TEACHING LOGARITHMIC INEQUALITIES USING OMNIGRAPH

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A research project in partial fulfilment of the requirements for the degree Magister Scientiae in the Department of Statistics, University of the Western Cape.

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November 2007

CONTENTS

ABSTRACT

In a teaching experiment conducted over a period of six weeks, nineteen third-year teacher training students were exposed to the teaching of logarithmic inequalities in a computer laboratory with the use of the mathematical software package Omnigraph.

The research suggests students' achievement is positively affected when they are exposed to both the algebraic as well as the graphical method to solve logarithmic inequalities.

This research project reports on the results of the teaching experiment.

KEYWORDS

Logarithms

Inequalities

Teaching and Learning

Omnigraph

Mathematics

Teachers

Graphical

Algebraic

Technological Tools

Mathematical package

DEDICATION

To my mother, Zulaiga Basadien, with love and gratitude.

ACKNOWLEDGEMENTS

I wish to thank:

- My supervisor, Prof R.J. Blignaut, for her guidance, encouragement, patience and support.
- My colleagues in the department of Education at the Cape Peninsula University of Technology (Bellville campus).
- My family, for their love and patience.

The financial assistance of the National Research Foundation towards this research is acknowledged.

DECLARATION

I declare that *Teaching logarithmic inequalities using Omnigraph* is my own work, and that it has not been submitted before or simultaneously for any degree to any other tertiary institution of higher education. All sources quoted have been indicated and acknowledged by complete references.

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1. Introduction and literature review

In the teaching experiment conducted over a period of six weeks, nineteen third-year teacher training students in the Education department at the Cape University of Technology (CPUT) (Bellville campus) were exposed to the teaching of logarithmic inequalities in a computer laboratory. These students are studying towards a Bachelor's Degree in Education (B.Ed), which is a four year course and upon graduation they qualify as Mathematics, Science and Technology high school teachers. In most instances, these students come from previously disadvantaged communities as is evident from the background information questionnaire and were only exposed to Mathematics on the standard grade at high school. Furthermore, they only achieved an average of less than 40% for Mathematics (E symbol) in their matriculation examination (Appendix C).

Over the last few years it became clear that the students struggle with the basic concepts of logarithms and inequalities, let alone logarithmic inequalities due to the lack of exposure of these concepts at high school. In order to fully comprehend logarithmic inequalities, a good understanding of the logarithmic graph is important. Thus, the opportunity was seen to change the method of instruction by introducing the graphical method to solve logarithmic inequalities.

Omnigraph (http:/www.spasoft.co.uk), a mathematical software program was available in the department and it was decided to use it in this experiment. Some of the advantages of using Omnigraph according to Software Production Associates (SPA) are:

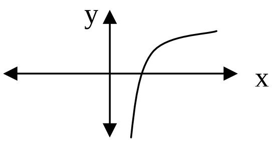
- graphs are drawn quickly an accurately;
- graphs can be changed dynamically;
- graphs can be customized for extra legibility.

Having a graphical package at our disposal brought a new dimension into the teaching and learning environment. Students could now solve logarithmic inequalities algebraically (using paper and pencil), then support their results graphically or vice versa.

(Appendix A sets out an example of the kind of worksheet students were exposed to during the teaching experiment using Omnigraph).

Furthermore, multiple representations of mathematical concepts became possible. For example, the logarithmic function could be thought of in three different ways, namely algebraic (symbolic), numeric as well as graphic (Figure 1).

Figure 1. Multiple representations of the logarithmic function

<table>
<tr><th>Algebraic (Symbolic) form</th><th>Graphical</th><th colspan="2">Numeric</th></tr>
<tr><td rowspan="4">$y = \log_2 x$</td><td rowspan="4"></td><td>X</td><td>Y</td></tr>
<tr><td>1</td><td>0</td></tr>
<tr><td>2</td><td>1</td></tr>
<tr><td>4</td><td>2</td></tr>
</table>

The objective therefore was to ascertain whether exposure to a graphically enriched environment would enhance the student's understanding of logarithmic inequalities.

Computer technology offers a number of didactic advantages such as conjecturing and exploring that can be exploited to promote a more active approach to learning. Students can become involved in the discovery and understanding process, no longer viewing Mathematics as simply receiving and remembering algorithms and formulae. Schoenfeld (1990) have explored the role computers played in a constructivist teaching environment. He suggested that:

> 'Mathematics instruction should provide students the opportunity to explore a broad range of problems and problem situations, ranging from exercises to open- ended problems with exploratory situations.'

Omnigraph can assist in developing an exploratory approach to learning Mathematics and, in particular investigating logarithmic inequality problems. Students can be encouraged to make conjectures, experiment and analyze the results and even consider alternative solutions. Waits (1994) suggested a few fundamental activities in a technology-rich classroom:

- approach problems numerically;
- use analytical manipulations to solve equations and inequalities and support these using visual methods;
- use visual methods to solve equations and inequalities and then confirm results using algebraic methods;
- classify and explore various connections among different representations of a problem situation.

However, technology also introduces some serious problems due to its limitations, which include having little control over the presentation of the solution. (Appendix B sets out an example of two possible solutions obtained from Omnigraph for the same question.). It is therefore essential that students have adequate mathematical competency to interpret the output computer packages such as Omnigraph or any other mathematical software produces.

Another concern is that students may accept results from the output of Omnigraph without question, which may lead to poor understanding and misconceptions.

The methodology will be discussed in the next section.

2. Methodology

The introduction of computer technology brings new opportunities into the teaching and learning environment, allowing students to explore, conjecture and test different types of Mathematics problems graphically. Multiple representation of the same concept becomes possible opening up a different dimension of Mathematics teaching and learning (Gagatsis:2004).

When students are able to recognize links between the different representations of mathematical concepts they would be able to switch between the different representations when required to do so. The method of this teaching experiment was developed using this as background.

At the onset of this experiment, students were given a pre-test with the aim of establishing whether they had the mathematical skill to solve logarithmic inequalities. The pre-test consisted of six questions regarding logarithms, inequalities and graphs. These questions were very basic, similar to the ones in the grade 12 syllabus (Appendix E).

After the pre-test, teaching took place during class time in a computer laboratory. The specific emphasis of the lessons was on logarithmic inequalities. Normally logarithmic inequalities, together with the rest of the Mathematics course, would be conducted in a general classroom situation. The computer laboratory used during the experiment could comfortably accommodate 40 students. Students were quite familiar with Omnigraph because it was introduced during their first-year of study at our university. During each session, students were given worksheets. These worksheets (Appendix A) were designed to explore the basic concepts needed to solve logarithmic inequalities.

After using Omnigraph (the intervention) for six weeks, a post-test was conducted. The post-test included all the questions of the pre-test to establish whether there was an improvement in the students' understanding of the concepts. The post-test also included an additional question that was neither part of the syllabus nor part of the worksheets that was done during the intervention. This was included to test the students' ability to solve different but related questions.

Due to the sample size being so small the non-parametric Wilcoxon signed ranks test was used to compare the pre-and post-test results. In the following section the results of the analysis will be provided.

3. Results and discussion

3.1 Descriptive statistics

(Appendix C sets out detailed frequency results)

Of the 19 students who participated, 11 were female and 8 were male. This was interesting as one expects more male students to be interested in becoming Mathematics teachers at high school level. However, the sample was quite small to draw any firm conclusion on this. Figure 2 represents the gender distribution of the students who participated in the study.

Figure 2. Gender distribution

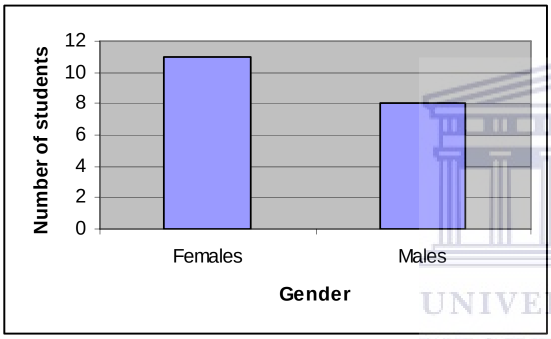
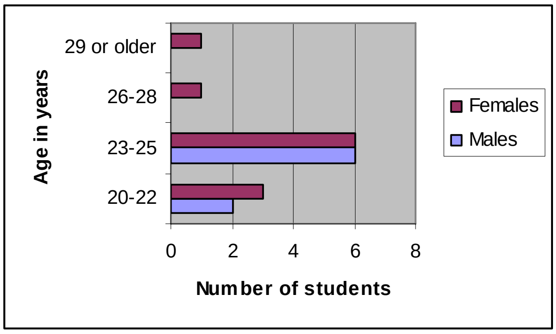


Figure 3 represents the age distribution of the participating students. Taking an average age of 18 years when students matriculate, it is expected that students in their third year of study would normally be 21 years of age. However, in this study, a large proportion 63% (12) of the students was in the age group 23 to 25 years, while only just over one quarter 26% (5) was in the expected age group. This may indicate that these students took longer to matriculate or spend time doing something else after matriculation before commencing their studies.

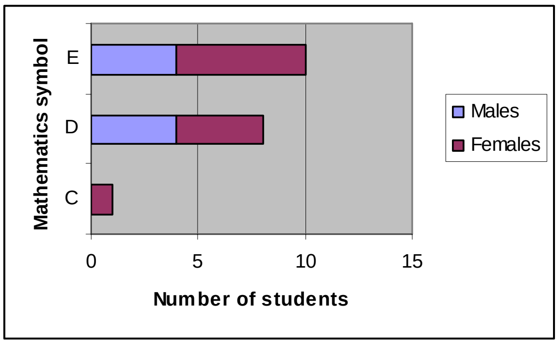
Figure 3. Age distribution



Other relevant statistics to this study indicate that more than half of the students 53% (10) were only exposed to computers during their first-year of tertiary education. This statistic was further supported by the fact that only 21% (4) of the students have access to their own home computers. However, most of them 84%(16) are exposed to technology with the ownership of cellular phones.

The distribution of the mathematics symbol achieved at matriculation of the students is represented in Figure 4.

Figure 4. Matriculation Mathematics symbol distribution (standard grade)



Only one female had a C symbol for Mathematics on the standard grade in matric, whilst eight students received a D symbol and ten students passed with less than 50%. This is definitely a grave concern as these will be the future Mathematics and Science teachers with a rather weak Mathematics background. What is quite obvious is that the students with higher-grade Mathematics are not attracted to the teaching profession probably due to the fact that not many students do Mathematics on higher grade at high school and the average pass rate for the Mathematics higher grade in the matriculation examination is 5% (WCED: 2004).

Most of the students at the University of Technology are Xhosa-speaking, which is reflected in the language distribution amongst the Mathematics student teachers. Table 1 shows the language distribution of the students.

Table 1. Language distribution by gender

Language	Females	Males	Total
Xhosa	9	5	14 (74%)
English	2	1	3 (16%)
Afrikaans	0	2	2 (10%)
Total	11 (58%)	8 (42%)	19

Almost half of these students were resident in the Western Cape whilst the other half are from the Eastern Cape. This study did not further analyze the difference of results between the two groups since the size of the sample was too small to draw any conclusion on expected trends in future.

Most students who participated in this experiment continued their original registration towards to the B.Ed degree. Only 11% (2) of the students changed their courses since first registration, indicating that the first choice of these students was in the teaching profession. Only 2 students are repeating the third year Mathematics course. This is a good indication of the pass rate of the Mathematics 3 course in our department.

Most of the students 58% (11) study for a few days before a test, while 26% (5) of them review the study material daily. The remainder reviewed the work on a weekly basis.

3.2 Question-by-question analysis of pre- and post-test results

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Table 2 represents the results of the Wilcoxon signed ranks test. Since the number of students that participated in the experiment was only nineteen, it was decided to execute the non-parametric Wilcoxon signed ranks test. The comparative results were only considered for those students who wrote both the pre-and post-tests.

Table 2: Results of the Wilcoxon signed ranks test question by question

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H_0 : Post-test = Pre-test

H_0 : Post-test > Post-test

$\alpha = 0.05$

degrees of freedom = n-1 =15

t-value=1.753

	Wilcoxon rank	$p-$value	Conclusion
Question 1.1	0.05	$p > 0.05$	Cannot reject H_0
Question 1.2	4.68	$p < 0.05$	Reject H_0
Question 2.1	8.50	$p < 0.05$	Reject H_0
Question 2.2	3.09	$p < 0.05$	Reject H_0
Question 3.1.1	4.95	$p < 0.05$	Reject H_0
Question 3.1.2	4.23	$p < 0.05$	Reject H_0
Question 3.1.3	5.46	$p < 0.05$	Reject H_0
Question 3.1.4	6.71	$p < 0.05$	Reject H_0
Question 4.1	7.23	$p < 0.05$	Reject H_0
Question 4.2	4.40	$p < 0.05$	Reject H_0

From Table 2 it is clear that there were significant improvements between the pre-and post-tests for all questions except Question 1.1 where no improvement in the results was seen. Table 3 reflects the results of the questions that appeared in the pre- as well as in the post-tests.

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Table 3: Results of the Wilcoxon signed ranks test on overall result of the pre- and post-test

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H_0 : Post-test = Pre-test

H_0 : Post-test > Pre-test

$\alpha = 0.05$; degrees of freedom $= n - 1 = 15$

	Wilcoxon rank	p – value	Conclusion
Total	7.23	$p < 0.05$	Reject H_0

From table 3 it is clear that a significant improvement in the results of the post-test was achieved after the intervention.

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3.3 *Question-by-question discussion of pre- and post-test results*

QUESTION 1.1 What do you understand by an inequality? [If you were supposed to give a definition of an inequality, what would it be?]

The purpose of this question was to investigate the student's understanding of the concept of an inequality. This concept, which is a mathematical statement, indicates order relationship of numbers. It is introduced to students at primary school (Scheiber, 1995) and is developed during high school years. Little emphasis is placed on inequalities in the standard grade matriculation syllabus. However for the higher-grade syllabus, students are expected to apply inequalities to various topics, one of which is logarithmic inequalities. From the students' responses in the pre- and post-tests, it is evident that they have an inadequate comprehension of the inequality concept. They, however, do have a vague understanding of the mathematical symbolism used to indicate the inequality relationship. There were no significant differences between the students' explanations in the pre- and post-test. [Wilcoxon signed rank test 0.05, $p > 0.05$]. After the pre-test, students were encouraged to consult textbooks for the definition of an inequality, but it would seem that the students did not expect they would be tested on the same question again in the post-test. Another reason for the poor response may be that the high school Mathematics text books (Bester,1998) do not give the explicit definitions for mathematical concepts that are found in more advanced Mathematics textbooks.

QUESTION 1.2 What do you understand by logarithms? [If you were supposed to give a definition of logarithms, what would it be?]

The aim of this question was to determine whether students have an understanding of logarithms; i.e., that a logarithm of a number is an exponent. A basic definition would be [$\log_b x$ **:** is the exponent to which b must be raised to get the value of x].

There was a significant difference between the students' responses in the pre- and post- tests [Wilcoxon signed rank test 8.50, $p < 0.05$]. The students scored more in the post-test which could be attributed to the fact that the students used the definition in their worksheet activities during the sessions. Emphasis was placed on the different formats that numbers could take on, and that logarithms are just another format in which a number can be expressed. Table 4 represents the different representation of a number.

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Table 4. Different representations of a number

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Number	Exponential form	Logarithmic form
8	$8 = 2^3$	$\log_2 8 = 3$

QUESTION 2.1

Sketch an increasing function

With this question, the aim was to establish whether the students could draw an increasing function. The concept of an increasing function plays an important role in solving logarithmic inequalities algebraically. Thus, should students have a clear comprehension why a graph is increasing locally as well as globally, it will help them with the understanding of the algebraic algorithm when solving logarithmic inequalities. There was a significant improvement between the pre- and post-test on this question [Wilcoxon signed rank test 8.5, $p < 0.05$]. Thus, the students improved on the drawing of an increasing function and this could possibly be ascribed to the intervention of exploring increasing and decreasing functions using Omnigraph. Most of the students drew logarithmic graphs in the post-test as their example of an increasing function.

QUESTION 2.2

Sketch a decreasing function

The purpose of this question was to establish whether the students could draw a decreasing function. Similar to the increasing functions in the previous question, decreasing functions play an important role in the solving of logarithmic inequalities algebraically. In the algebraic algorithm, it is also important to know whether the graph is decreasing since then the inequality sign changes, either to *less than* or *greater than*, depending on the original relationship. Students performed significantly better on this question in the post-test than in the pre-test [Wilcoxon signed rank test 3.09, $p < 0.05$].

QUESTION 3.1

Given the graph: $y = \log x$; the sketch was also given.

[Questions 3.1.1 to 3.1.4 relates to this graph]

3.1.1 Give the coordinates of the x-intercept of the graph

The aim of this question was to determine whether students could find the x-intercept when given the sketch of the function. Students were supposed to make the connection that the x-intercept of any graph is the point or points with a y-coordinate equals zero. Thus, substituting y = 0 in the above function and converting to exponential form results in the equation $x = 10^0$. Therefore, the co-ordinates of the x-intercept will be (1;0). Students were also expected to observe that, irrespective of the base of the logarithm, the x-intercept of any logarithmic graph in the standard form will always be (1;0). There was a significant improvement of the result in the post-test [Wilcoxon signed rank test 4.95, $p < 0.05$]. By the time the students were doing the post-test, they drew quite a number of these graphs, which demonstrated a significant improvement in their understanding of the properties of the logarithmic graphs.

3.1.2 Give the domain of the graph

Generally, students always have major problems in understanding what the domain of the graph is, and they fail to see that it is all the x-coordinates of the points that make up the graph. Again, this was overcome by exposing them to the graphical solution, since it is much easier to look at the graph done by Omnigraph and trace the points on the screen. A significant improvement was noted [Wilcoxon signed rank test 4.23, $p < 0.05$].

3.1.3 Give the range of the graph

The range of any graph is the y-coordinates of the points that make up the graph. Students generally have problems with this concept, but with the help of Omnigraph, the students' understanding was improved significantly [Wilcoxon signed rank test 5.46, $p < 0.05$].

3.1.4 Is the graph increasing or decreasing? Justify your answer.

A significant improvement in the results of the post-test compared to the pre-test was observed [Wilcoxon signed rank test 6.71, $p < 0.05$]. Again we can ascribe this result to the exposure to Omnigraph and also to the many types of logarithmic graphs that the students had seen during the intervention. They also had to consciously be aware of whether the graphs were increasing or decreasing, as that was part of the algebraic algorithm.

QUESTION 4.1

Solve for $x: \log_{\frac{1}{3}}(x+4) > -2$

In the post-test, students were asked to also give the graphical solution, and then they had to comment on the solutions. The purpose of this question was to solve the logarithmic inequality by different methods and to reconcile the different modes of their solutions. There was a significant improvement in the algebraic solution for this logarithmic inequality. At the time they did the pre-test, they only knew of one method, i.e. the algebraic method to solve logarithmic inequalities [Wilcoxon signed rank test 7.23, $p < 0.05$]. As we have pointed out earlier (Appendix B), two solutions were possible using Omnigraph, depending on how one entered the original inequality into Omnigraph. This sometimes created a sense of uncertainty when students had to interpret the solutions Omnigraph presented and their own algebraic solutions. The interpretation of the solutions given by Omnigraph was very challenging to students, and here it was found that students interacted with the Mathematics and also collaborated with their peers.

QUESTION 4.2

Solve for $x: \log_2(6x+4) - \log_2(x-6) > -4$

The object of this question was to determine whether students could solve a standard logarithmic inequality question. Again, in the post-test, students were also required to give the graphical solution and comment on the solutions. A significant improvement on their algebraic solution [Wilcoxon signed rank test 4.4, $p < 0.05$] was observed. The mean score obtained for the graphical solution was 4.2 out of 10. From this result, it seems that students are still struggling with the interpretations of the graphical method. Also, to communicate their findings on paper seem to be difficult. They were able to see the solution on the screen but were unable to translate it onto paper. More work should be done in this regard.

QUESTION 4.3

Given $y = |\log_3 x|$

4.3.1 Solve for $|\log_3 x| = 1$

The aim of this question was to determine whether students could now apply the knowledge gained during the teaching experiment and whether they would use Omnigraph as a mathematical tool to solve different types of questions that they would encounter. Earlier in the year, students were exposed to solving equations involving the absolute value. While there was a significant improvement in the results of the pre- and post-tests, students did not take advantage of the opportunity of having Omnigraph at their disposal to solve this question. It may be that they dealt with inequalities and suddenly had to solve a logarithmic equation. Over and above this, the problem also involved the *absolute value* concept. More exposure to the different teaching methods, i.e. graphical demonstration, may help students in doing and approaching mathematical problems differently. Students need to realize that Omnigraph is a tool that could help them with understanding and solving many mathematical problems.

Given $y = \left|\log_3 x\right|$

4.3.2 Solve for $\left|\log_3 x\right| < 1$

Most of the students attempted this question by using only the algebraic method; it did not occur to them that they could use Omnigraph to help them with their solution. This is probably due to the normal way of approaching mathematical problems via the algebraic method. In order for students to utilize a different method naturally, in this case the graphical method, Omnigraph should become part of the teaching and learning situation.

3.4 Discussion of questions 8 to 11 in the post-test

(Appendix D sets out more detailed analysis)

Question 8

The purpose of this question was to determine how students would approach solving a logarithmic inequality, having been exposed to two ways of solving logarithmic inequalities: algebraic and graphical methods. The responses were as follows:

Ten students gave a detailed algebraic method as to how to solve a logarithmic inequality; eight students indicated that they would solve the logarithmic inequality algebraically, and then they would use Omnigraph to solve it graphically; one student responded as follows: “The question will be: Solve the following inequality”. It appeared that this student did not understand the question.

Question 9

Eighteen students said that using Omnigraph improved their understanding about logarithms and logarithmic inequalities. A typical student response to the question was:

Yes, by typing in the formulae and being able to see the graphs, one starts to see how the graph behaves when certain things are changed (x or y or numbers). It is also a good way of comparing your Algebra to the solution that the computer provides.

Only one student said, “No.” This was his response:

No, Omnigraph doesn’t show you how to plot the graph; it does everything for you.

Question 10

Seven of the students preferred the algebraic solution; a typical response was:

Algebraic method because once you understand the basics, then it is very much easier when you are doing it alone.

Eight students preferred the graphical method: one student's response was:

The graphical method is the easiest one, because I can get the answers without calculating the expression, so I prefer graphical.

While four students indicated that they preferred both methods, one student's response was:

Both methods, because you can check your answers.

Question 11

Eighteen students would use Omnigraph as a teacher if it was available at the school.

One student indicated that he would not use it.

The following was a response from one of the students:

Definitely I will use Omnigraph because it make it easy for the learners to draw the graph. As we all know, most learners hate drawing graphs so Omnigraph makes things easier. I will use Omnigraph in my school.

4. Conclusions

Computer technology is a powerful tool, yet in the context of the Education Department (Bellville), it has not reached its potential as an instructional tool. According to Waits (1994), “Technology empowers students to solve difficult problems.” Educators may not embrace computer technology because of the lack of resources and support.

The present study shows that there is definitely an improvement in the understanding of logarithmic inequalities when using Omnigraph. There was an improvement in the post-test results indicating that the intervention was significant (Appendix D and tables 2 and 3). However, research on a bigger scale needs to be done, especially on logarithmic inequalities and the use of Omnigraph or any other graphical software package.

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From the comments of the students, it seems that they enjoyed using Omnigraph, especially when they could use Omnigraph to verify algebraic solutions (Appendix A). Several good discussions were observed during the lessons: they trusted their algebraic solutions more and the challenge was to find out what Omnigraph presented as a graphical solution. Omnigraph generated interest and enthusiasm amongst students and contributed to their learning experience. The value of Omnigraph lies not only in enabling the student to plot graphs but it can also be used to generalize about the “family of curves”. It could thus aid students to observe the properties of the various “families of graphs”. This is a way to become actively involved during the mathematical learning situation.

Since Omnigraph produces graphs on the computer, there is no need for the students to have the skills required to produce graphs by pencil and paper. Attention can be focused directly on the interpretation of the graphs. This is quite an important skill for students to acquire.

With the availability of Omnigraph, many concepts in Mathematics can now be learnt more thoroughly due to the multiple representations of solutions. Multiple representations facilitate students' understanding of mathematical concepts.

Omnigraph has its limitations, and students need to be made aware of these. The different modes of solutions help in alleviating this problem. One of the problems with Omnigraph is that one has little control over how the solution is being presented. It is therefore essential that students have sufficient mathematical skills to be able to interpret the output that they obtain from Omnigraph.

Waits (1994) suggested that Mathematics in the future will be far more technology enhanced, richer, interesting and applicable than in the past. Business and industry want employees today who can think, read and understand problem situations, work cooperatively in groups, understand the use of technology and communicate effectively with others. This study demonstrates that the appropriate use of technology in the Mathematics classroom helps build these important skills.

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6.1 Appendix A *(An example of a worksheet)*

Let us establish the properties of the logarithmic graph.

Consider $0 < a < 1$

Use Omnigraph to draw three different graphs of $y = \log_a x$ by choosing any three

values for a between 0 and 1

Now answer the following questions:

1.1 Where does the graphs cut the $x-$axis?

1.2 Where does the graphs cut the $y-$axis?

1.3 What are the domain of the graphs?

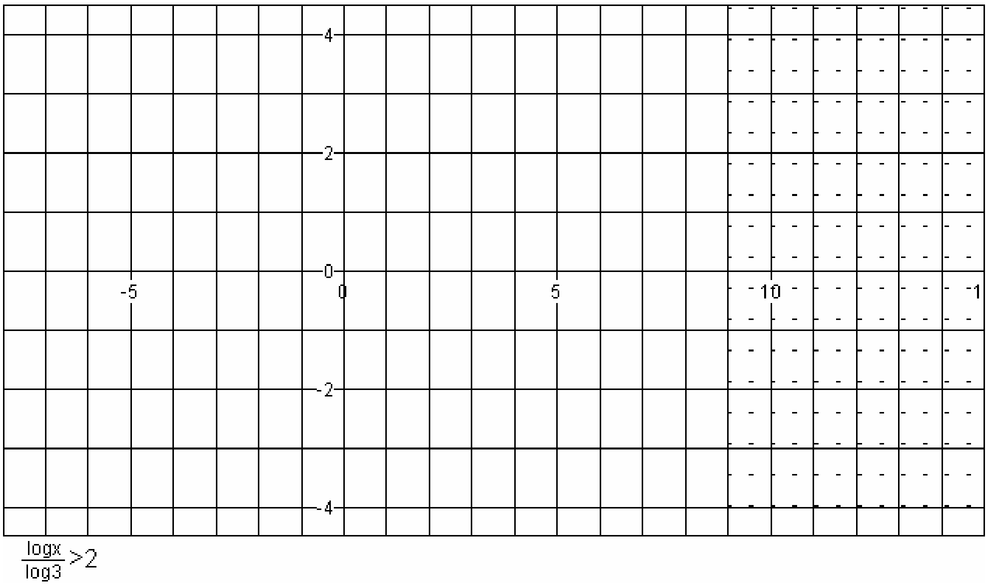
1.4 What are the range of the graphs?

1.5 Are the graphs increasing or decreasing?. Explain your answer.

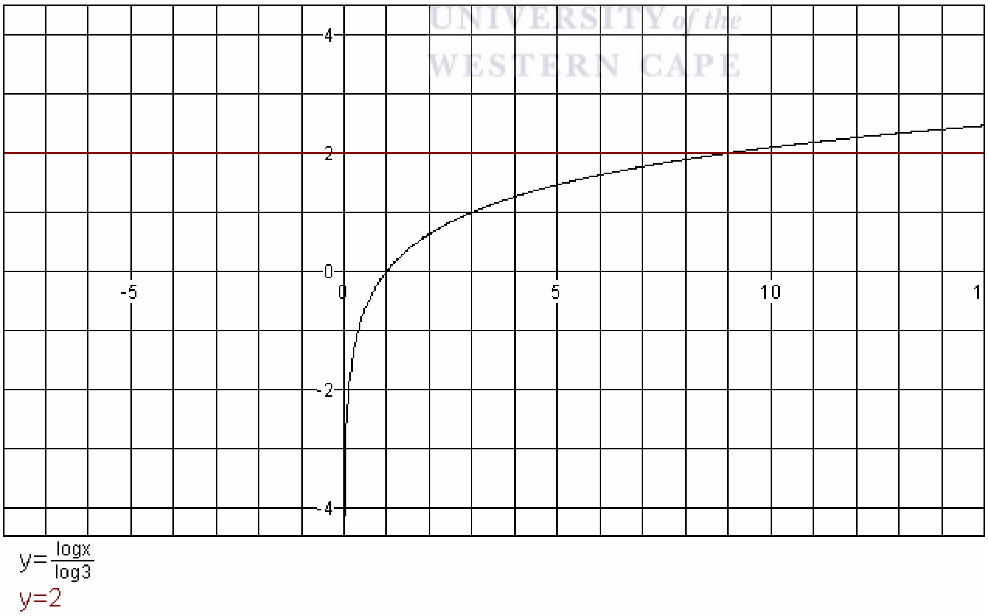
6.2 *Appendix B* ***(Two solutions from Omnigraph)***

Two solutions to the same question:

Solve $\log_3 x > 2$



Solve $\log_3 x > 2$



6.3 *Appendix C* (*Frequencies*)

Gender				
	Frequency	Percentage	Cumulative Frequency	Cumulative Percentage
Females	11	57.89	11	57.88
Males	8	42.11	19	100.00

Age				
	Frequency	Percentage	Cumulative Frequency	Cumulative Percentage
20-22	5	26.32	5	26.32
23-25	12	63.16	17	89.47
26-28	1	5.26	18	94.74
>29	1	5.26	19	100.00

Does student own a computer				
	Frequency	Percentage	Cumulative Frequency	Cumulative Percentage
Yes	4	21.05	4	21.05
No	15	78.95	19	100.00

Does student own a cellular phone				
	Frequency	Percentage	Cumulative Frequency	Cumulative Percentage
Yes	16	84.21	16	84.21
No	3	15.79	19	100.00

Matric year				
	Frequency	Percentage	Cumulative Frequency	Cumulative Percentage
2001	7	36.84	7	36.84
2000	2	10.53	9	47.37
1999	6	31.58	15	78.95
Before 1998	4	21.05	19	100.00

Matric symbol				
	Frequency	Percentage	Cumulative Frequency	Cumulative Percentage
C	5	26.32	5	26.32
D	9	47.37	14	73.68
E	5	26.32	19	100.00

Mathematics symbol (Standard grade)				
	Frequency	Percentage	Cumulative Frequency	Cumulative Percentage
C	1	5.26	1	5.26
D	8	42.11	9	47.37
E	10	52.63	19	100.00

Province				
	Frequency	Percentage	Cumulative Frequency	Cumulative Percentage
Western Cape	9	47.37	9	47.37
Eastern Cape	10	52.63	19	100.00

Language				
	Frequency	Percentage	Cumulative Frequency	Cumulative Percentage
English	3	15.79	3	15.79
Xhosa	14	73.68	17	89.47
Afrikaans	2	10.53	19	100.00

Date of first registration				
	Frequency	Percentage	Cumulative Frequency	Cumulative Percentage
2002	15	78.95	15	78.95
2001	1	5.26	16	84.21
2000	2	10.53	18	94.74
Before 1999	1	5.26	19	100.00

Was course changed since first registration?				
	Frequency	Percentage	Cumulative Frequency	Cumulative Percentage
Yes	2	10.53	2	10.53
No	17	89.47	19	100.00

Repeat Mathematics course in 2004?				
	Frequency	Percentage	Cumulative Frequency	Cumulative Percentage
Yes	2	10.53	2	10.53
No	17	89.47	19	100.00

First contact with computers				
	Frequency	Percentage	Cumulative Frequency	Cumulative Percentage
High School	9	47.37	9	47.37
University 1st year	10	52.63	19	100.00

Study Approach				
	Frequency	Percentage	Cumulative Frequency	Cumulative Percentage
Review daily	5	26.32	5	26.32
Review weekly	3	15.79	8	42.11
Few days before test	11	57.89	19	100.00

6.4 *Appendix D* ***(Pre-test)***

MATHEMATICS RESEARCH PROJECT

LOGARITHMIC INEQUALITIES

PRE-TEST

Initials and Surname:………………………………

Student Number:…………………………………..

Answer the following questions:

1.1 What do you understand by an inequality?

[If you were supposed to give a definition of an inequality, what would it be?]

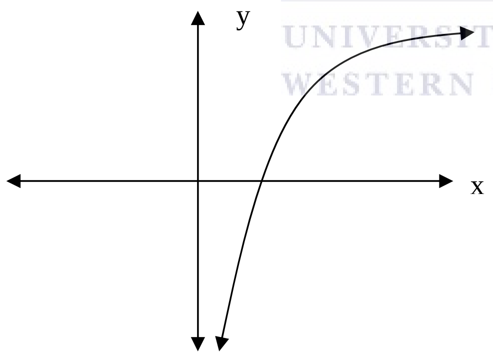
1.2 What do you understand by logarithms?

[If you were supposed to give a definition of logarithms, what would it be?]

2.1 Sketch an increasing function.

2.2 Sketch a decreasing function.

3.1 Given the following graph: $y = \log x$



3.1.1 Give the coordinates of the x – intercept of the graph

3.1.2 Give the domain of the graph

3.1.3 Give the range of the graph

3.1.4 Is the graph increasing or decreasing?. Justify your answer.

Solve for x:

4.1 $\log_{\frac{1}{3}}(x+4) > -2$

4.2 $\log_2(6x+4) - \log_2(x-6) > -4$

4.3 Given: $y = |\log_3 x|$

4.3.1 Solve: $|\log_3 x| = 1$

4.3.2 For which values of x is $|\log_3 x| < 1$

6.6 *Appendix E* ***(Post-test)***

MATHEMATICS RESEARCH PROJECT

LOGARITHMIC INEQUALITIES

POST-TEST

Initials and Surname:………………………………

Student Number:…………………………………..

Answer the following questions:

1.3 What do you understand by an inequality?

[If you were supposed to give a definition of an inequality, what would it be?]

1.4 What do you understand by logarithms?

[If you were supposed to give a definition of logarithms, what would it be?]

2.3 Sketch an increasing function.

2.4 Sketch a decreasing function.

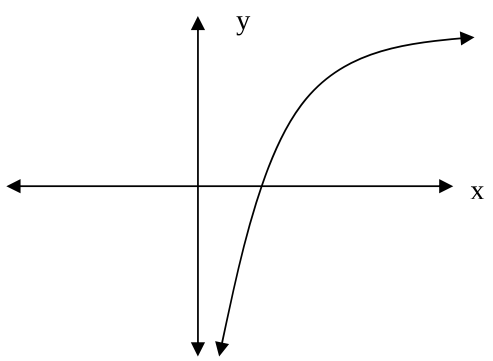
3.1 Sketch the following graphs and say whether they are increasing, decreasing or neither.

3.1.1 $y = \log_a x$ where $a > 1$

3.1.2 $y = \log_a x$ where $0 < a < 1$

3.1.3 $y = \log_a x$ where $a = 1$

4.1 Given the following graph: $y = \log x$



4.1.1 Give the coordinates of the x – intercept of the graph.

4.1.2 Give the domain of the graph.

4.1.3 Give the range of the graph.

4.1.4 Is the graph increasing or decreasing. Justify your answer.

Solve for x: $\log_{\frac{1}{3}}(x+4) > -2$

Algebraically

5.1 Graphically

5.2 Comment on your solutions

Solve for x: $\log_2(6x+4) - \log_2(x-6) > -4$

6.1 Algebraically

6.2 Graphically

6.3 Comment on your solutions

7.1 Given: $y = |\log_3 x|$

7.1.1 Solve: $|\log_3 x| = 1$

7.1.2 Solve: $|\log_3 x| < 1$

8. If you were given an logarithmic inequality to solve, how would you approach the question?

9. Do you think that by using Omnigraph with logarithmic inequalities Improved your understanding about logarithms and logarithmic inequalities? Explain.

10. Which method do you prefer the algebraic method or the graphical method. Explain.

11. If you are a teacher at high school and Omnigraph is available, would you use it to teach logarithmic inequalities. Explain.

6.6 *Appendix F* ***(Background questionnaire)***

MATHEMATICS RESEARCH PROJECT

LOGARITHMIC INEQUALITIES QUESTIONNAIRE

BACKGROUND INFORMATION

Initials and Surname:……………………………………..

Student Number:……………………………………………..

Thank you for completing the questionnaire. It will be used as input to the research project.

Your responses will be treated with the utmost of confidentiality.

Make your selection by **drawing a circle** over the relevant answer.

1. Gender

Female
Male

2. How old are you

17-19
20-22
23-25
26-28
29 or older

3. Do you have a computer at home

Yes
No

4. Do you own a cell phone

Yes
No

5. In which year did you write your matric?

2001
2000
1999
1998
Before 1998

6. What was your final matric symbol?

80%-100%	A
70%-79%	B
60%-69%	C
50%-59%	D
Less than 50%	E

7. What was your final mathematics symbol?

80%-100%	A

70%-79%	B
60%-69%	C
50%-59%	D
Less than 50%	E

8. On which grade did you do mathematics?

HG
SG

9. Where did you matriculate?

Western Cape
Northern Cape
Eastern Cape
Gauteng
Other

10. My home language is:

English
Xhosa
Afrikaans
Zulu
Other

11. When did you first register at Pentech?

2001
2000
1999
1998
Before 1998

12. Have you changed your course since your first registration?

Yes
No

If yes, what did you study before?…………………………………..

13. Are you repeating the Mathematics 3?

Yes
No

14. My first contact with computers was at:

Pre-school
Primary school
High school
Technikon in my 1st year
Technikon in my 2nd year

Technikon in my 3rd year

15. Which of the following describes your approach to studying best?

I review the study material daily
I review the study material weekly
I study a few days before a test