-facilitated instruction the subjects were school age children. McCoy also noted that students pre-existing attitudes to technology and the teacher's role as a facilitator of learning plays a crucial role in overall results achieved by computer facilitated instruction (p454). It is therefore important to include qualitative data to gain a better understanding of the research results.

O'Callaghan (1998) compared the effects of computer intensive algebra and traditional algebra instruction on college algebra students' conceptual understanding of the function. The results from this experimental study show that computer supported instruction achieved a better overall understanding of concepts covered and scored a higher percentage of success rate.

The study by O'Callaghan (1998) is of special significance due to the fact that the methods of instruction included a problem solving approach based on constructivist approaches to teaching (p22). Although this study provides a strong support for computer facilitated instruction the results can not be taken on their face value. The study results need to be interpreted in the light that there was a non-random selection of subjects for this experimental study.

Although a majority of studies on computer-facilitated mathematics instruction report enhanced achievement for computer-supported group, a small number of studies report to the contrary (Ford & Klicka, 1998, Hamtini, M., 2000). These studies found that traditional
instruction resulted in better achievement for the control group even though the experimental
group showed improvement in attitude towards mathematics. This confirms the view by McCoy
(1996) that factors such as the teacher's role, teaching methodology and the design of the
computer facilitation plays a significant role in the success or failure of computer facilitated
instruction.

The studies concerned with computer-facilitated instruction clearly show a possibility of
enhanced mathematical achievement using computers but they do not show clearly what
programs of instruction under what setting contribute to positive results.

**Online Facilitated Learning**

Research studies on the use of online learning environments in mixed mode delivery span
a range of discipline areas and only a small sample is reported in this review due to limitation of
space.

Freeman (1997) reports on a web based teaching trial program involving 550
undergraduate business students from the University of Technology Sydney. The online
environment used *Topclass* as a delivery platform. Students were enrolled in an on-campus
business finance subject that ran for 13 weeks. Notes, quizzes and a discussion board on the web
complemented course content and face-to-face instruction. The study gathered data on students'
perceptions and usage of web-based instruction. Results indicate that a large number of students
(82%) value course based support via the web and most of them (94%) felt that Topclass would
have a positive impact on their grade. However, the study was not designed to measure any
differences in students' achievement attributable to online access.

Jones (1999) reports on the results from a study using Internet inquiry projects with 100
grade 9 and 10 high schools students. In this study he divided the sample into two groups and
researched how different quality and amounts of online support affected students biology
achievement and motivation towards learning. Jones provided well-structured web based support
to one group while the other group was left to explore their own way to work on projects. The
hypotheses suggested that the less structured group would be more motivated as they could
explore a greater number of websites for their work. The results of the study show that the
students from the less structured group spent less time on the Internet compared to the structured
group. There was no significant difference between two groups in their achievement or
motivation levels. Although inconclusive results were obtained from this study, it becomes clear that a well-developed structure, such as the one available at MCA online, is necessary to engage students to use the potential of web based learning.

In a similar study Oliver and Omari (1999) researched the affect of using online technologies to support problem-based learning with two groups of undergraduate students. The results showed that students respond very positively to changed learning environment. This study also reported that students continuously reminded the researchers that face-to-face input of teachers was very valuable. The point raised about the value of face-to-face instruction to support any online activity is worth noting and comes up repeatedly in similar studies.

**Online Facilitated Mathematics Instruction**

Research literature shows only a limited number of studies covering online facilitated instruction in mathematics. It is understandable due to the relative newness of online infrastructure and support in mainstream education. The following studies show the state of mathematics instruction with online environments.

Mathai (2000) in a study of the use of Internet to foster self-directed learning in community and technical colleges investigated the viability of using the Internet as a tool to foster self-directed learning in the two year college maths and science classes. She held five focus group discussions with maths and science teachers to seek their responses. The study found that teachers see the Internet as a resourceful tool to facilitate self directed learning in motivated students. The study reports that the instructors who are self-directed as learners tend to encourage self-direction in their students. Mathai recommends that maths and science curriculum must be redesigned to incorporate self-directed leaning as an option and Internet acts as a resourceful tool for this purpose.

Gerber and Shuell (1998) report their findings from a study of using the Internet to learn mathematics with 8th grade students. In her ethnographic study eight students from two classes were observed for a period of five weeks. The study aimed to explore ways in which Internet might be used in conjunction with a mathematics project and how students go about using this type of learning environment. Results on the issue of students understanding of the Internet reveal that the students conceived the Internet as a means for obtaining information and talking to people. The investigation of students' approach to searching the Internet found that while
searching for data, only on a few instances students persisted in the face of adversity, such as opening an empty page or having nothing returned from a keyword search. The findings show that most students required some form of scaffolding to focus their surfing tendencies and perform more goal oriented and fruitful searches. As far as appreciation of mathematics is concerned, the study found no striking difference between Internet and non-Internet students. The results from this study are not surprising and further reinforce the view that simply bringing a new technology to students will have little or no impact on students' overall performance or attitude. It is necessary to provide adequate scaffolding to online learners and research is needed to explore how students' motivation and performance is affected when online learning is supported with properly designed learning systems.

From this selected literature review from latest studies it is clear that the research concerning the use of online facilitation in mathematics learning has produced mixed results. The assumption that the use of computers in mathematics instruction is likely to enhance students' performance has not been proved to be always correct. It seems that there are certain sets of conditions that result in favourable use of computers in mathematics instruction. We need to study individual sets of conditions where online facilitated mathematics instruction occurs so that an integrated body of research data based on both quantitative and qualitative analysis can inform the field. It is important to recognize the role of teachers in online facilitated instruction and research needs to show how teacher’s skills and intervention may play a key role in the learning process.

Studies on the online use in mathematics teaching seem to suggest a potential for positive outcomes in terms of students' achievement and attitude towards mathematics, but empirical evidence needs to be gathered to quantify these claims. In addition, qualitative data is required to show what elements of online facilitation are necessary for its best use by students and how teachers can develop new methodologies to integrate online facilitated instruction for an improved teaching and learning in mathematics.
**Aims of the Study**

Key questions this study aims to address are:

- How does the use of online facilitated mathematics instruction affect students’ attitude towards mathematics?
- Does the use of online resources in teaching enhance students’ mathematics achievement?
- How do students access and use online environments for their learning needs?
- What factors influence students’ participation in online environments for learning?
- How does integrating an online environment in classroom-based learning affect a teacher’s role?

**The Method**

The study is based on an experimental methodology and aims to make use of both quantitative and qualitative data. The experimental part of the study is designed to measure differences in mathematical attitude and achievement resulting from the use of online resources in classroom based learning. It is hypothesised that students in online facilitated instruction will show significant improvement in achievement and attitude towards mathematics. In addition, qualitative techniques from action research will be used to study factors affecting application and use of online environments in mathematics learning.

**Participants**

Subjects for this study are 40 students enrolled in a business mathematics module of a TAFE diploma course in business and marketing. These students are young adults between the ages of 18 and 40, most have completed their secondary schooling recently. The group is broadly representative of TAFE students enrolled in diploma and certificate courses across several campuses of Victoria University. The sample for this study consists of two classes that are enrolled in the same mathematics module at the same campus and are taught by the same tutor. For the purpose of this study one class is assigned as control group and will receives instruction in the traditional manner. The other class is assigned as an experimental group and will engage in classroom instruction integrated with online facilitation. The experimental group will have the same mathematics tutor but will be assisted by a co-teacher (researcher) in the design and implementation of online support. See Figure(1) for a summary of methodology.
Design

The quantitative elements of this study use a common experimental design. The subjects (N=40) will be randomly allocated to two groups. The same teacher will teach the same subject to both groups. One group will be taught by traditional lecture method and is considered to be a control group. The other group will be taught by online facilitated method and will be considered the experimental group. Both groups will complete tests and questionnaires before and after a semester of instruction. This pre-test/post-test design will allow the development of each group to be assessed and statistically compared to that of the other group.

The qualitative elements of the study involve the collection and analysis of students' weekly journal entries and a semi-structured interview conducted with a subset of informants from both groups. Six students from each group will be selected randomly. From the experimental group this selection will be representative of high, moderate and low users of online technologies. The journal entries and hours of online use will be used to categorise high, moderate and low users. From the control group the interview selection will be representative of high, moderate and low achievers based on class mathematics tests. In addition, logs of students' postings on an electronic discussion board will also be used to identify patterns in the use of online facilities. The researcher will undertake classroom observation with both groups and assist the subject teacher in offline and online instruction. The subject teacher will be interviewed to provide a deeper insight into the issues concerning the methodologies, content and personal factors affecting the use of online facilitation.

Measures

The Aiken-Dreger Mathematics Attitude Scale (Aiken, 1974) will be used to determine students mathematics attitude pre and post instruction. This scale includes 20 questions concerning thoughts and feelings about mathematics and participants answer by selecting one of a range of answers arranged on a Likert scale. Aiken-Dreger Mathematics Attitude Scale is a fairly standard instrument used in educational research and several recent studies (Patterson 1993, French 1997 and O'Callaghan 1998) have used this scale successfully in their research. The reliability coefficient of Aiken-Dreger Scale has been found to be 0.85 (Adwere-Boamah, et.al., 1986). A pre-test in selected mathematics topic (statistics) will be given to all students to assess student's general understanding of the subject at the beginning of the instruction and also
to ascertain any pre-existing differences in the performance of two groups. The post-instruction achievement will be assessed by a final test given by the tutor. The post-test measures student understanding of the content covered in the mathematics topic (statistics). The same final test will be given to both groups.

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<th>Controlled Variables</th>
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<td>- Teacher</td>
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| Independent Variables                | temporary Classroom lecture based on text book and notes as support material | classroom based with online facilitation integrated with conventional teaching. |
|                                      |                                                                             |                                                                         |

| Data Collection Tools                | Aiken-Dreger Mathematics attitude test given at pre and post treatment stages | Aiken-Dreger Mathematics attitude test given at pre and post treatment stages |
|                                      | mathematics achievement test at pre treatment stage                         | mathematics achievement test at pre treatment stage                     |
|                                      | post treatment class test                                                   | post treatment class test                                              |
|                                      | interview with selected students                                            | interview with selected students                                       |
|                                      | classroom observation of traditional mathematics learning                  | weekly journal of online activities                                    |
|                                      | teacher interview                                                          | postings on discussion board                                           |
|                                      |                                                                             | classroom observation of online use in mathematics learning           |
|                                      |                                                                             | teacher interview                                                      |

*Figure 1: A summary of methodology and research tools*
The methods used in collection of qualitative data are consistent with those of the action research (Wadsworth, 1997). Some of these methods involve audio recording, transcribing and sifting the data into categories for further analysis. Such research methods have been used successfully in previous research studies concerning the effects of language and technology on mathematics instruction. For example Gerber (1998) used audiotaped interviews and field notes along with data obtained from questionnaires to analyse use of Internet by eighth grade students to learn mathematics. Moschkovich (1993) used audio-taped and video-taped observations along with data from peer discussions to analyse high school students' conceptions and language use in their understanding of linear equations and graphs.

**Analysis**

Quantitative data analysis will be based on standard parametric statistical procedures using Statistical Package for the Social Sciences (SPSS) software package. The control and the experimental groups will be tested for statistically significant differences in the pre-test mathematics achievement and post test mathematics achievement, and pre test attitude score and post test attitude score. Statistical techniques employing *t*-test and analysis of variance methods will be used to analyse data. Information gathered by qualitative techniques will form the basis for verifying results obtained through quantitative measures as well as establishing answers to research problems concerning how do students' access and use online learning environments for their learning needs and what factors affect their participation in these environments. Using grounded theory methods (Strauss & Corbin 1990) will enable formation of tentative hypotheses from the interviews and journal entries. Under this method of qualitative data analysis inductive reasoning is used to derive tentative hypotheses from raw data and it can be used to augment, verify and/or explain the findings derived from quantitative analysis.
References:

[1] MCA Online Website at: http://www.staff.vu.edu.au


