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An examination of learner control in a low achieving mathematics class

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AN EXAMINATION OF LEARNER CONTROL IN A LOW ACHIEVING MATHEMATICS CLASS

BY

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ABSTRACT

This study examines the effect of learner control on the use of the software package Math Blaster Mystery (MBM) by low ability mathematics students. MBM is a mathematical software package which consists of four activities, each with four levels of difficulty, involving problem solving and worded problems. Each activity has four levels of difficulty. The purpose of the study was to answer the following questions;

1) Is the implementation of *Math Blaster Mystery* designed with a low level of learner control more effective with lower ability students than implementation with a higher level of learner control?

2) Do lower achieving students who are afforded a high level of learner control use the *Math Blaster Mystery* package more efficiently than students who are afforded a low level of learner control?

The students chosen for this study came from two country district high schools in Western Australia. The schools were similar with respect to the funding allocated to them and the student population. The students were identified through the Monitoring Standards of Education Tests as being low achievers with respect to mathematics.

The sample of students chosen for this study was not random as the focus of the study was on low achieving students. One group of students had a high

level of learner control which enabled them to choose the content and the path of their learning. The other group of students had a pre-determined content and path. The data collected for the study took the form of anecdotal notes from observations of students using MBM, interviews with the students, and test results.

In this study it appeared that the students used the software more efficiently when the software was implemented with a low level of learner control. While there were no differences in test scores between the two groups, the low level of learner control group used MBM more efficiently with a structured path ensuring the content was covered. The method used by the low level of learner control group also ensured a logical method of completing the activities which ensured a more effective use of the package. Students with a high level of learner control displayed limited capabilities in monitoring and making effective decisions with respect to their own learning.

The main implication of this research for teachers is that learning environments for low ability students need to be structured even when using computers so that effective learning can take place. Teachers need to take on the role of monitor in determining student learning as students lack the knowledge and motivation to do it themselves. Study into learner control needs to be more defined with respect to the features being examined so that more general findings can be established.

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Introduction

Computers and associated technology were viewed initially by many educators (e.g. Montague & Wulfeck, 1983) as the answer to many, if not most, educational problems that are encountered by teachers and students. However, this has consistently failed to be realised in practice (Pitts & Schneider, 1981). Various strategies have been used to implement computers in schools in an attempt to enhance learning outcomes. The use of computers has been considered for nearly every aspect of education (Strickland, 1989), particularly those associated with various roles in learning processes. The roles that the computer may take in supporting learning processes are often described by characteristics of the software design. For example, Alessi and Trollip (1991) describe instructional software design as taking the form of one or more of: tool, tutor, drill and practice, simulation and games.

Rationale

Research into the effectiveness of computers as a learning tool have revealed strengths and weaknesses in their application. For example, Tilidetzke (1992) examined four groups of students, two in a traditional classroom setting and two using a computer tutorial package for a pre-calculus course. He concluded that

when comparing the CAI (computer assisted instruction) environment to one of a conventional classroom setting, "the two CAI sections as a group performed as well or better than the two control sections as a group" (p. 59). However, Williams (1993) focused on reading comprehension and mathematics when using CAI with 54 sixth-grade students from rural schools. She concluded that there was a significant difference between pre and post test reading comprehension scores, however, there was no difference in mathematics scores. Williams stated that "for CAI programs to be successful, they must be closely monitored" (p. 20). McCallister and others (1988) identified time as the determinant in the success or failure of CAI in reading and mathematics in that the longer students used CAI the higher their post test scores were. Darter and Phelps (1990) found the impact of CAI in the classroom as having a "positive effect on student and teacher attitudes and motivation" (p. 3). Hardman (1994), found no difference in reading achievement when utilising CAI and she concluded that CAI was effective in some instances and neutral in others. Muldner, Muldner and Van Veen (1997), concluded that computer-based teaching was "ineffective" when designed to emphasise "technology rather than course information" (p. 116).

For the purposes of this study the researcher focused on one design characteristic of educational software, the degree of student learner control. As with the general implementation of computers into the classroom, the concept of learner control has been widely examined with varying results. There is controversy about the definition of learner control, the optimum degree of learner control and the resulting student learning outcomes. Friend and Cole (1990) refer to learner control

as "allowing the learner some control in an individualised lesson" (p. 47). Steinberg (1989) focused on learner control using the computer, and stated that "Students who are beginners in a subject are likely to lack ... skills that facilitate learning and that are important for effective learner control" (p. 120). Kinzie (1990) acknowledged the problem of individual differences in stating that a "possible reason for mixed learner control results is the existence of individual differences in student abilities and prior knowledge" (p. 11). Clearly research has to be more defined with respect to the target groups so that data collected and outcomes achieved can be interpreted more usefully.

Advances in technology have meant that software on the market is more powerful than ever before with highly developed interactive and feedback capabilities. The features of a software package which may impact on learner control are more extensive now than ever before (Reeves, 1993a; Rowe, 1995). Software available today enables the user almost unlimited control in the initial choice of program characteristics and its navigation. This freedom that has been afforded the user needs to be examined in terms of its relationship to achieving desired learning outcomes. Unlimited control by a student in progression through a package may lead to less efficient learning taking place. It is possible that a student may take 30 minutes to complete a lesson when they only needed 15 or 20 minutes (Simons, 1989).

When examining the learning environment of students using computers the teacher needs to consider the curriculum, software and student attributes. Student

performance differs across the curriculum (Williams, 1993) and also within subject areas. Teachers need to be aware of the students' metacognitive processes to ensure that they make effective decisions in relation to their learning (Baird & White, 1984). In a CBL environment these decision-making skills and learning outcomes are influenced by the ability of the student in the subject area (Ross & Rakow, 1981) as well as their attitude (Kinzie, 1990) and motivation (Kinzie & Sullivan, 1989). The use of software that gives the students a high level of learner control also affects their learning outcomes (Goetzfried & Hannafin, 1985b). Goetzfried et al. (1985b) progress to mention that students of varying abilities responded differently when given a high level of learner control, in that high ability students performed better than low ability students.

Research Questions

The problem addressed by this study was how much learner control should be given to low ability students using Math Blaster Mystery (MBM). The problem is narrowly defined because many researchers studying learner control in educational software have found their results to be inconclusive (e.g., Steinberg, 1989; Kinzie et al., 1989; Plomp & Pelgrum, 1992) and a possible reason behind this was that the samples were too large and the topics too broad. Sample sizes quoted by Steinberg (1989), range from 140 to 700 and the topics described only relate to broad subject areas such as chemistry, whilst Kinzie et al. (1989) fail to mention either sample size or topic. Consequences of large sample sizes could include that the student characteristics and abilities as well as the learning environment are not considered

in the research. From the researcher's own teaching experience, mathematics classes tend to be streamed to reduce the impact of different abilities, and enable teachers to better accommodate a reduced number of individual differences. The learning needs of the student for a particular topic can be accurately determined and resources used effectively to maximise learning outcomes.

When teaching mathematics in a traditional setting, teachers often change strategies for different topics and for different students. It is difficult to decide which strategy is the best for a particular topic without looking at the total environment in which the learning is taking place. Therefore, this study only considered low ability and low motivational students with one specific mathematical topic. This study aimed to investigate whether a high or low level of learner control was suited for the low ability students, as evidenced by efficiency in using MBM, and effectiveness in retaining mathematical concepts embedded in the software. Two specific questions were addressed by this study.

Question One

Is the implementation of *Math Blaster Mystery* designed with a low level of learner control more effective with lower ability students than implementation designed with a higher level of learner control?

Question Two

Do lower achieving students who are afforded a high level of learner control use the *Math Blaster Mystery* package more efficiently than students who are afforded a low level of learner control?

It was expected that a sequentially presented implementation of interactive software, such as MBM, which provides a low level of learner control, would be a more effective method with the target students compared to implementation which provided a high level of learner control. That is, it was expected that lower achieving students would be more suited to a low level of learner control. Findings in this research will add to the body of knowledge in respect to learner control when using this type of software across schools.

Selection of the Student Sample

The purpose of this study was to consider the relationship between learner control in a computer supported environment and learning effectiveness and efficiency for lower ability students. The research questions were focused on the degree of learner control and various indicators of learning outcomes achieved. The reference to curriculum area and student ability was relevant because of the varying suitability of CBL packages with students from different backgrounds and with different needs. This study focused on students who had poor motivation and below average results in mathematics. They also tended to come from families with low socio-economic status

The sample of students came from two country district high schools, Stuart District High School and Nelson District High School (pseudonyms). Stuart DHS qualified for PSP (priority schools program), and PCAP (priority country area program) funding which was a reflection of the school's isolation and low socio-economic status. Nelson DHS is a similar school situated approximately 400km from Stuart DHS. The number of students, and their socio-economic status was comparable to that of Stuart DHS. Both of these schools had an Aboriginal representation of approximately 60-70 percent.

Motivation levels of most children in mathematics classes at schools such as those in the study are usually low which are reflected in their generally poor achievement (Kinzie, 1990). However, this problem of motivation only relates to particular areas of the curriculum with these students often excelling in areas such as design and technology, art and agriculture. The researcher had observed that if students are not motivated, structured learning environments tended to have a settling influence. This observation may also apply to computer supported learning. If such an environment is unstructured, then teachers may find that problems still exist even though the students are working on the computers.

The students selected from both schools were randomly allocated into two groups, one to experience a high level of learner control (High group) and one to experience a low level of learner control (Low group). Each group were given the same amount of time on the computers using the software package (MBM). Pre and post

tests were used as a measure of difference in specific mathematics learning outcomes between the two groups.

Learner Control in this Study

The key focus for this research was an evaluation of the effect of the degree of learner control in a computer supported environment on the achievement of learning outcomes. Reeves (1993b) defined learner control "as the design features of computer based instruction (CBI) that enables learners to choose freely the path, rate, content, and nature of feedback in instruction" (p. 821). Reeves went on to recommend that "researchers need to clearly define what aspects of learner control are being examined in the research" (p. 823). For this research the aspects of learner control considered relevant were *content* and *path*. The *content* related to the choice of activity that the student had in MBM and the *path* was the navigation route taken in the activity. Students with a high level of learner control were able to freely navigate MBM with respect to the activities chosen and the degree of difficulty level within each activity. Students with low level of learner control had a pre-determined sequence of problems that were required to be completed with the activity difficulty levels being attempted in a set order. The time allocation for the completion of activities did not vary. Both groups of students progressed through the problems at their own individual rate. The feedback that MBM provided was the same for both groups of students.

Software Selected for this Study

The software used for this study was *Math Blaster Mystery* (MBM). MBM is a mathematics software package which consists of problem solving activities including worded problems. There are four activities with each having four levels of difficulty. MBM was selected for this study because of its content and apparent good design features. A description of MBM and a rationale for its choice is given in Chapter 3.

Report of the Study

In Chapter Two a review of relevant literature is presented. Chapter Three will present and discuss the methodology used for the study. The results are presented in Chapter Four and then discussed and concluded in Chapter Five.

Chapter Two

Literature Review

The continuing advancement of technology provides educators with the potential to give students increased control over their own learning. A student's control over learning can extend to a computer-supported learning environment, where they can determine the level of learner control in a software package. Research into learner control has revealed inconsistencies in the relationship between level of learner control and learning outcomes. Reasons behind this include a lack of uniformity in a definition of learner control (Reeves, 1993b). Learner control features in software encompass a varied range of options including the path, content, feedback and amount of instruction that a student can choose. These options relate directly back to the software design of the package being used. Well designed software has the potential to cater for the individual needs of students. Educators need to be aware of the individual needs of their students, so appropriate software can be used to ensure that these needs are met. Student characteristics including prior knowledge and achievement, attitude and motivation all need to be considered when selecting software to ensure that student learning outcomes are maximised.

Learner Control

Reeves' (1993b) definition of learner control (given earlier) focused on the design features of computer based instruction which allowed the user to determine the control of particular aspects in the lesson. One problem Reeves (1993b) identified in this area of research was the lack of a uniform definition of learner control. Friend et al. (1990) and Higginbotham-Wheat (1990) both define learner control by identifying features of learner control with the latter referring to "learner control as student decision making" (p. 254). In both of these studies the researchers focused on particular aspects of learner control. Johansen and Tennyson (1983) discuss the concept of learner control without a definition being stated and focus primarily on the range of computer-based environments from those with high levels of learner control through to almost complete program control (i.e. no learner control). The meta-analysis conducted by Niemiec, Sikorski and Walberg (1996) identified "little theoretical or operational agreement on the meaning of learner control" (p. 169), and progressed further to suggest that it may benefit researchers to look outside the limited CAI research on the topic.

With advancements in technology being so rapid in recent times, research into learner control has been questioned with respect to its datedness. Friend et al. (1990) argued that early studies of learner control probably focused on mainframe computers with very limited resources. As a result of this, early research and conclusions in this area may no longer be relevant because of design limitations on the hardware and software available at that time.

The present study focused on the learner control features connected with the content and navigation path when using the software package of MBM. Students with a high level of learner control had control over two aspects of the package. They could choose the content, being any of the four activities in the package. Once the activity has been chosen the path they took through the activity with respect to the levels of difficulty could also be determined by the student. Students with a low level of learner control had no choice in the activity or level of difficulty that they had to complete.

Software Design for Learner Control

One of the problems facing teachers in all classrooms is the need to accommodate the individual differences between students. Teacher limitations in accommodating individual differences have been highlighted by Friend et al. (1990) who argue that computers can allow for individualised instruction where this would be impossible for a teacher. This is also argued by Higginbotham-Wheat (1990) where she states, "The use of computers in education has finally made individualisation a feasible goal" (p. 3). She goes on to say that the computer has the "potential ability to accommodate the needs of individual learners" (p. 3).

Software design is the critical feature in determining the potential levels of learner control that are available to the user. Well designed software has features that enable students to utilise learner control facilities effectively. Friend et al. (1990)

believe that learner control "must be seriously considered in instructional design and implementation" (p. 49). With respect to low ability students, Goetzfried et al. (1985b) found that linear designed features were more suited to low ability students. They also claim that linear designed software is inexpensive and "is likely to be more readily designed, produced, and installed into typical instructional settings" (p. 17). The variability of contexts presented to the student can also vary the learning outcome. Higginbotham-Wheat (1990) found that personalised contexts proved beneficial to the learning process. Morrison, Ross and Baldwin (1992) state that "(contextual) adaption helps ensure the material is relatable to students' backgrounds and interests and thus serves to promote attention and meaningful learning" (p. 5). Learner control can extend to the choosing of screen design (Niemiec et al., 1996), and text density that ranges from sparsely worded to full explanations of concepts (Simons, 1989). Simons found that when text density was a decision variable, "the learner control groups learned better than the groups receiving standard materials" (p. 9). Clearly there is a wide range of software design features which influence the potential for learner control facilities, all of which may have varying impacts on the learning outcomes for a user.

Mathematics and Learner Control

It is possible today for students to have been exposed to computers in mathematics classes from early primary school right through to adult education (Goetzfried et al., 1985b; Holmes, Robson & Steward, 1985). Topics which have been covered include numerical skills (Ross et al., 1981), algebra (Simons, 1989), logic

(McCahill, 1994) and statistics (Saleem & Azad, 1992). Learner control in mathematics software packages can vary with respect to which features are available to the student. It has ranged from virtually no learner control (program control) through to essentially total control for the learner. Results of studies have again been inconclusive; however, there appears to be more success in improving learning outcomes with high ability students (Goetzfried et al., 1985b; Lee, 1990). High ability students tend to be able to manage a greater degree of learner control in software. They are more aware of their metacognitive processes and as such, can make better decisions with respect to choosing to optimise learning. High ability students also tend to have a better attitude towards mathematics and are more motivated when using software with a high level of learner control (Ross et al., 1981).

Low Ability Students and Learner Control

Previous research on learner control with respect to using computers has seen a number of general, and inconsistent findings that relate to the learning process and outcomes of low ability students. Niemiec et al. (1996) concluded that "students benefit from some form of learner control" (p. 166). Cameron (1992) stated that learner control, can, to a certain extent "alleviate boredom, frustration and anxiety because it enables students to bypass elements of the content" (p. 65). Robson et al. (1987) noted that "school children of 14/15 years of age are able to make thoughtful choices, which take into account their current tasks and learning situations, when given control over elements of computer-based lessons" (p. 102). The children's

academic ability prior to the study was not mentioned by these researchers. Cameron (1992) concluded that learner control was only suited to high ability students. However, the present researcher disagrees with the broadness of this statement. With low ability students a key aspect of success in respect to learner control is their own motivation. High motivational areas of the curriculum such as design and technology may find that these problems are diminished.

Inconsistency in results with reference to academic achievement has been highlighted by Morrison et al. (1992), Cameron (1992) and Niemiec et al. (1996). Ross and Morrison (1989) also found results to be inconclusive; however, they noted that low achieving students had been found to "lack the knowledge and motivation to make appropriate decisions" (p. 28). Morrison et al. (1992) focussed on student individual characteristics and found that "low achieving students lack the knowledge and motivation to make effective decisions" (p. 6). Cameron (1992) expressed concern at the possibility that low achieving students were missing important content due to their inability to monitor their own learning. Goetzfried & Hannafin (1985a) extended the group of low achieving students to include younger students, who having less background knowledge in content are unable to make appropriate judgments.

Motivation and Attitude

The motivation of low ability students impacts on their success or failure when using learner controlled software. The motivation of a student, as defined by Kinzie, Powers and Foss (1993), is the "student's willingness to learn" (p. 101).

Kinzie et al. (1993) found that students using software with a high level of learner control "seemed keen to use the computer programs" (p. 97). The students progressed further, tended to maintain interest and go beyond the required learning when in a learner controlled environment. The attitudes of students have also been examined, with Friend et al. (1990) noting that students given high levels of learner control "expressed a more negative attitude toward the CBI" (p. 48). On the contrary Holmes et al. (1984) found that "when learner control is offered, students generally display a more positive attitude in the learning process" (p. 106). Researchers have found that learner control can improve a student's attitude (Goetzfried et al. 1985); however, Higginbotham-Wheat (1990), found that there were no differences in attitude or motivation between students using software with high levels of learner control and students using software with no learner control.

Learning Efficiency

The efficiency in learning was one of the focuses of the present study. Relan (1995) defines efficiency as "the amount of learning per second" (p. 147). Goetzfried & Hannafin (1985a) found that high ability students were more efficient learners than low ability students when given higher levels of learner control in a CAI environment. The impact of environment on efficiency is acknowledged by Holmes et al. (1984), when he found that often the period of time that students spent on the computers was not enough time for them to adjust to the new environment to derive maximum benefit. Lee and Lee (1991), and Kinzie, Sullivan and Berdel (1992) acknowledged that a greater prior knowledge in relation to the

topic being studied increased the learning efficiency, however the latter also highlighted concerns in that low ability students given learner control still missed important aspects of the topic. When students are made aware of the specific learning requirements then these omissions can be reduced (Johansen et al., 1983). Lee et al. (1991) identified that the "learner control strategy may work better for tasks of simple content structure, in which minimal prerequisite knowledge is required" (p. 497).

Conclusion

The use of computers in schools is controversial with respect to the learning outcomes being achieved. Teachers are encouraged to place students on computers to use software to enhance their learning. Software design available today can provide students with a wide degree of learner control. Research into the degree of learner control given to students and resultant learning outcomes has not been conclusive; in fact, a wide range of findings has occurred with different samples of students. The empirical nature of the research undertaken has largely ignored the large characteristic differences that occur between students, it is therefore appropriate to consider smaller samples and to be more realistic in attempting to accommodate these differences. The software selection process undertaken by teachers can then be tailored towards meeting the needs of a specific population of students, so that the required degree of learner control can be determined and subsequent learning outcomes maximised.

Chapter Three

Method

In this chapter the software package and rationale for using MBM are discussed. The student sample characteristics are then presented and the computer systems used for the study described. The procedures of the study that were common to both Stuart DHS and Nelson are presented which include the tests and interview. The individual differences in procedures that occurred at both schools are then discussed along with the role of the researcher while the students were on the computers.

The Software Package

In lower school mathematics students are required to perform calculations that require interpretation of worded problems. Some of these require the students to identify the mathematical component of the problem, formulate an equation, solve for the unknown variable and then to convert the solution back into a meaningful answer. These problems can vary in difficulty from one step to multi-step problems incorporating a range of concepts. MBM is a software package that highlights these processes along with enhancing other numerical skills.

Description of the Software

MBM was written in 1989 and consists of four activities designed to enhance problem solving skills. Each activity has distinct characteristics and four levels that increase with difficulty with a change in level. The distinction between levels is apparent with the number of steps required to solve the problem and the mathematical concepts required to reach a solution. The four activities are *Follow The Steps*, *Weigh The Evidence*, *Decipher The Code*, and *Search For Clues*.

Follow The Steps This activity consists of word problems where the objective is to identify what the problem is asking, select the relevant information, identify the correct mathematical expression and then solve. The number of steps required differentiates the four levels. For example level one has one or two-step solutions using basic number skills such as addition and multiplication using whole numbers and fractions. Level four problems include decimals and percentages along with use of ratio and equations in two and three-step problems.

Weigh The Evidence With this activity students are presented with a screen consisting of three scales. The objective is to move specific weights off the first scale onto either the second or third scale in the least number of moves. The differing levels are determined by the use and combinations of percentages, decimals, fractions and whole numbers.

Decipher The Code This activity requires the student to generate equations from given information. Students are given information such as the number of digits in the equation and at level one, the location of the equal sign. Again with the increased levels of difficulty the operations required to be solved become more complex with combinations of +, -, x and ÷ along with the location of the = sign being required.

Search For Clues The final activity places emphasis on the organising of information that the student obtains in determining the mystery number. Clues are provided in a visual activity that requires the student to look behind items in a house presented on the screen. The levels of difficulty are determined by the range of the mystery numbers (level 1, 1 to 50, to level 4, -100 to 100) and the complexity of the clues provided.

MBM also provides the teacher with a basic editing facility that enables new questions to be written into the package, thus enabling the catering for individual needs to be fully utilised (this facility is for the activity of *Follow the Steps* only). A motivational aid is also provided to the students in the form of a points tally and a certificate that provides personal details of the progress made by each user.

The version of the MBM software package used in this study had to be able to be run on a 486 Intel processor with Windows 3.11. MBM has been written to accommodate a number of operating platforms; however, the Windows platform was used as this is available to both of the schools. In addition, to use different

platforms would only introduce another variable and complicate the validity of the results (MBM has significantly different graphics in a Macintosh environment compared to a Windows environment).

Rationale for Choice of Software

To increase the validity and generalisability of the study it was important that students had access to high quality software (with respect to learner control) for the study. Research into the effectiveness of CBL needs to implement software that utilises the facilities available in an interactive multimedia (IMM) environment. Software design, which is the key to high quality software, needs to be addressed to ensure that the research conducted does justice to the CBL environment being examined.

Ring, Ellis and Reeves (1994), acknowledged deficiencies in the area of software design, stating that "Current design principles are largely based on beliefs unsupported by research knowledge of the way users interact with IMM environments" (p. 485). They went on to address issues such as interactivity, human factors, individual differences and cognitive load in respect to the human computer interface issues. Aspects of these factors directly influence the selection of the software for this research. For example, Ring et al. (1994), believed that as a result of using computers the normal cognitive load associated with learning was expanded, with the structure of the program and the method of response being required to be known by the user. There is a minimal increase in cognitive load

using MBM as the user is required to be familiar with a number of conventional computer operating techniques. These include use of a mouse to select appropriate responses, pull-down menus and basic DOS operational commands.

Certain characteristics need to be incorporated into the design so that the target group of students find the CBL environment stimulating whilst achieving outcomes in the most efficient manner available. Glatz, cited in Phillips and Crock (1992), believed that screen design was a crucial factor in the overall design of the software. Aspects of a well designed screen included meeting the needs of the individual users as well as utilising the capabilities of the software (p. 238). Phillips et al. (1992), concluded that "Perhaps the most important rule of screen display design is, the "simpler the better" (p. 242). The screen design of MBM is characterised by its consistency and simplicity. The package initially asks for the student's name and then the user is presented with four activities presented in the form of icons. Once in the activity students have a clear understanding of what is required to solve the problems.

The software should ideally incorporate a number of testing facilities so that student outcomes can be accurately measured. When students are completing these tests certain features should be present in the design so as to simulate traditional testing methods. Ring (1992) discussed a number of desirable features, of which the researcher believed the most important is the facility enabling the students to change responses prior to finishing a test. With the problem of having students of low ability and motivation, this could be a critical feature in determining the

success or failure of a piece of software. MBM has a facility which enables editing to take place for the activity of *Follow The Steps*. The teacher can create problems for any level of difficulty, which can be used as a testing facility. The courseware program provides a hardcopy of examples, which can be used as a test item bank. The researcher believed that when testing occurs it would be better to use the hardcopy examples that MBM provides as it enables students to change responses as required. The software package itself doesn't provide this facility under a testing environment.

While the design of software was not the focus of this study, for an accurate evaluation of the degree of learner control to take place, the design of the software must be of a high quality and must relate to the specific outcomes desired. The selection of MBM has been made because of the strengths it has in meeting a number of key features described above.

Research Questions

The researcher aimed to address the following questions in relation to the level of learner control using MBM.

Question One

Is the implementation of *Math Blaster Mystery* designed with a low level of learner control more effective with lower ability students than implementation designed with a higher level of learner control?

Question Two

Do lower achieving students who are afforded a high level of learner control use the *Math Blaster Mystery* package more efficiently than students who are afforded a low level of learner control?

Sample of Students

The study was conducted with seven students from Nelson District High School and nine students from Stuart District High School (both pseudonyms). The researcher randomly divided the students from each school into two groups, either a high level of learner control (hereinafter referred to as the High group) or a low level of learner control (hereinafter referred to as the Low group). None of the students had used the package of MBM previously, in fact, MBM had to be installed on all the computers prior to the study taking place.

The students at Stuart DHS, the researcher's own school, were used to a structured learning environment in mathematics. Usually the only control they had was in the rate at which problems were completed. As such, the researcher expected that students in the High group using MBM would find difficulty in monitoring their own progress and making effective decisions regarding their own learning. From speaking to the teacher at Nelson DHS the researcher concluded that the students were used to a similar learning environment. The students from both schools had undertaken MSE (Monitoring Standards in Education) testing at the beginning of

the year. Both of the schools provided the researcher with the results of these tests which were used to confirm the students' general low achievement in mathematics.

Procedure at Nelson DHS

The sessions at Nelson DHS were conducted first. The students selected for this study had been identified from the MSE tests as being low achieving. Four of the seven students were randomly selected for the High group. The remaining three students were allocated to the Low group.

The students in the High group were placed on one side of the computer room, and the students in the Low group were placed on the other side of the room. This seating arrangement was maintained for all of the sessions except for the post-test. For this session the students were spread out so that they could not see the screens of other students.

Procedure at Stuart DHS

The sessions at Stuart DHS were conducted a week after the completion of the sessions at Nelson DHS. The students had also been identified as being low achieving by the researcher as he had taught the students at a low level for the previous two years. Five of the nine students at Stuart DHS were randomly selected for the High group. The remaining four students were allocated to the Low group. As with the Nelson DHS students, a pre-test was given prior to starting on the MBM package. Students again were supplied with calculators for the pre-test

and these calculators were available to them for the sessions on the computer. Instructions given prior to the test were the same as at Nelson DHS.

The students in the Low group were placed together on the computers located at the back of the computer room. They had the same log sheets as the Low group at Nelson DHS. The procedure for completion of the log sheets and sequence of activities taken was also equivalent. The number of sessions varied because of the length of the periods at Stuart DHS. An additional period was given to the students so that they had the same amount of computer contact time as the students in Nelson DHS. Students carried over the activity from the first session for a period of 15 minutes before commencing on the next activity. This continued for the remaining sessions.

The High group were placed on the remaining computers in the computer room and they were seated all together. They utilised the same log sheets as their counterparts in Nelson DHS. They also had an additional period so that the contact time was the same.

For the final test, the students remained in the same seats as for the activities. The reason for this was that there wasn't the space or facilities available to duplicate the seating arrangements that occurred at Nelson DHS.

Role of the Researcher

In both of the schools the role of the researcher was the same. The researcher demonstrated the aims of each of the activities and navigation through the package. The researcher had four main tasks to perform throughout the sessions at both schools.

Task One

The activities had to be demonstrated a number of times by the researcher throughout the sessions as the students were unsure of what was required. The students were reluctant to utilise the help facility of the package even though they had been shown it.

Task Two

The researcher continuously moved amongst the students to ensure that the data that they were collecting was correct and that they were remembering to log the data on their log sheets.

Task Three

The researcher asked the High group of students questions concerning their path through the package, freedom of control that they had, and their general feelings towards the activity itself. Similar questions were also asked of the low level of control students, however; the navigational questions were not required.

Task Four

The researcher found it necessary to explain the use of some functions of the scientific calculator as, for example, the students were unfamiliar with the fraction button and percentage functions. Other instruction was also necessary in relation to the mathematical contents of the package. Some students were unsure of how to solve the problems so some assistance was given.

Computer Systems

The students at Nelson DHS accessed MBM using IBM compatible computers with Pentium 166MMX processors running Windows 95. A shortcut was placed on the desktop so that students accessed the package simply by clicking on this icon after startup. The students at Stuart DHS accessed MBM using computers with 486 DX2/66 processors running DOS 6.22 and Windows 3.11. The researcher was unable to create an icon to run MBM from Windows 3.11, so the students accessed the package through DOS. The instructions for this were placed on the whiteboard for the students to follow. Students of both schools had access to scientific calculators in addition to the calculator provided by MBM.

Procedures

Prior to using MBM all of the students were given a pre-test. The pre-test was a hardcopy test that consisted of examples from the four activities in MBM. Students used the same calculators for this test as they used with MBM. Prior to the test

students were instructed on the correct format in answering the questions. There was no further assistance given to the students during the test.

At the start of the first session, all of the students were shown how to access the package on the desktop. The activity of *Weigh the Evidence* was demonstrated to the students along with basic navigational features so that the High group could navigate around the package. The sessions totaled four hours on the computers. This was to enable students to have an opportunity to have one hour per activity. There was one session each day and all the sessions were completed within one week.

The Low group were given a Log sheet (Appendix C) which enabled them to record the number of questions completed and the average number of points that the student received for each question. Once the student had completed five questions at level 1, for the activity they would record their results on their log sheet and proceed to the next level.

This procedure was repeated for the other three sessions so that students covered all of the activities in the given time. Each student in this group worked at their own pace. The implication of this was that each student completed a different number of problems and reached different levels on the same activity.

The High group were given a different Log sheet (Appendix B) so that they could record the path they took through the package. Each student logged the order of

activities they took as well as the number of questions and the average score they received for each level. This procedure was the same for all of the sessions. Each student had the previous day's logs in front of them so that they knew where they had been before in the package. There was no requirement for the students to complete a set number of problems in any activity or level prior to moving to another activity or level.

At the conclusion of each session the students powered off the computers and the class as a whole had the opportunity on the activities for the session, the paths that they took and any other pertinent comments.

End Test

After the completion of the four sessions the students were given the End Test. The process involved students being given a number of questions to complete from each of the activities provided by MBM. The test involved use of MBM and as such it was completed on the computers. The students had a choice of which activity and level to choose the questions from. The one limitation placed on the students was that they could answer a maximum of five questions from any given level in an activity. Students could answer less if they wished. When the students wanted to leave the level they informed the researcher and the results were recorded on their test log sheet (Appendix D).

The students had no assistance in the use of the calculator, the navigation of the package, or the problems themselves. The only exception to this was the Stuart DHS group of students. Because of the nature of entry to the package, the DOS commands required to start the program were given. The Nelson DHS students only had to access the shortcut on the desktop.

The Concluding Interview

At the end of the sessions and the final test each student was interviewed (Appendix E) concerning the sessions on the computers, MBM and their general attitude towards mathematics and computers. The procedure for this was the same for students from both schools. The researcher conducted each interview with a student on a one to one basis. The process involved the researcher asking the questions one at a time and noting the responses. When necessary the researcher explained the questions to the students as they were unsure of the exact meaning of the question. No students had the opportunity to discuss the interview questions with other students prior to their interview taking place.

Post Test

Three weeks after the conclusion of the sessions a Post Test was given to both groups of students at each school. The researcher was not present for the tests at Nelson DHS, and therefore gave instruction to the students' normal teacher regarding the structure of the test. The students' teacher took on the role of the

researcher and recorded the students' results on the Post Test log sheet (refer to Appendix F). All other conditions were the same as for the End Test.

Summary

This chapter has presented and explained the method employed by the study. The next two chapters present and discuss the results and limitations of the study and draw final conclusions.

Chapter Four

Results

The data obtained from, and about, the students at Nelson DHS and Stuart DHS are presented in this chapter. Firstly the results of the MSE test are given and then observations and student progress that occurred in each session are discussed. The three test results are then tabulated in forms that illustrate both the results and learning efficiency that took place. The data collected from the student log sheets used during the sessions are then presented. Students recorded both the path and number of questions attempted for each session on these sheets. Finally, the interview data is used to highlight commonalities in responses relating to prior knowledge, attitude and the path taken through the package of MBM.

Student Performance Profiles

The researcher's first aim was to identify the students used in the study as being low achieving. The test used for this was supplied by the Education Department of Western Australia. The Monitoring Standards of Education (MSE) test was administered to students by their respective teachers at both of the schools prior to this study taking place. This test is conducted regularly by the department and was not specifically given for this study.

The MSE test addressed three strands of mathematics: measurement, space and number. The results given in the Table 4.1 provide details of the students' performance in the areas of measurement and number as these were the

predominant strands relevant to the package of MBM. The results confirmed the selection of students as being below the normal level of achievement for children of this age.

Table 4.1

Students scores on the MSE Test for the Measurement and Number Strands

		Score on Mathematical Strand	
School	Student	Measurement[a]	Number[b]
Stuart DHS	Carol	3	2
	Fiona	2	2
	Helen	2	1
	Gwen	n/a	n/a
	Cathy	2	2
	Andrew	3	2
	Laura	1	3
	Kent	1	1
Nelson DHS	Kim	0	0
	Mathew	1	1
	John	0	1
	Tim	3	3
	Wayne	2	1
	Ben	1	0
	David	2	3
	Julie	2	2

Note. Gwen was absent on the day that the MSE was given to students.
[a]Maximum possible score of 17, statewide 25th percentile of 6.
[b]Maximum possible score of 22, statewide 25th percentile of 5.

The student performance profiles for students in Western Australia provide the following information. The possible scores that students can achieve range between 0–18 for measurement and 0–22 for number. The state average for the strand of measurement classifies the middle 50 percent of student performance as ranging between scores of 6–10. In respect to the strand of number the middle 50 percent of performance ranges between the scores of 5–12. These results confirm

that all the students in the present study all lie in the lower 25 percent of student achievement for these strands of mathematics.

Observations at Nelson DHS

The students at Nelson DHS were observed in four one-hour sessions using MBM.

Session One

In this session all students were introduced to MBM and the activity *Weigh the Evidence* was demonstrated to all of the students. The students in the Low group were then instructed to start this activity for the session. The students in the High group were introduced to the other activities and then were allowed to chose their own activity. All students responded well to the instructions. All students preferred to use a scientific calculator in preference to the calculator provided by the package. The students did not like how the calculator remained on the screen and covered the assigned mathematical problems. This made the use of the computer-based calculator cumbersome.

All of the students in the High group, except one (David), preferred to start on the activity of *Weigh the Evidence*. David started on *Follow the Steps*. Most of the students required guidance in the use of the package as they were reluctant in using the help facility provided by MBM. The students were reluctant to ask questions initially, probably because they didn't know the researcher very well. Their usual

teacher was also present and assisted the students in a manner similar to that of the researcher.

Session Two

The students in the Low group worked on the activity of *Follow the Steps*. These students worked at their own pace through the problems; however, they all required instruction as to what was required in terms of responses. The assistance was minimal and all of the students became familiar with the activity very quickly. One student (John) progressed into level 2 and 3 very quickly. His scores became very low and the researcher suspected that this was due to the student guessing responses. His regular teacher who was present also suspected this.

Students in the High group started on various activities. It was apparent that when these students were unsure of what was required to be done they returned to the activities they had done in the previous session. The researcher again felt that they were reluctant to ask questions. However, they did ask each other for help. Only one of these student's (David) asked for help in relation to the mathematical content of the activities. The students were also hesitant in moving to level 2 in each activity as they were aware that these problems were more difficult.

Session Three

The Low group worked on the activity of *Search for Clues*. The students were unfamiliar with the basic algebra skills that were required to be known and this was

explained to them. Progress through this activity was slow and students resorted to guessing at times just to complete the problems. Once the fraction button was demonstrated to them on their calculators they progressed more rapidly.

The High group all started on different activities; however, they were still reluctant to move to the more difficult levels (only Julie moved to level 2). Another student (Wayne) continued with the same activity that he had been working on for the previous two sessions. He enjoyed this activity and felt no need to progress to a different one.

Session Four

The Low group started the activity of *Decipher the Code*. These students completed more questions in this session then any of the other previous sessions. The students required a minimal amount of help with respect to the requirements of the activity. There was no other need for assistance. When questioned regarding the activity, they all had little to say; however, they said that they were enjoying it.

Two of the students (Wayne and Julie) in the High group started to become bored with the package and started moving around the room. The researcher permitted this as they were not disturbing other students. After about 10 minutes they returned to their seats and recommenced work. A different student (David) moved to level 2 for two activities and then for the last 15 minutes of the session jumped to level 4 in the activity, that of *Follow the Steps*.

Summaries of Student Progress - Nelson DHS

The progress of students at Nelson DHS was summarised according to their group.

Low Level of Learner Control

Table 4.2 summarises the progress of the students in the Low group. They were instructed to complete five questions from a level before moving to a higher level. Some students completed more questions than were required in a particular level and these results have been recorded. Each session was restricted to one activity.

Mathew found no difficulty in the use of MBM, however, he found the mathematical content difficult in level 2. John experienced the same difficulties as Mathew. His scores in the activity of *Follow the Steps* reflect the researcher's observation that he was guessing answers in an attempt to complete as many questions as possible. Tim was absent for one session. He said that if he knew that the session was being conducted then he would have attended as he was enjoying the activities.

Table 4.2

Number of Questions Attempted and the Average Score (%) By Level for Nelson DHS Students in the Low Group

		Questions Answered (Average Score)			
Student	Activity	Level 1	Level 2	Level 3	Level 4
Mathew	Weigh the Evidence	5 - (49)	4 - (36)	-	-
	Follow the Steps	5 - (46)	5 - (50)	-	-
	Search for Clues	7 - (70)	7 - (56)	-	-
	Decipher the Code	5 - (62)	5 - (84)	5 - (64)	-
John	Weigh the Evidence	5 - (75)	3 - (35)	-	-
	Follow the Steps	5 - (50)	5 - (18)	5 - (22)	5 - (35)
	Search for Clues	n/a	-	-	-
	Decipher the Code	n/a	-	-	-
Tim	Weigh the Evidence	5 - (69)	5 - (63)	2 - (20)	-
	Follow the Steps	n/a	-	-	-
	Search for Clues	10 - (63)	5 - (43)	5 - (44)	-
	Decipher the Code	5 - (88)	5 - (52)	5 - (84)	5 - (62)

Note. n/a implies that John was absent for 2 sessions and Tim was absent for 1 session.

High Level of Learner Control

The general path taken for each student is described below. Each student in this group (Wayne, Ben, David and Julie) took a different path in MBM for each session. A table presentation has not been used (as in Table 4.2) because it would not adequately present the data collected. Since the High group could choose their own path, a similar table would not illustrate the path taken by the students. A description of the path by each student given below provides a more clear and accurate account of the content accessed and path taken by the High group through MBM.

Wayne started on the activity of *Weigh the Evidence* and he remained on this activity for the first two sessions. In session two he moved to level 2 for a period of time and returned to level 1 as level 2 was too difficult. In session three he remained on this activity and at the end of the session he completed one question from *Decipher the Code*. Session four was similar to session three; however he completed more questions from *Decipher the Code*. He only attempted questions from level 1 for this activity.

Ben started on the activity of *Weigh the Evidence* and continued on this activity for most of the first two sessions. He only completed two questions from other activities. He kept on level 1 for these sessions and was absent for sessions three and four.

David attempted a number of questions from each of the four activities for the first three sessions. Unlike the other students he did not focus on any one activity, however it was not until the final session that he moved to level 2. He completed a number of questions at this level for the activity of *Follow the Steps* and then moved straight to level 4 and completed more questions. He said that he wanted to know how hard the questions got.

Julie attempted questions from all of the activities except for *Decipher the Code*. She spent approximately the same amount of time on the three other activities for the first three sessions, however, she only once moved to level 2 for the activity of

Search for Clues. In the final session she spent most of her time on *Search for Clues* as this was her favourite activity.

Observations at Stuart DHS

There were five sessions at Stuart DHS because of the difference in the times of the school periods. The descriptions below describe the progress of students in the Low group for four one-hour sessions, with one session for each activity. The High group of students are described in each of the five periods. The reason behind this is that the periods in the school timetable at Stuart DHS were less than one hour. Students in the Low group had one hour on each activity; therefore, they continued their activity into the next period to complete one hour. This occurred for all of the sessions on the computers. The High group of students did not need to have time allocated into hour sessions so the researcher collected data over the five periods.

Session One

The first session took a similar form to that of Nelson DHS. All of the students were introduced to MBM. The Low group then commenced the activity of *Weigh the Evidence* and the High group were shown the other activities. Throughout the session all of the students asked questions in relation to the mathematical content and navigation of the package. The difference between this group and the students at Nelson DHS was that the researcher had been teaching these students mathematics for the previous two years and they felt more at ease asking questions. The Low group progressed through the activity and levels 1 to 3 well, except for

one (Fiona) who found it difficult to understand what was required. This was even the case after the researcher and other students had explained the requirements to her.

The High group started on various activities and all progressed slowly. The tendency for each student was to do a couple of questions from each activity and then progress to another. The students' reasoning behind this was to see which was the best activity to do.

Session Two

The Low group commenced the activity of *Follow the Steps*. All of the students except one (Gwen) reached level 3 before the end of the session. All needed minimal instruction with respect to what was required and also in the use of fractions on the scientific calculator. When the researcher queried the students in relation to the package all were happy using MBM and that it was better than doing bookwork.

All except one student (Laura) of the High group started on the activity *Weigh the Evidence* and this she changed to this activity after completing one problem. This was because she wanted to do the same as the others. When these students changed activities it was for the reason that they felt like doing something else. Only one student (Andrew), gave another explanation who started a methodical approach in

completing one question from each level and then progressing to another. He said that he wanted to complete questions in all of the areas of MBM.

Session Three

The Low group commenced the activity of *Search for Clues*. Progression through this activity was quicker with only one student not reaching level 4. The students used the hint facility constantly when the researcher demonstrated it to one of the students. There was cooperation throughout the group in this session.

The High group started on different activities; however, they were all on level 1. All of the students progressed through to level 2 except one during the session. The student (Andrew) in session two who commenced the strategy of one question per level continued this strategy. Two other students (Cathy and Laura) had a race for most of the session to see who could complete the most questions in the activity of *Decipher the Code*. When questioned about this, the students said it was fun to work this way. The average scores they received were of no concern to them.

Session Four

The activity of *Decipher the Code* was completed in session four with the Low group. The questions asked by the students primarily related to the mathematical content of the package and the interpretation of mathematical symbols. All of the students were reluctant to use the help facilities. One student (Gwen) in particular

found the language in the help facility difficult to comprehend. They all agreed that it was easier to ask the teacher.

The High group again all started on various problems; however, they were all on level 1. The student (Andrew) who commenced a strategy in answering one question from each level continued this in this session. Some of the students (Cathy and Laura) started to become bored with one student's exiting out of the program to play a game. Once other students saw this, they all wanted to do the same. The researcher instructed the students that they didn't have to use MBM if they didn't want to; however, they were not allowed to play games instead. All of the students then returned to using MBM for the remainder of the session.

Session Five

The High group remained on level 1 for the entire session except the one student (Andrew) who again attempted one question from each level and activity. No students made any comment about how they were going besides "being OK". Students continued to chose an activity because that's what they wanted to do.

Summaries of Student Progress – Stuart DHS

The progress of students at Stuart DHS was summarised according to their group.

Low Level of Learner Control

Table 4.3 summarises the progress of the Low group students through MBM. They were instructed to complete five questions from a level before moving to a higher level. Some students completed more questions than were required in a particular level and these results have been recorded. Each session was restricted to one activity.

The four students interacted with each other a lot more than the students at Nelson DHS. The researcher attributed this to two reasons. Firstly, the seating plan used meant that the students were in a more confined space than the students at Nelson DHS, and secondly, they were used to having the researcher as their mathematics teacher.

Table 4.3

Number of Questions Attempted and the Average Score (%) By Level for Stuart DHS Students in the Low Group

Student	Activity	Questions Answered (Average Score)			
		Level 1	Level 2	Level 3	Level 4
Carol	Weigh the Evidence	6 - (81)	6 - (83)	5 - (73)	-
	Follow the Steps	5 - (81)	2 - (72)	5 - (59)	-
	Search for Clues	5 - (68)	2 - (50)	5 - (49)	-
	Decipher the Code	6 - (86)	5 - (76)	-	-
Fiona	Weigh the Evidence	1 - (45)	1 - (20)	-	-
	Follow the Steps	5 - (49)	5 - (57)	5 - (48)	5 - (52)
	Search for Clues	5 - (29)	3 - (58)	6 - (56)	3 - (20)
	Decipher the Code	5 - (60)	5 - (77)	5 - (82)	-
Helen	Weigh the Evidence	5 - (73)	1 - (29)	-	-
	Follow the Steps	5 - (54)	2 - (47)	4 - (56)	-
	Search for Clues	5 - (73)	5 - (64)	4 - (56)	1 - (20)
	Decipher the Code	4 - (67)	2 - (60)	-	-
Gwen	Weigh the Evidence	5 - (86)	7 - (70)	3 - (95)	-
	Follow the Steps	5 - (65)	2 - (60)	-	-
	Search for Clues	n/a	-	-	-
	Decipher the Code	n/a	-	-	-

Note. n/a implies that Gwen was absent for 2 sessions.

High Level of Learner Control

The general path taken for each student is described below. Each student in this group (Cathy, Andrew, Laura, Kent and Kim) took a different path in MBM for each session. Once again a table presentation has not been used (as in Table 4.3) because it would not illustrate the information required.

Cathy concentrated on the activities of *Weigh the Evidence*, *Decipher the Code* and *Search for Clues* for the first two sessions. Most of her work was in level 1 with

only a few attempts being made in the more difficult levels. In session three and four Cathy concentrated on *Decipher the Code* and *Search for Clues* and only attempted three questions in level 2. She never attempted questions in level 3 or 4 for any of the activities. Cathy was absent for the final session.

Andrew started session one on *Weigh the Evidence*. He moved to level 2 after one question. During session two Andrew changed the way that he was completing the questions and started on completing one question from each level for each activity. This strategy was maintained for the remainder of the sessions except for session three when he was absent.

Laura started on the activity of *Follow the Steps* and completed 3 questions. She then moved to *Decipher the Code* and *Search for Clues* where again she only completed a small number of questions. For the remaining sessions she concentrated nearly exclusively on the activities of *Weigh the Evidence* and *Decipher the Clues*. Laura occasionally moved to level 2 in these activities.

Kent withdrew from the study after completing the pre-test. He stated that he no longer wished to participate. No other reason was given. The researcher suspected that because his best friend wasn't participating then he wasn't going to either. This was quite often the case in other activities in the class.

Kim was sitting next to Laura and completed the activities in a similar way concentrating almost exclusively on the activities of *Weigh the Evidence* and *Decipher the Code*. He did, however, move to level 2 more frequently than Laura.

Pre-Test

The pre-test (Appendix A) was given to all the students prior to any computer contact with MBM. The purpose of the test was to ascertain if there was any difference between the students based on the content of the activities that they were going to do with MBM. The pre-test was obtained from written material supplied with MBM. The scores from the test are shown in Table 4.4 to which a non-parametric test (Kruskal-Wallis) was applied. The purpose of conducting this test was to determine if there was any difference in the results obtained from the two groups (High and Low).

Table 4.4

Pre-Test Scores for all Students, Presented by Group

Group	Student	Score (%)
Low level of learner control	Carol	60
	Fiona	52
	Helen	21
	Gwen	39
	Mathew	27
	John	23
	Tim	66
High level of learner control	Cathy	34
	Andrew	30
	Laura	33
	Trent	11
	Kim	17
	Wayne	21
	Ben	27
	David	43
	Julie	17

The null and research hypotheses for this test are,

H_0 : The mean of students with a low level of learner control are equal to that of students with a high level of learner control.

H_A: The mean of students with a low level of learner control are not equal to that of students with a high level of learner control.

The application of the Kruskal-Wallis test gave that $H = 0.57$. The value of $\chi 2$ at 0.05 level of significance for 1 degree of freedom was 3.841, therefore, H_0 cannot be rejected. The two groups performed equally in the pre-test. Therefore, there were no significant differences between the two groups with respect to the mathematical content of MBM prior to the sessions using MBM.

End Test

The purpose of the End Test (Appendix D) was to ascertain if there was a difference between the students' outcomes in learning based on which group they were in. The End Test occurred immediately following the sessions on MBM. This test involved the students using the MBM software that they had been using during the sessions. Each student had the choice of completing five questions from each level of the four activities. Once the student had completed a level in an activity the number of questions and the average score was recorded before the student commenced the next question. These results have been recorded in Table 4.5. Again the Kruskal-Wallis test was used to compare the results for the two groups.

Table 4.5

End-Test Scores for all Students, Presented by Group

	Student	Score (%)
Low level of learner control	Carol	71
	Fiona	31
	Helen	36
	Gwen	n/a
	Mathew	36
	John	n/a
	Tim	79
High level of learner control	Cathy	62
	Andrew	33
	Laura	64
	Kim	44
	Wayne	43
	Ben	28
	David	67
	Julie	43

Note. Kent withdrew from the study.
n/a implies that Gwen and John were absent on the day of the test.

The null and research hypotheses for this test are,

H_0 : The mean of students with a low level of learner control are equal to that of students with a high level of learner control.

H_A: The mean of students with a low level of learner control are not equal to that of students with a high level of learner control.

The application of the Kruskal-Wallis test gave that H = 0.021. The value of χ^2 at 0.05 level of significance for 1 degree of freedom is 3.841, therefore, H_0 cannot be rejected. The difference in the two groups are not significant. The researcher concluded that there was no significant difference in student scores between students with a low level of learner control and students with a high level of learner control.

Activity Completion Efficiency in the End Test

Further investigation of the End Test can be conducted with each of the four activities given an equal weighting. The students were instructed to complete as many problems as they could in the testing session provided. The only restriction was that they could only attempt five questions from any level in the activities. When examining the questions attempted by the students and weighting each activity equally a vastly different set of results appear and these are given in Table 4.6. This is a measure of their efficiency in using MBM.

Table 4.6

End-Test Results (%) When Equal Weighting is Given for Each Activity

	Follow the Steps	Weigh the Evidence	Decipher the Code	Search for Clues	Total
Low Group					
Carol	0	83	78	78	60
Fiona	0	0	60	0	15
Helen	0	67	0	58	31
Gwen	n/a	-	-	-	-
Mathew	47	92	80	0	55
John	n/a	-	-	-	-
Tim	0	80	81	75	59
High Group					
Cathy	0	69	79	64	53
Andrew	50	74	79	61	66
Laura	0	89	79	42	53
Kim	0	95	83	43	55
Wayne	32	61	53	0	36
Ben	40	68	55	55	55
David	77	88	55	55	68
Julie	44	75	72	68	65

Note. Kent withdrew from the study.
n/a implies that Gwen and John were absent on the day of the test.

The null and research hypotheses for this test are,

H_0 : The mean of students with a low level of learner control are equal to that of students with a high level of learner control.

H_A: The mean of students with a low level of learner control are not equal to that of students with a high level of learner control.

The application of the Kruskal-Wallis test gave that H = 0.77. The value of χ^2 at 0.05 level of significance for 1 degree of freedom is 3.841, therefore, H_0 cannot be rejected. The student's results varied greatly if they didn't attempt questions from

each of the activities; however, there was still no significant difference between the two groups of students on the End test.

Post Test

The post test (Appendix F) was conducted at both schools approximately three weeks after the end test. The conditions for the post test were identical to that of the end test. The Kruskal-Wallis test was used again to examine the differences in performance with Table 4.7 providing the results.

Table 4.7

Post-Test Scores for all Students, Presented by Group

	Student	Score (%)
Low level of learner control	Carol	62
	Fiona	22
	Helen	25
	Gwen	n/a
	Mathew	22
	John	n/a
	Tim	61
High level of learner control	Cathy	n/a
	Andrew	36
	Laura	36
	Kim	26
	Wayne	n/a
	Ben	29
	David	58
	Julie	28

Note. Kent withdrew from the study.
n/a implies that Gwen, Cathy, Wayne and John were absent on the day of the test.

The null and research hypotheses for this test are,

H_0 : The mean of students with a low level of learner control are equal to that of students with a high level of learner control.

H_A: The mean of students with a low level of learner control are not equal to that of students with a high level of learner control.

The application of the Kruskal-Wallis test gave that H = 0.30. The value of χ^2 at 0.05 level of significance for 1 degree of freedom is 3.841, therefore, H_0 cannot be rejected. The difference in the two groups are not significant. The researcher concluded that there was no significant difference in student scores between students with a low level of learner control and students with a high level of learner control.

Activity Completion Efficiency in the Post Test

The examination into student efficiency in using MBM when completing the Post Test followed the same criteria as the End Test. The results are listed in Table 4.8.

Table 4.8

Post-Test Results (%) When Equal Weighting is Given for Each Activity

	Follow the Steps	Weigh the Evidence	Decipher the Code	Search for Clues	Total
Low Group					
Carol	79	96	87	69	83
Fiona	45	60	75	34	54
Helen	0	74	0	0	17
Gwen	n/a	-	-	-	-
Mathew	80	0	75	0	39
John	n/a	-	-	-	-
Tim	0	75	67	42	46
High Group					
Cathy	n/a	-	-	-	-
Andrew	83	79	70	54	72
Laura	0	62	74	22	39
Kim	0	98	72	0	43
Wayne	n/a	-	-	-	-
Ben	20	81	63	60	56
David	77	87	47	0	53
Julie	33	86	80	45	61

Note. Kent withdrew from the study.
n/a implies that Gwen, Cathy, Wayne and John were absent on the day of the test.

The null and research hypotheses for this test are,

H_0: The mean of students with a low level of learner control are equal to that of students with a high level of learner control.

H_A: The mean of students with a low level of learner control are not equal to that of students with a high level of learner control.

The application of the Kruskal-Wallis test gave that $H = 0.53$. The value of χ^2 at 0.05 level of significance for 1 degree of freedom is 3.841, therefore, H_0 cannot be rejected. Again the student's results significantly varied if they didn't attempt

questions from each of the activities; however, there was still no significant differences between the two groups of students.

Log Sheets

To examine the efficiency of use of the package in the sessions the researcher analysed the number of questions that each student completed throughout the sessions as provided in their log sheets (The High group log sheet is Appendix B and the Low group log sheet is Appendix C). Although there was no statistically significant difference between the two groups in test scores the number of questions attempted was examined for any difference. Table 4.9 below lists the total number of questions attempted by each student in each activity.

Table 4.9

The Number of Questions Answered from Each Activity for All of the Sessions

Low Group	Follow the Steps	Weigh the Evidence	Decipher the Code	Search for Clues	Total	Adjusted Total
Carol	12	17	11	12	52	52
Fiona	20	2	15	17	54	54
Helen	11	6	6	16	39	39
Gwen	7	15	14[a]	16[a]	22	52
Mathew	10	9	15	14	48	48
John	20	8	10[a]	13[a]	28	51
Tim	20[a]	12	20	20	52	72
High Group						
Cathy[b]	0	8	54	29	91	112
Andrew[b]	12	15	8	8	43	53
Laura	3	40	50	8	101	101
Kim	1	26	21	0	48	48
Wayne	0	43	6	0	49	49
Ben[b]	1	20	0	1	21	42
David	44	27	20	20	111	111
Julie	17	22	0	48	87	87

Note. Gwen, John, Tim, Cathy, Andrew and Ben were absent for one or more sessions.

[a]Data given represents anticipated questions answered if the student had attended the session. Data has been calculated based on the number of questions answered in previous sessions compared to the other students in the same group.

[b]Adjusted total has been calculated on a pro rata basis based on the amount of time that the students in this group were absent from the sessions.

The null and research hypotheses for this test are,

H_0: The number of questions attempted by students with a low level of learner control are equal to that of students with a high level of learner control.

H_A: The number of questions attempted by students with a low level of learner control are not equal to that of students with a high level of learner control.

The application of the Kruskal-Wallis test gave that $H = 4.246$. The value of χ^2 at 0.05 level of significance for 1 degree of freedom is 3.841, therefore, H_0 is rejected.

From analysis of the above data, a number of the students in the High group attempted more questions than students in the Low group. This is particularly the case when the number of minutes for which three students were absent was considered. The researcher also observed that the High group tended to concentrate on particular activities and the most common reason for this was that the students enjoyed these activities more than the others. The researcher believes that the students in the Low group used the package more efficiently as they covered the activities more evenly and completed less of the questions to obtain a similar result in the two tests completed.

Interview

The researcher noted that in general, the students were reluctant to give answers to the interview questions that were more than one or two words long. When opinions were asked for, most students indicated they did not have one. As a result of this, the interviews were not the comprehensive source of data the researcher had hoped.

The researcher interviewed each student (Appendix E) after the End test. The purpose of the interview was to identify any characteristics in the students that may have affected their performance. Three students, John, Gwen and Laura did not participate in the interview because they were absent. There were some notable responses that occurred that were common for most students. Firstly, most of the students recognised that they were low achievers with respect to mathematics,

however, they considered themselves to be reasonably computer literate. The activity sessions on the computer did not change their attitudes towards mathematics. Only one student (Fiona) in the low level of control group wanted more control over how she used the package, all of the others did not mind being told what activity to do. The students with a high level of learner control largely chose their path based on whether or not they liked the activity. They also observed what the other students were doing and if necessary stopped their activity so they could change to another. One student (Andrew) aimed at attempting one question from each level in each of the four activities, and another (Laura) chose to do five questions from each level and then progress to the next activity. It is noted, however, that Laura's actual path taken during the sessions did not reflect her response in the interview.

Summary

In this chapter a number of observations and statistical results were presented. The most important findings of the chapter included the different decisions made by the High group of students in the content attempted and path taken through MBM. The results of these decisions by the students in the High group did not lead to statistically significant difference in the End and Post Tests when compared with students in the Low group. However, the students in the High group generally attempted more questions than the Low group. These questions, though, were mostly concentrated on each student's favourite activity. The attitudes of both groups of students towards MBM were largely unchanged; however, some students

started to become bored with the package towards the end of the sessions. Most students were also content with the degree of learner control they had when using MBM. These results are discussed in relation to the degree of learner control that the students had with respect to software design, motivation and attitude, and learning efficiency in the next chapter.

Chapter 5

Discussion and Conclusion

From the results presented in Chapter Four a number of issues in relation to the impact of learner control on student learning outcomes have arisen. This chapter discusses the results in terms of two focus questions of the study along with other observations that the researcher considered significant with respect to the amount of learner control given to students. The limitations of the study and implications for further research are also addressed.

The purpose of this study was to examine the impact of learner control in software on low achieving mathematics students. The two questions can now be addressed from the observations and results obtained from the study.

Research Question One

Is the implementation of *Math Blaster Mystery* designed with a low level of learner control more effective with lower ability students than implementation designed with a higher level of learner control?

The End and Post test results gathered from the study indicated that there was no statistically significant difference between the two groups of students with respect to content-based learning outcomes using MBM. In general, the high level of learner control students attempted many more questions from MBM than the low

level of learner control students, however, this did not translate to higher scores in the tests. The Low group answered a more even spread of questions throughout the package and even progressed into the more difficult levels, and as such, the researcher believes the Low group used MBM more effectively than the High group.

Research Question Two

Do lower achieving students who are afforded a high level of learner control use the *Math Blaster Mystery* package more efficiently than students who are afforded a low level of learner control?

The paths that students in the High group took through MBM was limited and somewhat disjoint. As such, large numbers of questions from one activity were answered and other activities virtually ignored. Students either stayed on a particular activity too long or changed too quickly to enable learning outcomes to be maximised. On the other hand, the Low group did not have this choice and as a result had time to develop skills from a basic to a more advanced level on one activity. This draws the researcher to conclude that the Low group in fact used MBM more efficiently than the High group.

Software Design of MBM

In the early stages of the sessions the students in both groups used the calculator. It became obvious immediately that the calculator provided by MBM had problems.

When the student displayed the calculator on the screen it covered the problem making the use of it cumbersome. The researcher identified this as a design problem, however, it had little effect on the students with respect to learner control as they used their own calculators instead.

The following observations concerning the Help and Hints facilities were restricted to students in the Low groups. Students in the High group made only token attempts to locate and use the Help and Hints facilities provided by MBM. The Help facility was "discovered" by one of the students in the Low group even after it was demonstrated at the beginning of the sessions by the researcher. The students in the Low group found that the terminology in the Help facility was confusing, and therefore, they preferred to ask the researcher. The researcher believes that the language used by MBM was more suited to students who had a better understanding of mathematics. An example of the language used was the term addend referring to the addition of numbers. The researcher agrees with Phillips et al. (1992) in that well designed software has to be able to meet the needs of its users. The MBM help facility needs refinement with respect to the language used if it aims to meet the target audience that it claims.

Students also found the Hint facility difficult to use. However, they found the feature useful, although, it was not available in all of the activities and this confused the students. The researcher believes that the Hint facility had its limitations in that it actually provided the answer to students on occasions depending on the progress of the student in a problem. The student was then only required to respond giving

the answer that had been provided in the Hint facility. As a result of this students then tended to refer to Hints as a means of providing the answer not in the assistance of solving the problem. In this way the Hints facility gave the students a misconception of success in an activity by providing the students with the answer to a question.

The researcher believes that both the Help and Hint facilities of MBM influenced the students' learning in that its limitations affected the students' ability to use the package effectively. This resulted in students being hindered in making effective decisions relating to controlling their own learning. The researcher agrees with Friend et al. (1990) who place serious importance of learner control features (including feedback) in software design. These two feedback facilities need refinement so when students access them quality information can be obtained. Inadequate decisions, made by students in this study and others (Morrison et al., 1988; Morrison et al., 1992) with respect to learner control may then be reduced and learning outcomes improved.

Motivation and Attitude

From the interviews conducted with the students after the sessions using MBM it was apparent that for the majority of students, the impact of learner control had no effect on either the motivation or attitude of the students. Higginbotham-Wheat (1990) acknowledged this in her research. Only two students stated that their attitude towards mathematics had improved as a result of using MBM. However, these comments related to the use of computers in mathematics, not the degree of

learner control that they had. Towards the end of the sessions some students in the High group became bored with MBM which reflected their low interest level in mathematics. The researcher believes that the reluctance of these students to progress to more difficult problems contributed to this. This is in contrast with Kinzie et al. (1992), where they found that students with a high level of learner control maintained interest and went beyond their required learning. The researcher found that no students in the Low group demonstrated this behaviour; in fact, the majority of Low group students attempted more difficult questions than students in the High groups.

Learning Efficiency

Even though the results of the tests conducted on the students after the sessions indicated no statistically significant differences in the scores obtained it was clear that the High group used MBM differently to the Low group. A number of students did not like particular activities and as such did not attempt them. Kinzie et al. (1992) have acknowledged this in previous research stating that low ability students missed important aspects of topics. A possible reason behind this was the limited time (four one-hour sessions) in which the students had on the computers. Perhaps there was not enough time for the students to adjust to their new environment (Holmes et al., 1984). Students in the High group also had to adapt to having the control of their own learning, something that did not occur often in a traditional mathematics classroom environment. Prior knowledge of the students in respect to the mathematical content and the use of MBM may have influenced the decisions

of students in the High group (Lee, et al., 1991; Kinzie et al., 1992). From the researcher's own experience with the students at Stuart DHS and through consultation with the teacher at Nelson DHS, the students of both groups had been recently exposed to the majority of concepts covered by the package. Only the CBL environment in using MBM was unfamiliar. The researcher believes that the High group failed to consciously monitor their progress and allocate time to each of the activities. Lee et al. (1991) acknowledged this when they identified simple linear tasks as being more suited to low ability students. In respect to this study, linearity would reduce the learner control of the High group to that of the Low group, as it would eliminate both the content and path choices that were available to the High group.

Limitations

Limitations exist in the methodology undertaken by the researcher. The researcher believes that the students at both of the schools were somewhat reluctant to provide feedback in relation to the activity and paths being taken. This was addressed by the interview at the conclusion of the sessions. The small sample being examined has been addressed with respect to the non-parametric test analysing the results i.e. the Kruskal-Wallis test. Other limitations include the fact that only one piece of software was used to investigate learner control and that the students chosen for the study had not been at random. From the researcher's own experience in teaching at country schools it is not unusual for teachers to be severely restricted in the software (along with other resources) that are available to them. Teachers of

mathematics are also faced with students who at best struggle with mathematics. The focus of this research was to examine learner control with low achieving mathematics students in country district high schools.

Implications for Teaching

Implications from this study exist for teachers of low ability mathematics students. When placing low ability students on computers it is better to have structure in relation to the package being used. Teachers should ensure that students have a pre-determined set of tasks so that they have minimal problems monitoring their own progress. This can also enable students to be complete common activities and assist others in the class. Teachers should take on the role as monitor in determining the students' learning, as low ability students lack the knowledge and motivation to do it themselves.

Implications for Research and Software Development

This study adds to the body of knowledge with respect to students using software with a high level of learner control. However, there is a need for more research in the area of learner control so that general findings can be established. The key to future research is the clear definition of the aspect of learner control being examined. Studies should also be extended into all areas of curriculum and across all student abilities. Results from these studies will become more relevant in education as technology becomes embedded in the learning process. This in turn has ramifications for the software designers. With technology advancing rapidly

there is the facility to provide high quality software that can be tailored towards individualised instruction. Software developers have the responsibility to design software that can accommodate individual differences in learning. It is only then, that students having control over their own learning can maximise their learning outcomes.

Conclusion

The focus of this study was to evaluate the effect of learner control on student learning outcomes in a computer-supported learning environment. Two groups of low achieving mathematics students used the package of MBM to enhance number skills and problem solving skills. One group had a high level of learner control which enabled them to determine their own path and content in the package. The other group had no control with respect to path and content. Findings from the study indicate that whilst there were no significant differences in test scores, the low level of learner control group used MBM more efficiently as they covered the activities in a more structured manner. The low level of learner control group also used MBM more effectively in that they completed the problems in a logical and methodical way pre-determined by the researcher. The high learner control group found difficulty in monitoring their progress and failed to make appropriate decisions in relation to maximising their use of MBM. The researcher believes that some design features of MBM such as Help and Hint contributed to the inability of the high learner control group to make effective decisions. Another factor is that these students were unfamiliar with having to make decisions in relation to their

own learning in mathematics. Students will become more familiar with controlling their learning when they are given more assistance and opportunity to do so.

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Appendix A - Pre-Test

Pre-Test Maths Blaster.

Name:_____

Follow the Steps

1. Circle the information, which the problem asks you to find.
2. Underline the information which is required to solve the problem.
3. Write an equation.
4. Solve.

1. The Gordon family collects stamps for one year. They have a total of 256 stamps. Sara has 34 stamps and her father has 57 stamps. How many stamps hasn't Sara got?

2. Joe needs a new pair of pants for the school social. The pants have been marked down from $82 to $54. Mike has $120 how much will he have left over if he buys one pair of pants?

3. Peter is cycling around a large track. It takes 1 minute and 15 seconds to cycle around the track. If he starts cycling at 2:00pm and keeps going at the same speed until 3:30pm. How many laps of the track does Peter complete?

4. On holidays a family is travelling for 6 hours. If they stop twice for a total of two hours and they travel for 250km what was their average travelling speed?

5. Gail dug a hole in the backyard to get dirt for some sandbags. The hole was 1m deep 1m wide and 2m across. If each bag holds exactly 0.3 cubic metres of dirt, how many bags can Gail fill?

6. Dr Weight asked his patient Donna, "How much chocolate do you have each week?" She said, "I have 1 block for breakfast, one with my lunch, two at 2:00 o'clock. My father won't let me have any on Saturday, so I have twice as much on Sunday. How much chocolate does Donna eat each week?

Weigh the Evidence: Write the numbers in order of increasing value

1. -18, 5, 0, -7 _____

2. 4, -6, 3.5, -2 _____

3. $\frac{2}{4}, \frac{3}{5}, \frac{4}{9}, \frac{6}{7}$ _____

4. 0.53, 42%, 4.2, 0.5 _____

5. 0.92, 100%, 85%, 0.71 _____

6. 2.51, 150%, 1.52, 321% _____

7. Find and circle ten combinations of three digits that total 12. The three numbers must touch edges. All circles will be circled only once.

6	5	1	7	1
8	2	9	3	4
2	6	3	0	5
5	4	3	8	5
6	3	1	3	2
2	4	6	6	0

Search for Clues
Can you find out the possible answers.

N is divisible by 2
276 is a multiple of N
$N < 95$
$N \leq 122 + 23$
$N < 100 - 2$
$N < 25 \times 30$
$N \leq 200 \div 2$
N = _____

Find the mystery equation by filling in the missing signs. 3 2 5 = 3 + 2 = 5

4 5 6 7 1 1 2 = _____

3 5 2 7 0 = _____

Appendix B - Log Sheet for High Level of Learner Control

High Level of Learner Control Log Sheet

Name:_____

Session 1:

Activity	Level 1	Ques /Avg	Level 2	Ques /Avg	Level 3	Ques /Avg	Level 4	Ques /Avg
Follow the Steps								
Weigh the Evidence								
Decipher the Code								
Search for Clues								

Session 2:

Activity	Level 1	Ques /Avg	Level 2	Ques /Avg	Level 3	Ques /Avg	Level 4	Ques /Avg
Follow the Steps								
Weigh the Evidence								
Decipher the Code								
Search for Clues								

Session 3:

Activity	Level 1	Ques /Avg	Level 2	Ques /Avg	Level 3	Ques /Avg	Level 4	Ques /Avg
Follow the Steps								
Weigh the Evidence								
Decipher the Code								
Search for Clues								

Session 4:

Activity	Level 1	Ques /Avg	Level 2	Ques /Avg	Level 3	Ques /Avg	Level 4	Ques /Avg
Follow the Steps								
Weigh the Evidence								
Decipher the Code								
Search for Clues								

Appendix C - Log Sheet for Low Level of Learner Control

Name:_____

Session 1:
Write down the number of questions completed and the score.

Weigh the Evidence	Level 1 Questions	Level 2 Questions	Level 3 Questions	Level 4 Questions

Session 2:

Follow the Steps	Level 1 Questions	Level 2 Questions	Level 3 Questions	Level 4 Questions

Session 3:

Search for Clues	Level 1 Questions	Level 2 Questions	Level 3 Questions	Level 4 Questions

Session 4:

Decipher the Code	Level 1 Questions	Level 2 Questions	Level 3 Questions	Level 4 Questions

Appendix D - End Test

End Test Math Blaster Mystery

Name:_____

Attempt as many questions as possible from the activities.

When you complete a level of an activity inform the teacher and they will record the questions attempted and the average score obtained.

A calculator may be used during the test.

Do not proceed to the next activity until the teacher has recorded the results.

Activity	Level 1	Level 2	Level 3	Level 4
Follow the Steps	# ques = Av =	# ques = Av =	# ques = Av =	# ques = Av =
Weigh the Evidence	# ques = Av =	# ques = Av =	# ques = Av =	# ques = Av =
Decipher the Code	# ques = Av =	# ques = Av =	# ques = Av =	# ques = Av =
Search for Clues	# ques = Av =	# ques = Av =	# ques = Av =	# ques = Av =

Appendix E - Interview Questions

Interview Questions for Students using Math Blaster Mystery

Name:_____

1. How do you describe yourself in terms of mathematics ability?

2. Describe your attitude prior to using Math Blaster towards using computers.

3. Describe your attitude prior to using Math Blaster towards mathematics.

4. Describe your attitude after using Math Blaster towards using computers.

5. Describe your attitude after using Math Blaster towards mathematics.

6. Describe how you used Math Blaster. (High Control)

7. Were there reasons behind the path choices that you took? If so, what? (High Control)

8. Comment on the fact that you were not allowed to choose your own path. (Low Control)

9. Would you have used the package differently if given the activity again, and you had a choice of either a high level or low level of learner control?

10. What do you think was good about Math Blaster?

11. What do you think was bad about Math Blaster?

12. Any general comments.