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A comparative study involving two approaches to documenting computer software for mathematics teaching programs

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A COMPARATIVE STUDY INVOLVING TWO APPROACHES TO DOCUMENTING COMPUTER SOFTWARE FOR MATHEMATICS TEACHING PROGRAMS

by

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This comparative study was conducted to determine how college mathematics students respond to instructions that are primarily text as compared with instructions that are primarily illustrations.

The sample consisted of 50 students enrolled in mathematics classes at Forsyth Technical Community College during August 1993. A pretest survey was used to balance the treatment groups in terms of gender, age, and computer experience. The test consisted of two treatments: 1) Completing tasks on IBM's Mathematics Toolkit using directions that were traditionally textual. 2) Completing the same tasks using directions that were primarily pictorial. Test data consisted of the time it took each subject to complete the task and the number of correct responses on the task. Post test data consisted of answers to an attitude survey which was administered immediately after the test. Analysis of the attitude survey focused on: 1) the ability of subjects to coordinate

the documentation with the computer screen and 2) the subjects' judgement between the documentation used in the test and other computer documentation used by the subject.

The data from those using the textual approach was more favorable than the data from those using the pictorial approach in all areas except the subject's judgement between the documentation they used and other documentation they had used in the past.

APPROVAL PAGE

This dissertation has been approved by the following committee of the Faculty of the Graduate School at the University of North Carolina at Greensboro.

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CHAPTER I

INTRODUCTION

The first fully electronic computer was constructed out of vacuum tubes in 1946. In the late fifties transistors were used in computers, and in the late sixties integrated circuits were introduced. Each new invention made computers faster and less expensive, until the personal computer was within the financial reach of the average family in the United States. Today in the United States there are 50 million computer users compared to only 2000 users 15 years ago (Fernberg, 1992). The growth of computers in industry and in our homes has been matched by a similar increase of computers in our schools. Vacc (1987, p. 43) stated:

> In less than a decade, we have progressed from the rare situation of a school system having its own microcomputer to at least 85 percent of the schools in the United States having one or more microcomputers (Becker 1983). Although empirical studies supporting successful uses of microcomputers to supplement classroom instruction appear

> in the literature... effective use of this new technology to assist with classroom instruction remains a concern. A major problem is inadequate available software. More than 90 percent of the educational computer programs reviewed by classroom teachers hired by the National Education Association foundation were found to be unacceptable ("Flunked Software" 1984)...

Among the many problems facing producers of Computer Based Training (CBT) or Computer Assisted Instruction (CAI) is the attitude that students and teachers have towards learning new systems or programs. Students and teachers do not want to spend much time learning how to use new programs, especially when those new programs may not be helpful. As a result most classrooms just avoid using CBT or CAI. Dickey and Kherlopian (1987) reported that 59% of science teachers who had access to computers did not use them. When teachers and students spend time and energy to learn a new system the time and energy must be taken from other areas of learning. If the documentation makes a program appear to be difficult to learn, how can we expect teachers or students to risk their time to learn it? Therefore, producers of CBT and CAI, who expect their programs to be used, must not only create programs that are pedagogically sound, but document those programs so they can be learned quickly and easily.

Speaking of the general public Favin (1988, p. 118) echoed this sentiment as follows:

> We are now facing a finicky public and the material we place in the field MUST be accompanied by superb documentation. The public will not create gyp sheets or struggle with poor documentation. It is interesting to note that when documentation fails it is the product that gets blamed. "That PC7300... what a lousy machine. I can't get it to do anything right."

The point is that programs that may be very helpful to our schools are in jeopardy of being ignored unless those programs are supported by excellent documentation that allows users to learn those programs quickly and easily.

Purpose of the Study

The purpose of this study was to examine two approaches for documenting educational software to determine if one of those approaches had an advantage over the other. The motivation for this study is a concern that valuable software tools may be ignored by teachers and students because the documentation for the tools is difficult to use. This study begins to look at ways to improve documentation for mathematics learning programs. This issue bridges the field of education with the field of technical writing. Technical writing is a young profession whose members create instructions for making, installing, using, and maintaining equipment and software. Although such instructions have been used in industry for more than a hundred years, those instructions were typically written by the engineers who designed the equipment. However, in the last fifty years, a new profession has emerged to take over that task. Favin (1988, p. 117) explains:

> As a supervisor in a technical area, it took me a very long time to realize that the piece of equipment lying on my lab bench is NOT my product! It took quite a bit of time to realize that my product was pieces of paper telling others;
>
> - How it works
> - How to build it
> - How to test it
> - How to install it
> - How to test the installation

- How to operate it
- How to maintain it.

> My real product and that of the Bell Labs is actually paper....Engineers want to do engineering not writing. Similarly, software people want to write software, not documentation.... Management is aware of this and they apply a solution. Enter the technical writer.

Technical writing requires skill in language, in visual presentation, and in technical understanding. The field of technical writing has evolved into the field of technical communication so that it now includes multimedia (paper, on-line computer instructions, audio productions, and video demonstrations). The science of producing those instructions has received little attention from the academic community until the last decade. Ten years ago less than a dozen schools offered degrees in technical communication. Today there are about 200 institutions of higher learning that offer degrees in technical communications or technical writing.

Since degrees in technical writing are new on the academic scene we can expect research in technical writing to be in its infancy. Kirkman (1980) conducted research on the language and sentence structure used in technical writing. Very little research has been done on the use of illustrations (Rubens 1986). One positive outcome of this study would be additional studies that would lead software vendors to improve their method of documenting educational software programs.

Statement of Hypothesis

This study looks at how college mathematics students respond to instructions that are mostly text as opposed to instructions that are mostly illustrations. It begins to answer questions regarding presentation styles for educational software documentation. Specifically this study asks:

Do college mathematics students experience an advantage by using a pictorial approach as compared to students using the traditional textual approaches when learning to use software that is designed to assist in teaching mathematics?

The methodology described in Chapter III experimentally compares documentation that is mostly text with documentation that is mostly illustrations by measuring the time it takes the subjects to complete a task and the attitude of the subjects towards the documentation. The task involves stepping through several software commands, and then using an understanding of those commands to find the solution set of one polynomial and estimate one solution of another polynomial. If one type of documentation is easier to understand than the other we would expect that subjects using the easier-to-understand document to complete the task faster than the subjects using the other document. We would also expect the faster group to have a more positive attitude towards the documentation they used.

H_1: There will be no significant difference in the time needed to complete the task between treatment groups.

H_2: There will be no significant difference in the attitudes towards the documentation between treatment groups.

Definitions of Terms

The term 'graphics' covers a wide range of visual techniques in technical writing including typefaces, page layouts, tables, graphs, charts, schematics, line drawings, flowcharts, diagrams, sketches, illustrations, pictures, and photographs (Brown, 1978; Cury, 1979; Gross, 1990; Sullivan, 1990). Some of these terms overlap, and there exists disagreement on their usage in the literature.

Typefaces	Typefaces determine the shapes and sizes of letters. They are altered to create moods, improve readability, and to emphasize portions of text. There are more than five thousand registered typefaces (Beach, Shepro, & Russon, 1986).
Page Layout	Page layout considers the overall appearance of a spread (the facing pages of an open book). Decisions concerning page layout include the sizes of margins, the number of columns, the

length of text lines, the amount of white space, the placement of figures and so on (Linotype, 1988). The study of typefaces and page layout attempts to determine how these elements can be used to enhance the comfort of the reader. These graphic elements focus on the appearance of a page rather than a comprehension of it contents.

Tables — Tables graphs and charts condense information on a page or demonstrate relationships by using arrays and juxtaposition. They are typically used to help a reader find a single fact from a host of options.

Flow Charts — Flow charts and schematic diagrams use symbols to show procedures, processes, or functions.

Illustrations — Illustrations, pictures, sketches, and photographs provide two-dimensional representations of three-dimensional objects.

Tables, graphs, charts, flow charts, and diagrams are an extension of language (Gross, 1990). They derive their meaning from language and add elements such as symbols, juxtaposition, and relative size to present information in ways that are more readily understood, more accessible, or more quickly absorbed than the same information would be if it was presented as strings of words (Herrstrom, 1984).

Illustrations, pictures, sketches, and photographs are all methods of transmitting a sense of what the reader would see. These graphic elements are in a class by themselves in the sense they do not require language to have meaning. Gross (1990, p. 225) stated it this way:

> Two conclusions seem inescapable. First, illustrations are not part of the semantic set to which tables, graphs, and diagrams belong. Second, tables, graphs, and diagrams mean only because language means; theirs is a second-order meaning dependent on the prior existence both of language and of a system for writing language down.

Evidence of the above statement can be seen in the figure below. Most people regardless of their language can identify the cat, but only those who have been trained in the language of electronics could name the components of the tuning circuit. Similarly a table would have no meaning unless the reader understood not only the words or symbols used in its rows and columns, but also the meaning implied by their position in the table.

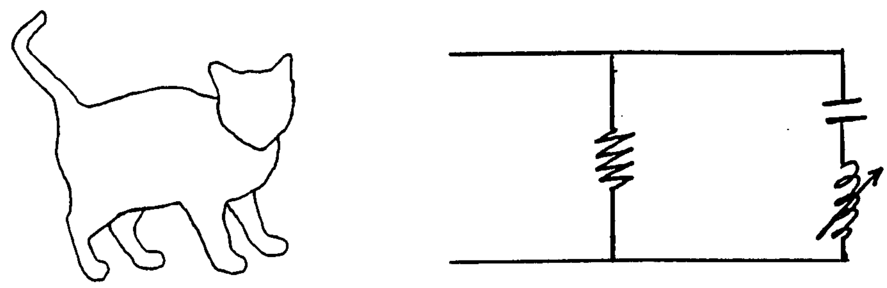

FIGURE 1 - Semantics of Figures

Assumptions and Limitations

This study did not come close to determining all of the variables that make up excellent documentation for educational software. It focused attention on one aspect of documentation that has received little attention in the past, in the hope it may stimulate additional studies.

In addition to these general limitations there were several factors that limit the application of the results.

1. All subjects were volunteers from the Forsyth Technical Community College in Winston-Salem, North Carolina.

2. The experiment was kept short to accommodate volunteers.

3. The subjects were available in small groups. This made it impossible to control minor factors such as time of day and ambient noise.

The following assumptions were made regarding keeping the two treatment groups as equal as possible.

1. The most important variable to be kept equal was prior computer experience, since such experience would give the subjects the advantage of anticipating certain details of entering computer commands.

2. After computer experience, age was the next variable to be kept as equal as possible.

3. Finally, gender was considered if the treatment groups could be kept equal in all three areas.

CHAPTER II

A REVIEW OF THE LITERATURE

One of the advantages of exploring young disciplines such as computers and technical writing is the privilege of breaking new ground, while a disadvantage is a lack of research upon which to build. A few authors have commented on this lack of research. This disadvantage is especially true in the area of illustrations used to document computer systems.

> In a recent literature search of studies on graphics in communication, we were surprised at the lack of empirical research on the use of photographs in text. Although a wealth of research has been done on other aspects of visual communications - typography, various aspects of layout such as page and column width, leading and arrangement, and such abstract notions as how graphic elements affect comprehensibility - an aspect of text production as omnipresent and vital as photo-illustration has been virtually ignored....Thus in practice as well as theory, research into the interaction of text and illustration is discouraged. (Bradford & Bradford, 1983, p. 259)

Five years later Sullivan (1988, p. RET-127) stated; "Technical communication theory asserts the importance of the visual dimension of meaning, but theories and pedagogies directed toward the making of 'visual meaning' are still under development." It is interesting to note that Sullivan was talking about all visual elements including those elements Bradford and Bradford considered amply covered. In that same year, Penrose and Seiford (1988, p. 357) said, "No publicly available survey has been conducted to determine the preferences of microcomputer users for software documentation."

Rubens (1986, p. 73) also complained that "principles of graphic theory have been largely ignored by the technical and scientific community. This impatience with theory creates numerous problems for the readers of technical information since about 30 percent of such material is graphic in nature."

Why has so little research on illustrations been conducted? One reason may be that illustrations have never been in the spot light in the field of technical writing, because costs and tradition have discouraged the use of illustrations.

Costs and traditions do not encourage using illustrations.

There are three reasons why the documentation industry is not rushing to fill the pages of how-to manuals with illustrations.

1. Illustrations have been difficult to produce.

2. Illustrations have been expensive.

3. The example set by tradition causes new writers to use few illustrations.

The difficulty of producing illustrations is articulated by Wulfeck, Chang, and Montague (1986 p. 192) when they remind us of the bad-old-days. "It used to be that it was hard to put these kinds of pictures, or even better ones, into text. It involved a rather mystical process where a graphics illustrator would do it at great expense and the primary designer of the text would have little to say about what the art work would look like." Although many publishing systems allow the writers to create their own illustrations, complicated drawings are still created through the same old mystical process. This complex process is not acceptable to writers who face the difficulty of meeting tight schedules. The difficulties involved in producing illustrations also makes the documents more expensive, and there are other factors connected with illustrations that affect the cost of a document.

Space and time are factors that drive up the costs of documents. Recognizing this problem, Bates (1990 p. 75) said, "Don't hesitate to augment narrative descriptions with tables, charts, graphs, or other illustrations. Some critics might consider this approach wasteful of space and paper; don't believe them." Meyer (1986 p. 20) said, "New look publications are costly." The new look format which was procedural documentation that was mostly illustrations required more time to create and more than twice the paper. Meyer therefore, did not recommend the new look format for highly technical publications. The costs of illustrations which include the artist, time, space or paper continue to inhibit the use of illustrations.

Another factor that inhibits the use of illustrations is tradition. Although the name technical writer has been promoted to titles such as "technical communicator", or "documentation specialist" the old connotation of "word smith" continues to exist. This concept is supported by the token support for illustrations already mentioned, and by authors whose books do not even mention illustrations. Examples of the last group are Rathbone (1985) and Kirkman (1980). The underlying message is that WORDS are the tools of the trade. Meyers (1986) adds his testimony that traditional documentation has a high ratio of text to illustrations. The fact that a format that is long on text and short on illustrations is considered traditional is one more reason why we can expect such formats for years to come. It does not matter that Meyers considers such formats ineffective. Their continued use is assured because they are traditional.

An example of the power of tradition is demonstrated by an experiment that measured the inclination of technical writing students to use visual markers such as figures, tables, and extra headings. Sullivan (1990) found out that students with humanities backgrounds were less apt to use visual markers than students with technical backgrounds. Her main interpretation was that humanities students were used to margin-to-margin text while the technical students had experienced text that included some diagrams and subject headings. The connection between example and behavior suggests that technical documents that are flooded with illustrations will continue to be rare for at least another decade, in spite of our increased ability to produce illustrations, and our awareness of the advantages of illustrations. This is because new writers entering the field are mentored by those who remember the bad-old-days when illustrations were an expensive, time-consuming, pain-in-the-neck. Even today many illustrations fit that category, so writers traditionally work around them.

In spite of these problems, which have been exacerbated by tighter and tighter product schedules, there exist a few proponents for documentation that is rich with illustrations.

Authors Support Illustrations

The advantages of illustrations are so intuitively obvious it is hard to imagine how one could begin to argue against them. In fact there does not appear to exist a single paper that discourages the use of illustrations in documentation that supports computer software or in any other support documentation. The question then is a matter of degree. Papers supporting illustrations run the gamut, from suggesting that illustrations enhance writing, to suggesting illustrations replace writing as much as possible.

The majority of authors look at illustrations as enhancing a document. Houghton-Alico (1985, p. 94) says only that illustrations MAY be used in documents that support software, but illustrations are more commonly used in documents that support computer hardware. Brown (1978, p. 238) recommends using all forms of graphics and states: "But why burden the audience with lengthy word descriptions ... when visual presentation can more aptly supplant verbal..." Penrose and Seiford (1988, p. 363) reported on the attitudes of computer software users towards documentation.

"Respondents left little doubt about the importance of visual support in printed manuals. Fifty percent strongly agree that drawings or illustrations help them understand documentation of software instructions."

Among authors of books about writing in general or writing about computers, Bates, Brockmann, and Sides favor graphics as an enhancement to a document. Bates (1990, p. 75) said, "Use tables, graphs, and pictures whenever they seem appropriate." Brockmann (1986, p. 180-181) recommends using graphics to emphasize points, increase interest, clarify or simplify discussions, accommodate both left-brain as well as right-brain preferences, and to increase a readers ability to skim through the document. Sides (1984, p. 100) said, "Too often writers overlook the importance of including graphic material in their reports and papers. Correctly done, graphics are attention getting and informative." Sides goes on to define graphic elements such as tables, graphs, and illustrations. None of these authors attempt to indicate the extent that graphics should be used in writing good documentation.

In their how-to book on writing technical manuals, Cohen and Cunningham (1984, p. 6) recommend making graphics an equal partner with text. They warn against expecting too much from illustrations, and counsel writers to support illustrations with text (p. 83-84). Farris (cited in Gatlin 1988) moves illustrations from equal partner to senior partner by claiming that we learn approximately 11% by hearing (or reading) and 83% by seeing. If technical writers took this last statement to heart, they would design their documents to present more than eighty percent of the information through graphics.

Meyer (1986, p. 17) proposed a "New-Look Format." This format replaced manuals that were mostly text with manuals that were mostly illustrations.

> The basic new-look text/illustration unit is called a module. A module is similar to a storyboard panel, which is used to plan film or videotape production; both contain the narrative and the visual elements for a single scene or topic. The new-look publication finalizes the storyboard as a series of printed pages. Ideal new-look pages include no more than one or two modules.

Meyer, a publications engineering specialist for Lockheed Electronics, helped develop the new-look format for equipment being sold to the military. The military has been increasingly concerned about the reading skills of its new recruits. The new-look format comes as close as possible to mimicking television with the printed page. Nontechnical and semitechnical personnel are the audiences for the new-look format. Although Meyer (1986, p. 19) does not cite any formal study, he states, "On the basis of our experience with the new look, Lockheed Electronics Company Technical Publications recommends this format primarily for crew and operator-level instructions." He does not recommend this format for complex or in-depth instructions, because of the added number of pages this format requires.

Gange and Lipton (1984) take the use of illustrations to the extreme by suggesting we use word-free instructions to reduce the cost of translating those instructions into other languages and to reduce the inaccuracies that typically accompany translated material. They suspect that we would see more word-free instructions if documentation specialists believed such instructions could be used on their complex equipment. In order to demonstrate that such a format was viable, Gange and Lipton created a document that instructed the average consumer to setup an IBM 5080 computer. The final document was 98% word-free.

Although Gange and Lipton (1984, p. 18) gave no details of their experiment, they did make the following statement:

> To test how effective the setup instructions were, we arranged, with the help of our human factors engineering group, to conduct tests with subjects brought in from a local employment agency. They had little if any data-processing experience and no professed mechanical ability. The early results of testing were encouraging, but we had to redo many illustrations to improve the perspective shown to the reader. We went through several cycles of testing to get the bugs out, but in the end we had a 75-page manual (about 98% word-free) that was effective and had a high degree of acceptance with the test subjects. Early comments from the field confirm that the word-free approach is popular.

These few, mostly informal, studies that support using more illustrations in documentation have barely influenced an industry that is pressed by tight schedules and tighter budgets. As these studies continue, we may find pictorial equivalents of passive sentences, dangling modifiers, or nominalizations. We may also find that documents that are rich with illustrations are only effective for limited audiences. But, if we find that documents that are mostly illustrative are advantageous for most applications, we will still need to wait until customers demand this type of documentation before the industry will produce it on a regular basis. For now, we need to find out which applications and which audiences can be benefited by documentation enriched by illustrations. Later we may want to study ways to improve the effectiveness of the illustrations we use.

Summary

This study looked at the relatively young field of technical writing to determine if there was evidence that supported saturating documentation with illustrations. The motivation for this study was to find ways of improving documentation for computer software that is used in education. Very little information was found on research concerning illustrations. The most probable reasons for this lack of research are:

1. Illustrations cost more than text.

2. Presenting information via text is the tradition.

3. Research in all phases of technical writing is in its infancy.

Among the few studies that have looked at illustrations all found that documentation that was rich with illustrations was easier for the user but more costly for the producer.

CHAPTER III

METHOD

The purpose of this study was to examine two approaches for documenting educational software to determine if one of those approaches had an advantage over the other. The motivation for this study is a concern that valuable software tools may be ignored by teachers and students because the documentation for the tools is difficult to use. Although there are many elements of documentation that are worth studying, this study looks at how college mathematics students respond to instructions that are mostly text as opposed to instructions that are mostly illustrations.

Specifically this study asked:

Do college mathematics students experience an advantage by using a pictorial approach as compared to students using the traditional textual approaches when learning to use software that is designed to assist in teaching mathematics?

To answer this question an experiment was conducted to compare documentation that is mostly text with documentation that is mostly illustrations by measuring the time it took the subjects to complete a task and the attitude of the subjects towards the documentation. The task involved stepping through several software commands, and then using an understanding of those commands to find the solution set for one polynomial and to estimate one solution to a second polynomial by using the graphing ability of the program. If one type of documentation is easier to understand than the other we would expect that subjects using the easier-to-understand document to complete the task faster than the subjects using the other document. We would also expect the faster group to have a more positive attitude towards the documentation they used.

The hypothesis tested were:

H_1: There will be no significant difference in the time needed to complete the task between treatment groups.

H_2: There will be no significant difference in the attitudes towards the documentation between treatment groups.

The treatment involved the Mathematics Exploration Toolkit (MET) which was developed by IBM. Permission to use the MET software and documentation for this experiment is shown in Appendix A. The MET consists of a set of instructions and computer software that has been designed to assist teaching mathematics through elementary calculus. The instructions for the MET were written in the traditional (mostly text) style by IBM. A few pages from the MET instruction manual (see Appendix B) were redesigned to be mostly illustrations (see Appendix C).

Both sets of instructions describe using MET commands involving:

- Adding
- Subtracting
- Multiplying
- Dividing
- Simplifying
- Factoring
- Finding values
- Finding reciprocals

- Graphing
- Changing graph limits

These particular commands were chosen for the following reasons:

Time	The experiment was designed to be completed in 30 minutes in order to maintain interest of the volunteer subjects.
Interest	The subjects were expected to be more interested in solving mathematical problems than in setting up the computer.
Focus	Since college mathematics students are expected to understand the concepts behind the MET commands, they should be able to focus on learning about the MET.

The instructions used in both treatments presented the same commands in the same order.

The following figure shows the first two instructions for both treatments.

1. Type 4 • 3 - 10. Use **Shift+8** to type the • symbol. Don't worry about typing the spaces exactly as shown. As you type, the expression appears on the *command line*.
2. **Press Enter.** The expression you typed now appears at the bottom of the *expression window* in standard mathematical format. The expression at the bottom of the expression window is called the *current expression*.

FIGURE 2 - IBM Textual Instruction

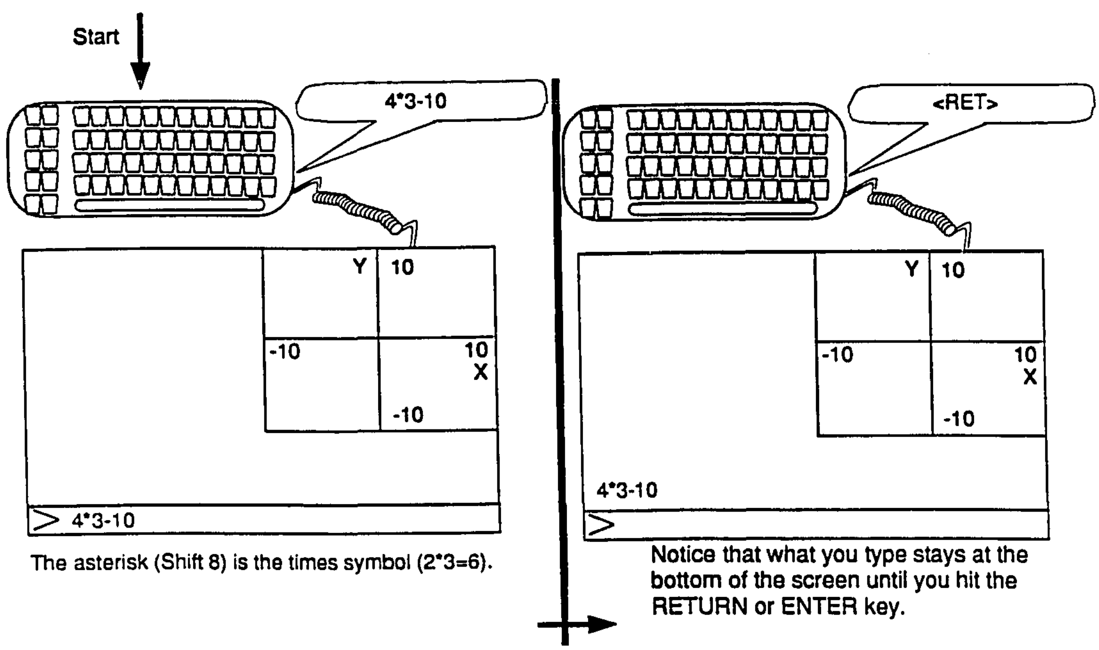

FIGURE 3 - Pictorial Instruction

Treatment Groups

The experiment was conducted within the following limits:

1. All subjects were volunteers from the Forsyth Technical Community College in Winston-Salem, North Carolina.

2. The experiment was kept short to accommodate volunteers.

3. The subjects were available in small groups. This made it impossible to control minor factors such as time of day and ambient noise.

The following assumptions were made regarding keeping the two treatment groups as equal as possible.

1. The most important variable to be kept equal was prior computer experience, since such experience would give the subjects the advantage of anticipating certain details of entering computer commands.

2. After computer experience, age was the next variable to be kept as equal as possible.

3. Finally, gender was considered if the treatment groups could be kept equal in all three areas.

Variables

The independent variable or treatment consisted of one of two sets of instructions as described above. One type of instruction was given to half of the subjects, and the other type of instruction was given to the remaining subjects. The dependent variables consisted of the time it took the subjects to complete the task and the attitude subjects had toward the instructions.

Procedure

Seventy subjects were given a questionnaire before their test session, and based on their answers the subjects were assign to a treatment group so that both treatment groups were as equal as possible in terms of computer experience, age, and gender. Of those who completed the questionnaire 50 attended the test sessions. No effort was made to balance the groups at the test sessions.

Subjects were expected to use the instructions given to them to become familiar with the selected MET commands and use an understanding of those commands to find the solution set of one polynomial and to estimate one solution of a second polynomial equation. One of the equations lent itself to a solution through factoring, while the other was solved most efficiently by graphing via the MET.

Each subject had a computer with the MET installed and ready to use. The computer setup and logon preliminaries were completed before the experiment began. The experiment was conducted in seven sessions of 50 minutes each. Therefore the introduction to the experiment was written to provide consistency between sessions (see Appendix D).

After the instructions were read to all subjects in a session, a clock was started as the subjects began using the instructions to learn about the MET and solve the polynomial equations. Each subject had a form (Appendix E) to write in the answers to the problems. As the forms were turned in, the time was recorded on the form. After turning in the answers to the problems, each subject was given an attitude survey (Appendix F) to determine their attitudes towards the instructions.

A search for a published instrument failed to yield a suitable set of questions, so the questions for the attitude survey were developed specifically for this experiment. The questions were patterned after those used by Duin (1990, p. 76) in an experiment that compared minimal and enhanced documentation for computer software. For example, Duin asked "How easy was it for you to put your file on the server?" Which is similar to the questions used in this experiment such as "How easy was it for you to factor polynomials?" The attitude surveys in Diun's experiment and this experiment both ask identical questions about coordinating the instructions with the screen and about how the instructions compared with other computer instructions the subjects may have used in the past.

Analysis

The data on which this study focused included the two treatments, the time to complete the tasks, and the attitude of the subjects towards the instructions. Other data available included previous computer experience, age, and gender of the subjects. The time data was measured in minutes and seconds and then converted to minutes accurate to the second decimal. Each question on the attitude survey had four choices. Each choice was given an ordinal value, 1, 2, 3, or 4, with '1' representing the greatest difficulty with using the instructions as viewed by the subjects. Computer experience was divided into four categories with 4 representing the most experience.

ANOVA was conducted for each of the two dependent variables with respect to treatment, computer experience, and gender. The Null Hypothesis was rejected for any F ratio representing a probability less than 0.1. This F ratio rather than the more stringent values representing probabilities of .05 or .01 was chosen because additional experiments are expected, making a Type I error more acceptable than a Type II error.

CHAPTER IV

ANALYSIS OF DATA

The data for this study was collected to determine if one set of instructions had an advantage over another for tasks involving using a computer learning program for mathematics. The two treatments consisted of directions for using a portion of IBM's Mathematics Exploration Tool Kit. One treatment used the traditional textual approach, while the other treatment used a pictorial approach. Pretest data looked at computer experience, age, and gender, each of which was considered a possible factor that would influence the outcome of the test. Test data consisted of the time each subject took to complete the task, the number of correct answers on the task, and the treatment used by each subject. Post test data was designed to determine the attitude of the subjects towards the treatment.

Means and analysis of variance were calculated for time, number correct, attitude, and various subsets of the attitude survey. These statistics were calculated for the two treatments across the entire sample and for each of the categories; age, gender, and computer experience. Although the categories were also looked at in pairs, little credibility can be given those results because the resultant sample sizes were small.

Description of the Sample

The test groups consisted of volunteers from seven mathematics classes that were in session August 1993 at Forsyth Technical Community College in Winston Salem, NC. The classes consisted of 82 students distributed in the following classes: one Introduction to Algebra, one Trigonometry, one Statistics, two Algebra, and two Calculus. Of these students, 71 completed pretest surveys (See Appendix G) and 50 attended the test sessions. There was one test session for each class. Efforts to balance the treatment groups in terms of computer experience, age, and gender were based on the pretest surveys, and no effort was made to balance these groups at the test sessions. As a result 21 subjects used the pictorial approach and 29 subjects used the textual approach.

There were four categories for experience on the pretest survey but, the majority of students used a computer less than two hours per week. Therefore, computer experience was limited to two categories for statistical analysis.

Ages ranged from 17 to 51. These were divided into two groups with ages 17 through 22 defining the young group and ages 23 through 51 defining the older group.

Table 1 summarizes the distributions of subjects with regard to treatment, computer experience, age, and gender.

Table 1

Distribution of Treatment Groups With Respect to Age, Gender, and Computer Experience.

Description of Group	Total in Group	Number Using Text	Number Using Pictures
Total Subjects	50	29	21
Experience - Less than 2hrs/wk	32	17	15
Experience - More than 2hrs/wk	18	12	6
Age - 17 through 22	28	15	13
Age - 23 through 51	22	16	8
Females	23	13	10
Males	27	16	11

Test Data

The first information considered while looking at the data was the time it took the two groups to complete the task. Since the experiment was conducted during class time no one was allowed to take more than 50 minutes for the task. The times for those using the textual approach (n = 29) ranged from 26.25 minutes to 50 minutes. The times for those using the pictorial approach (n = 21) ranged from 25.9 minutes to 50 minutes. The group using the textual documentation took an average of 39.92 minutes while the group using the pictorial documentation took an average of 41.92 minutes. Although there exists a difference in the two means, an analysis of variance (See Table 2) shows that the difference could have been caused by random error, and the Null Hypothesis should not be rejected.

Table 2

Analysis of Variance of "Time to Complete Task" Between Treatment Groups

Source	Sum of Squares	dF	Mean Square	F Ratio	Prob.
Between	48.500	1	48.500	0.60	.5148
Within	3871.266	48	80.651		
Total	3919.772	49			

The other test data considered was the number of correct responses put on the answer sheet during the task. There were subjects in both treatment groups who answered all questions correctly and others in both groups that answered none of the questions correctly. The possible point spread for the answer sheet was 0-6. The mean score for the group using the textual approach was 4.55 and the mean score for those using the pictorial documentation was 4.00. Again, these differences were not enough to reject the Null Hypothesis (See Table 3).

Table 3

Analysis of Variance of "Correct Responses" Between Treatment Groups

Source	Sum of Squares	dF	Mean Square	F Ratio	Prob.
Between	3.708	1	3.708	1.23	0.2737
Within	145.172	48	3.024		
Total	148.880	49			

Means for the time it took the subjects to complete the task and for the number of correct responses were also calculated for the two genders, two age groups, and two experience groups. An analysis of variance was calculated to determine if the data for the two treatment groups showed significant differences in the subgroups.

Test Data Considering Gender

Table 4 shows the means for the time to complete the tasks for males and females.

Table 4.

Means for "Time to Complete Task" by Gender and by Treatment

Gender	Treatment	N	Mean	Standard Deviation
Male	Pictorial	11	38.90	10.4157
Male	Textual	16	39.11	8.6098
Female	Pictorial	10	45.23	5.2437
Female	Textual	13	40.92	9.9741

The greatest difference occurred between the males using the pictorial documentation and the females using the pictorial documentation. However, the analysis of variance shown in Table 5 shows that the differences between these groups have a 31% chance of being caused by the variances within the groups.

Table 5

Analysis of Variance of "Time to Complete Task" Between Treatment Groups and Gender

Source	Sum of Squares	dF	Mean Square	F Ratio	Prob.
Between	281.277	3	93.909	1.24	0.3112
Within	3638.046	46	75.793		
Total	3919.772	49			

Table 6 shows the means for the number of correct responses for males and females, while Table 7 shows that there is insufficient evidence to reject the Null Hypothesis.

Table 6.

Means for "Number of Correct Responses" by Gender and by Treatment

Gender	Treatment	N	Mean	Standard Deviation
Male	Pictorial	11	4.18	1.8340
Male	Textual	16	4.75	1.6931
Female	Pictorial	10	3.80	1.9889
Female	Textual	13	4.31	1.6013

Table 7

Analysis of Variance of "Correct Responses" Between Treatment Groups and Gender

Source	Sum of Squares	dF	Mean Square	F Ratio	Prob.
Between	5.874	3	1.958	0.63	0.5995
Within	143.006	46	3.109		
Total	148.880	49			

Test Data Considering Age

Analysis also considered possible interaction between age groups for the time it took to complete the task and the number of correct responses. Table 8 shows the means for the time it took each age group and treatment to complete the task. Based on a predetermined probability of 0.10 and the results of the analysis of variance calculated from Table 8, Table 9 shows that there is insufficient evidence to reject the Null Hypothesis. However, the probability of 0.1214 is low enough to merit investigating the differences in age groups when using pictorial documentation in future experiments.

Table 8.

Means for "Time to Complete Task" by Age Group and by Treatment

Gender	Treatment	N	Mean	Standard Deviation
Old	Pictorial	8	47.50	3.8332
Old	Textual	14	40.50	9.2443
Young	Pictorial	13	38.48	9.2934
Young	Textual	15	39.38	9.2941

Table 9

Analysis of Variance of "Time to Complete Task" Between Treatment Groups and Age Groups

Source	Sum of Squares	dF	Mean Square	F Ratio	Prob.
Between	460.224	3	153.408	2.04	.1214
Within	3459.548	46	75.208		
Total	3919.772	49			

Table 10 shows the means by age group and by treatment, the number of correct responses on the task, while Table 11 shows that there is insufficient evidence to conclude that there are significant differences between those means.

Table 10.

Means for "Correct Responses" by Age Group and by Treatment

Gender	Treatment	N	Mean	Standard Deviation
Old	Pictorial	8	3.500	2.3905
Old	Textual	14	4.500	1.4005
Young	Pictorial	13	4.308	1.4936
Young	Textual	15	4.600	1.8823

Table 11

Analysis of Variance of "Correct Responses" Between Treatment Groups and Age Groups

Source	Sum of Squares	dF	Mean Square	F Ratio	Prob.
Between	7.011	3	2.337	0.76	0.5236
Within	141.869	46	3.084		
Total	148.880	49			

Test Data Considering Computer Experience

The population sample was divided into two groups with regard to computer experience. The "High" group used computers for more than two hours per week, while the "Low" group used the computer two hours or less per week. The means for the time it took each experience group within each treatment group to complete the task are shown in Table 12.

Table 12.

Means for "Time to Complete Task" by Experience Group and by Treatment

Gender	Treatment	N	Mean	Standard Deviation
High Experience	Pictorial	6	45.12	7.5573
High Experience	Textual	12	35.36	8.7360
Low Experience	Pictorial	15	40.63	9.1414
Low Experience	Textual	17	43.14	8.1748

The group with high experience using the traditional textual approach averaged almost ten minutes faster than the group with high experience using the pictorial approach. The analysis of variance, shown in Table 13, indicates that the differences between the four groups have a 6.9% chance of being caused by variances within the groups. Which is within the predetermined critical value of 0.10. Therefore another analysis of variance was calculated using only the high experience group (See Table 14).

Table 13

Analysis of Variance of "Time to Complete Task" Between Treatment Groups and Experience Groups

Source	Sum of Squares	dF	Mean Square	F Ratio	Prob.
Between	559.859	3	186.620	2.56	.0693
Within	3359.913	46	73.042		
Total	3919.772	49			

Table 14

Analysis of Variance of "Time to Complete Task" Between Treatment Groups for the High Experience Group

Source	Sum of Squares	dF	Mean Square	F Ratio	Prob.
Between	380.965	1	380.965	5.44	0.033
Within	1120.756	16	70.047		
Total	1501.722	17			

Table 14 shows the analysis of variance with respect to time for the two treatments from only the high experience group. The group means differ by almost 10 minutes and are significant to 0.033. We therefore reject the Null Hypothesis, and claim that for the high experience group there was a significant advantage to the group using the textual approach in terms of the time required to complete the task.

Table 15 shows the means of correct responses from the low and high experience groups with respect to treatment. Table 16 shows the analysis of variance for these means indicating there is insufficient evidence in this data to reject the Null Hypothesis.

Table 15.

Means for "Correct Responses" by Experience Group and by Treatment

Gender	Treatment	N	Mean	Standard Deviation
High Experience	Pictorial	6	4.333	0.8165
High Experience	Textual	12	4.667	1.6143
Low Experience	Pictorial	15	3.867	2.1668
Low Experience	Textual	17	4.471	1.6999

Table 16

Analysis of Variance of "Correct Responses" Between Treatment Groups and Experience Groups

Source	Sum of Squares	dF	Mean Square	F Ratio	Prob.
Between	4.911	3	1.637	0.52	0.6653
Within	143.969	46	3.130		
Total	148.880	49			

Post test Data

The post test data was taken from answers to surveys which the subjects completed immediately after the exercise (See Appendix F). The data called attitude was the sum of answers to questions one through six on the survey minus the answer to question seven. Calculating "attitude" this way causes a higher score to reflect a more positive attitude towards the documentation used by the subject. The data "attitude" was calculated for 47 of the 50 subjects because some questions were left unanswered on the surveys.

In addition, special attention was given to the first and last questions which were: (First) "How easy was it for you to coordinate your attention between the documentation and the screen?" (Last) "How do these instructions compare to other computer instructions you have used in the past?" Data for these two questions will be called "Coordinate" and "Compare" respectively. As with the test data, the post test data is considered over the entire sample and also within gender, age groups, and computer experience groups.

The overall mean for "attitude" was 16.02, while the means for the groups using textual and pictorial documentation were respectively 16.71 and 15.0. A analysis of variance revealed an F-ratio below the critical value for the predetermined probability of 0.10. No more will be said about "attitude" because the subsets of "attitude" (coordinate and compare) provide more insight into the results of the experiment.

The means for "Coordinate" and "Compare" for the two treatment groups are shown in Table 17. Because of the way the questions and choices were arranged, the documentation used in the treatment is favored by a high score when looking at the "Coordinate" data and by a low score when looking at the "Compare" data.

Table 17

Means for "Coordinate" and "Compare" Data by Treatment

Data	Treatment	N	Mean	Standard Deviation
Coordinate	Pictorial	21	2.905	0.6249
Coordinate	Textual	29	3.276	0.5914
Compare	Pictorial	19	2.368	0.8307
Compare	Textual	28	2.464	0.8381

An analysis of variance for the two sets of data in Table 17 provide insufficient evidence to reject the Null Hypothesis concerning the "Compare" data, but does indicate the "Coordinate" date is significant at 0.10 (See Table 18).

Table 18

Analysis of Variance of "Coordinate" Between Treatment Groups

Source	Sum of Squares	dF	Mean Square	F Ratio	Prob.
Between	1.677	1	1.677	4.57	0.0376
Within	17.603	48	0.367		
Total	19.280	49			

Post test Data Considering Gender

Table 19 shows the means for the "Coordinate" data with respect to gender. The differences between at least two of these means is significant at the 0.10 level as shown in Table 20. Additional calculations of analysis of variance for males and females as well as a Scheffe test between genders showed that the differences between the genders and within the female population were not significant at the 0.10 level. The differences within the male population and between the males using the pictorial approach and the females using the textual approach were significant at the 0.10 level. In both cases the data favored the textual approach.

Table 19

Means for "Coordinate" by Gender and by Treatment

Gender	Treatment	N	Mean	Standard Deviation
Male	Pictorial	11	2.727	0.467
Male	Textual	16	3.188	0.544
Female	Pictorial	10	3.100	0.738
Female	Textual	13	3.385	0.650

Table 20

Analysis of Variance of "Coordinate" Between Treatment Groups and Gender

Source	Sum of Squares	dF	Mean Square	F Ratio	Prob.
Between	2.684	3	0.895	2.48	0.0729
Within	16.596	46	0.361		
Total	19.28	49			

The means for the "Compare" data for genders and treatment groups are shown in Table 21. The analysis of variance for these groups produced very small F-ratios.

Table 21

Means for "Compare" by Gender and by Treatment

Gender	Treatment	N	Mean	Standard Deviation
Male	Pictorial	11	2.333	0.707
Male	Textual	16	2.375	0.806
Female	Pictorial	10	2.400	0.966
Female	Textual	13	2.583	0.900

Post test Data Considering Age

The "Coordinate" means for the two age groups and treatment groups are shown in Table 22. The "Coordinate" data has already been shown to be significant at the 0.10 level for all subjects, but the analysis of variance taken separately for the young groups falls short of being significant at the 0.10 level, while the older group showed a significant difference in favor of the textual approach. The young group had a more positive response than the old group for this survey question, but a Scheffe Test between these two groups yields an F-ratio of 0.91 which is below the critical value to be significant at the 0.10 level.

Table 22

Means for "Coordinate" by Age and by Treatment

Gender	Treatment	N	Mean	Standard Deviation
Old	Pictorial	8	2.625	0.744
Old	Textual	14	3.143	0.534
Young	Pictorial	13	3.077	0.494
Young	Textual	15	3.400	0.632

Table 23 shows the "Compare" means for the two age groups and the treatment groups. Table 24 lists the results of an analysis of variance of this data which shows that the differences are significant at the 0.10 level. These differences are significant between age groups as calculated by a Scheffe test and within the old group as shown in Table 25. Note from Table 23 that the old group gives better scores to the pictorial approach, while the young group gives better scores to the textual approach.

Table 23

Means for "Compare" by Age and by Treatment

Gender	Treatment	N	Mean	Standard Deviation
Old	Pictorial	6	2.167	0.408
Old	Textual	13	3.000	0.816
Young	Pictorial	13	2.462	0.967
Young	Textual	15	2.000	0.535

Table 24

Analysis of Variance of "Compare" Between Treatment Groups and Age Groups

Source	Sum of Squares	dF	Mean Square	F Ratio	Prob.
Between	7.425	3	2.475	4.42	0.0085
Within	24.064	43	0.560		
Total	31.489	46			

Table 25

Analysis of Variance of "Compare" Between Treatment Groups for the Old Group

Source	Sum of Squares	dF	Mean Square	F Ratio	Prob.
Between	2.851	1	2.851	5.49	0.0316
Within	8.833	17	0.520		
Total	11.684	18			

Post test Data Considering Computer Experience

Table 26 shows "Coordinate" data for the low and high experience groups with respect to treatment. Scheffe tests indicate that differences between experience groups and treatments are both significant at the 0.10

level, but analysis of variance calculated within the experience groups with respect to treatment do not show differences that are significant at the 0.10 level.

Table 26.

Means for "Coordinate" by Experience Group and by Treatment

Gender	Treatment	N	Mean	Standard Deviation
High Experience	Pictorial	6	3.166	0.4082
High Experience	Textual	12	3.500	0.5222
Low Experience	Pictorial	15	2.800	0.6761
Low Experience	Textual	17	3.118	0.6002

The "Compare" means for the high and low experience groups are shown in Table 27. The analysis of variance (Table 28) indicates no significance between "Compare" data for these groups.

Table 27.

Means for "Compare" by Experience Group and by Treatment

Gender	Treatment	N	Mean	Standard Deviation
High Experience	Pictorial	6	2.500	0.8367
High Experience	Textual	11	2.364	0.8090
Low Experience	Pictorial	13	2.308	0.8549
Low Experience	Textual	17	2.529	0.8745

Table 28

Analysis of Variance of "Compare" Between Treatment Groups and Experience Groups

Source	Sum of Squares	dF	Mean Square	F Ratio	Prob.
Between	0.439	3	0.146	0.20	0.8939
Within	31.05	43	0.722		
Total	31.489	46			

CHAPTER V

SUMMARY AND CONCLUSIONS

This study looks at how a group of college mathematics students respond to instructions that are mostly text as opposed to instructions that are mostly illustrations. It begins to answer questions regarding presentation styles for educational software documentation. Specifically this study asks: **Do college mathematics students experience an advantage by using a pictorial approach as compared to students using the traditional textual approaches when learning to use software that is designed to assist in teaching mathematics?** Although a few authors have discussed using documentation that is mostly pictorial, (See Chapter II) this author could find no other studies that compared textual documentation with pictorial documentation. For that reason the instruments used were created specifically for this study and not checked for reliability. The experiment does have obvious content validity.

The sample consisted of 50 students enrolled in mathematics classes at Forsyth Technical Community College during August 1993. A pretest survey was used to balance the treatment groups in terms of gender, age, and computer experience. The test consisted of two treatments: 1) Completing tasks on IBM's Mathematics Toolkit using directions that were traditionally textual. 2) Completing the same tasks using directions that were mostly pictorial. Test data consisted of the time it took each subject to complete the task and the number of correct responses on the task. Post test data consisted of answers to an attitude survey which was administered immediately after the test. Analysis of the attitude survey focused on: 1) the ability of subjects to coordinate the documentation with the computer screen and 2) the subject's judgement between the documentation used in the test and other computer documentation used by the subject.

The time it took subjects to complete the task was slightly better for the group using the textual approach, but the difference was insufficient to reject the Null hypothesis for the group as a whole and for the gender and age groups. However, in the age groups the older group using the textual approach did much better than the older group using the pictorial approach. The statistics for this difference in the older group fell a little short of meeting the 0.10 level of significance. In the groups considering computer experience, the group with high experience using the textual approach did better than the high experience group using the pictorial approach. The statistics for the time for the high experience group was significant to the 0.10 level.

The statistics for the number of correct responses on the task were insufficient to reject the Null Hypothesis for all combinations of the sample.

The statistics for coordinating the documentation to the screen favored the textual approach and were significant for the entire sample, within the male portion of the sample, and within the older portion of the sample. Also the younger group using the textual approach responded more positively than the older group using the pictorial approach, significant to the 0.10 level. Finally this statistic was significant to the 0.10 level between experience groups with the high experience group responding more positively than the low experience group.

Data that considered the subjects' judgement in comparing the documentation used in the test with other documentation on computers provided insufficient evidence to reject the Null Hypothesis when looking at the whole sample, the gender groups, and the experience groups. The older age group, however, favored the pictorial approach, significant to the 0.10 level.

Conclusions

The limited sample and the singularity of this study should make one cautious about drawing substantial conclusions from the data. The study does, however, indicate that there exists unstudied factors relating to documentation that affect how easy the document is to use and how the document is perceived.

In general the data favored the traditional textual approach, but the distribution of the data may suggest that familiarity with the textual approach rather than the advantages of the textual approach was the underlying factor for this result.

There was weak evidence that the textual approach had an advantage in the time it took to complete the task. This evidence was only significant in the high experience group, a group that would be most familiar with the traditional approach for learning computer programs. No groups showed a significant advantage in the number of correct responses with either treatment.

The data involving coordination between the screen and the documentation showed the most significant results in favor of the textual approach, but even these results were mixed. The overall sample showed significant differences but only the male group and old group showed significant results within the group.

The most interesting and surprising data occurred within the older group which favored the textual approach in the areas of "time to complete the task" and "coordinate," but significantly favored the pictorial approach in terms of judging between the instructions used in the experiment and other instructions used to learn computer programs. A possible explanation for this is that they were unfamiliar with the pictorial approach which caused them to slow down, but at the same time they preferred the pictorial approach either because it was new or because it aided their confidence.

Whether or not the above explanation is true, further experiments of this type should be conducted. Future experiments should take into account the possibility that the pictorial approach was at a disadvantage because of its newness. Experiments of this type in the future may include an extra session that allows the subjects to become familiar with both approaches to documentation. Future experiments may also consider several approaches that include a variety of documentation styles that range between the two extremes used in this study. The questions considered in this study have barely opened the door to an entire arena of academic research.

Recommendations

Additional studies are needed to consider the following questions:

- Can we create multiple instructional styles using illustrations similar to the way we can with text?
- Do specific age groups respond better to a given instructional style than other age groups?
- Do subjects with specific levels of education or experience respond better to a given instructional style than other subjects?
- Do subjects remember instructions better with one format when compared with other formats?

Answering such questions would require long term studies that would allow subjects to become familiar with the format of the instructions they would use in the final test. These studies would also involve larger numbers of subjects in order to consider the differences in age and education.

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APPENDIX A

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Upon completion of your study please mail a copy of your findings and the 15 copies of the MET Program to:

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Attention: Don Hyde

Good luck on your project.

Sincerely,

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APPENDIX B
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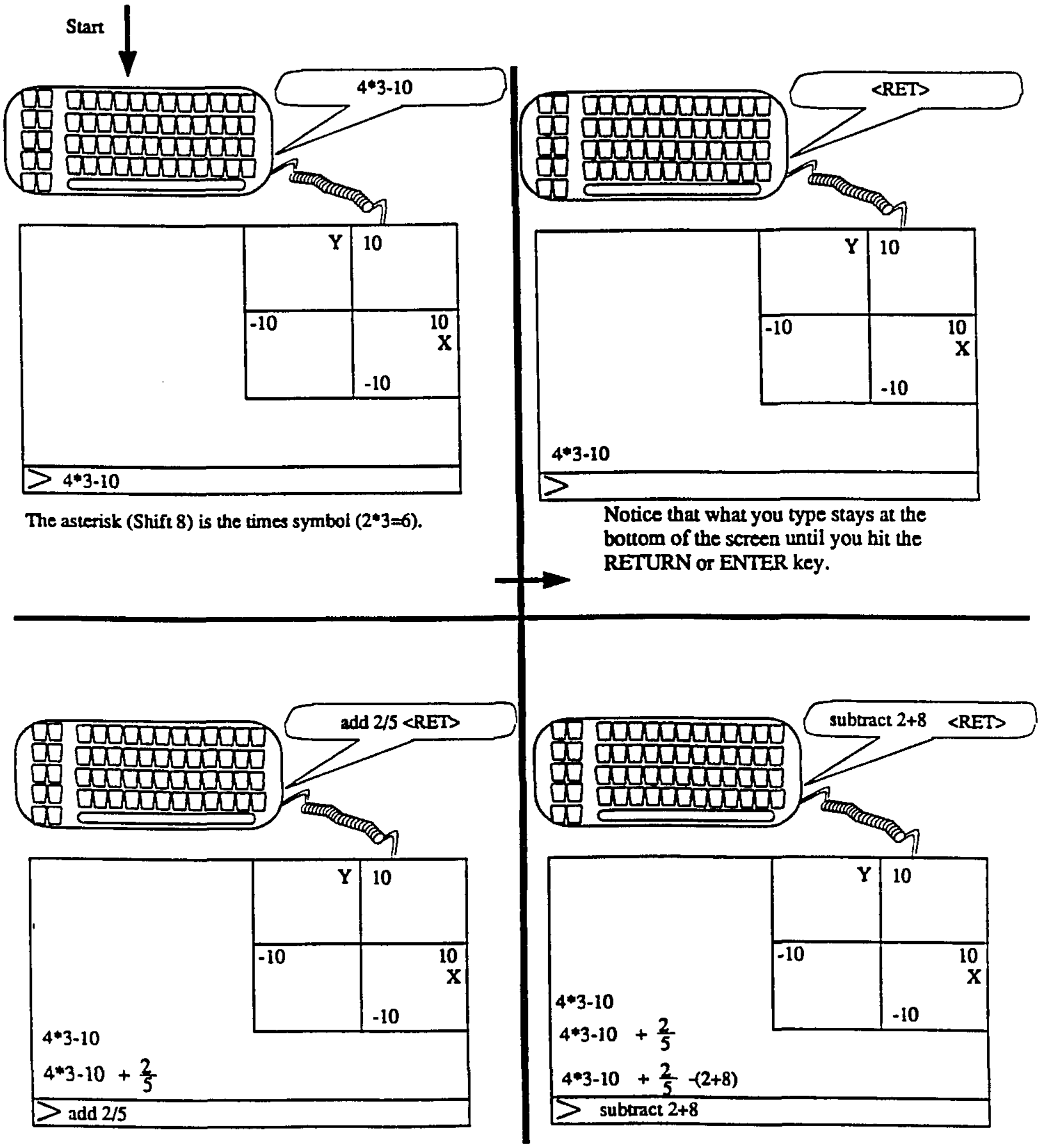
APPENDIX C

Examples of MET Commands

(Try these or make up your own equations.)



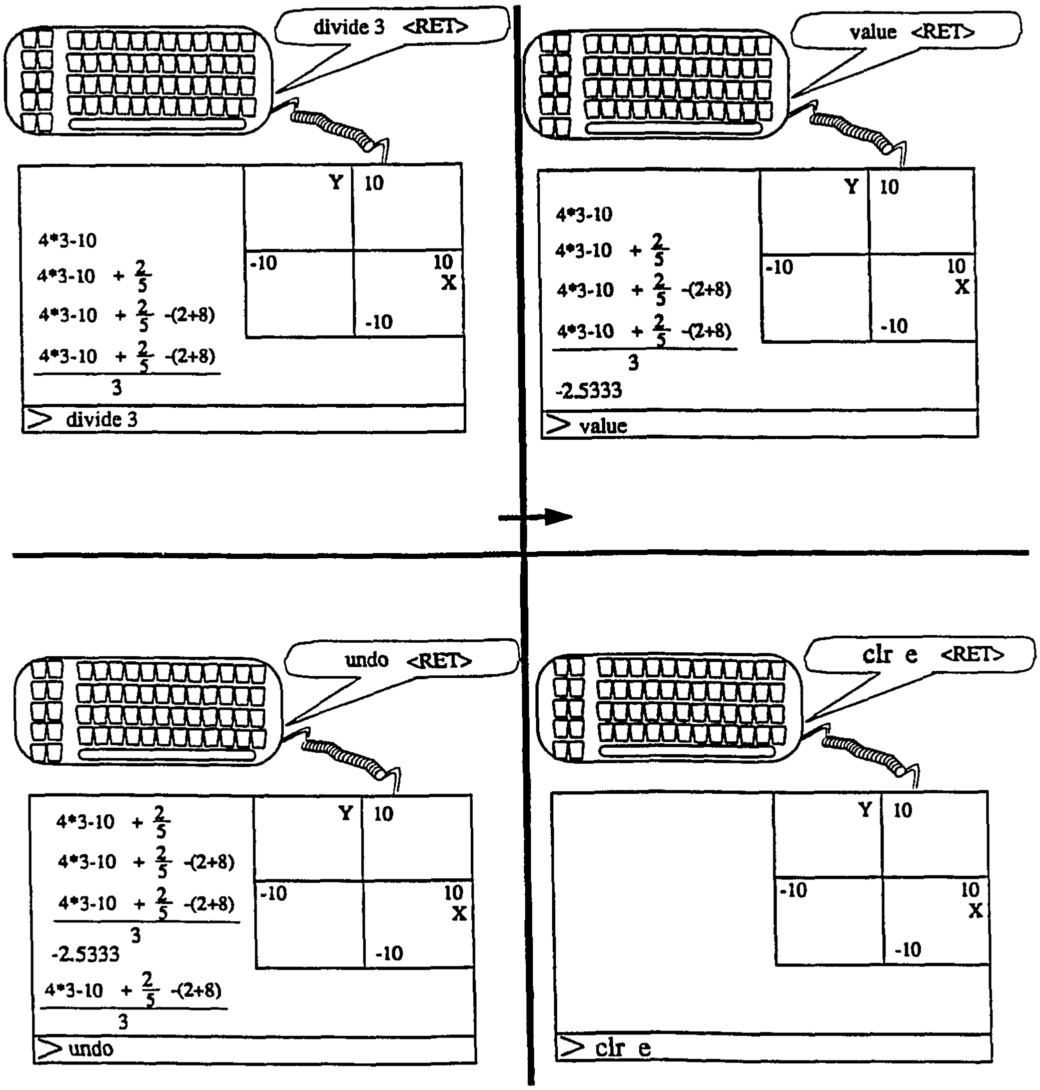
The asterisk (Shift 8) is the times symbol (2*3=6).

Notice that what you type stays at the bottom of the screen until you hit the RETURN or ENTER key.

APPENDIX C

Examples of MET Commands

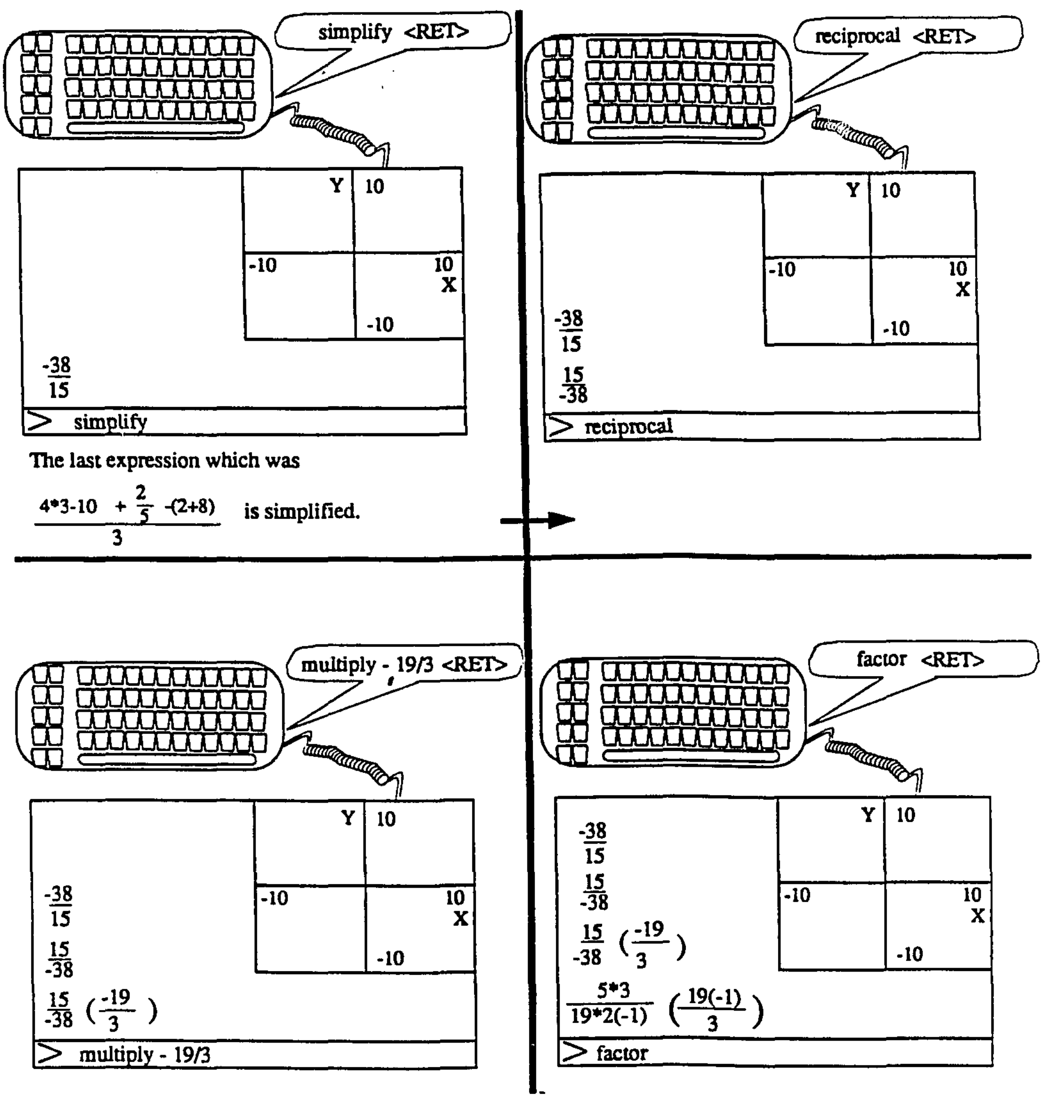
(Try these or make up your own equations.)



APPENDIX C

Examples of MET Commands

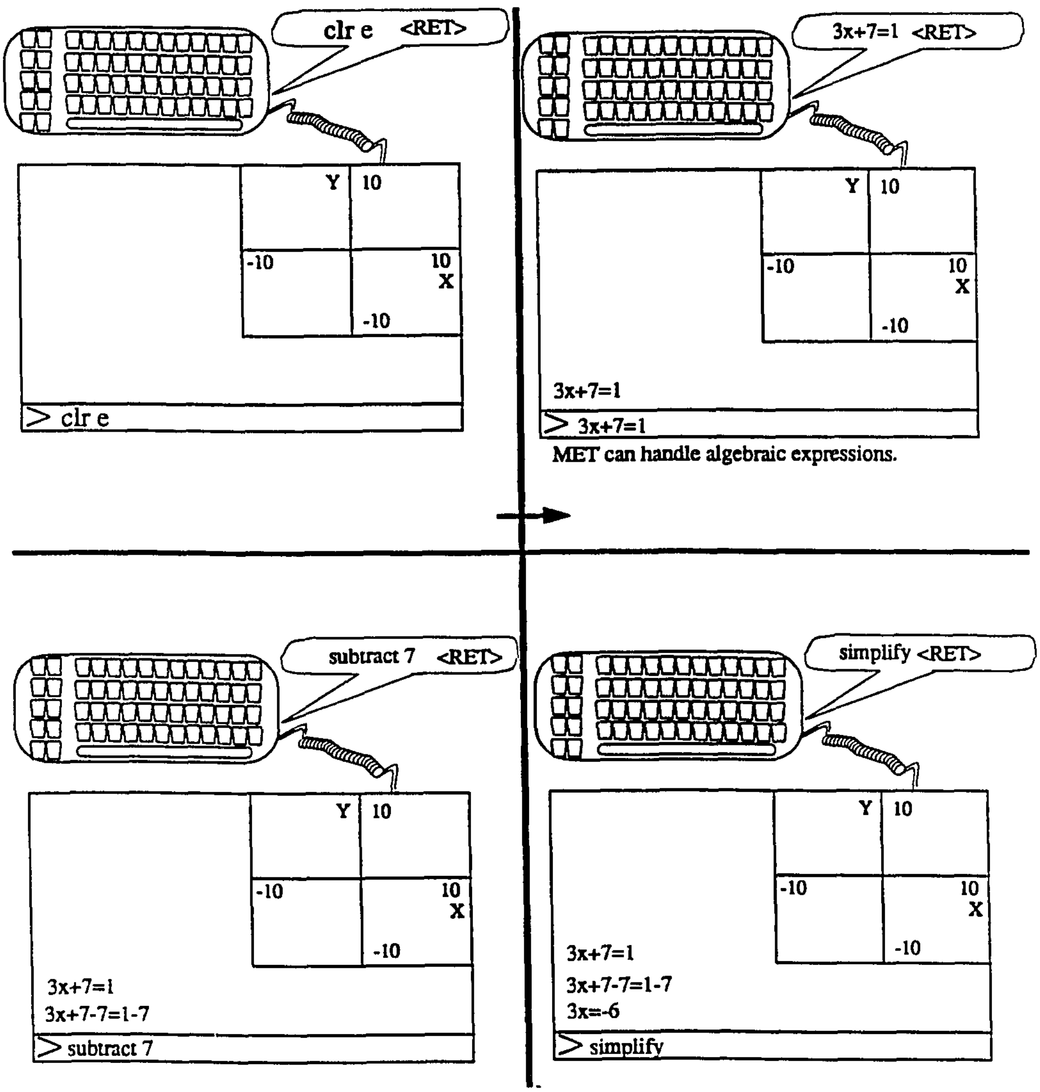
(Try these or make up your own equations.)



APPENDIX C

Examples of MET Commands

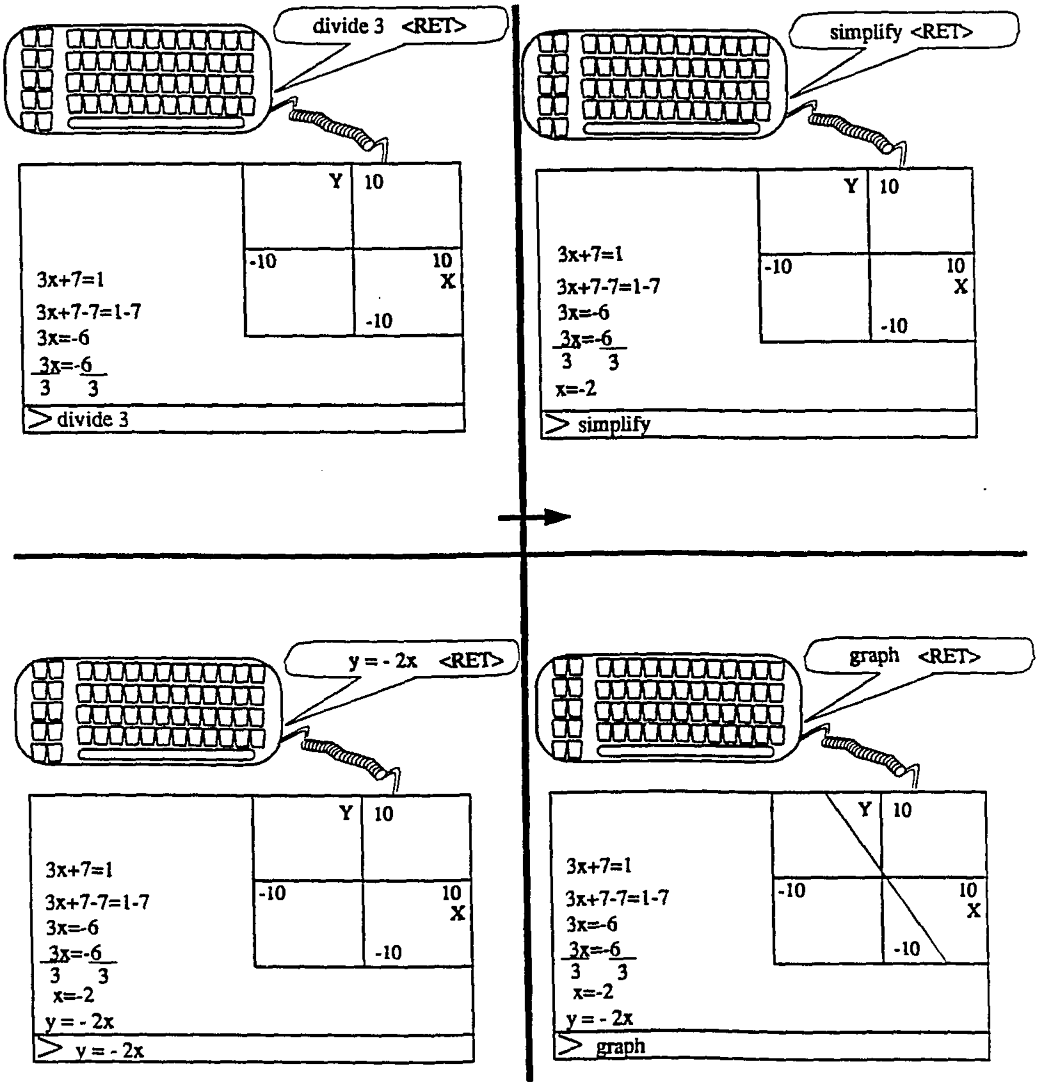
(Try these or make up your own equations.)



APPENDIX C

Examples of MET Commands

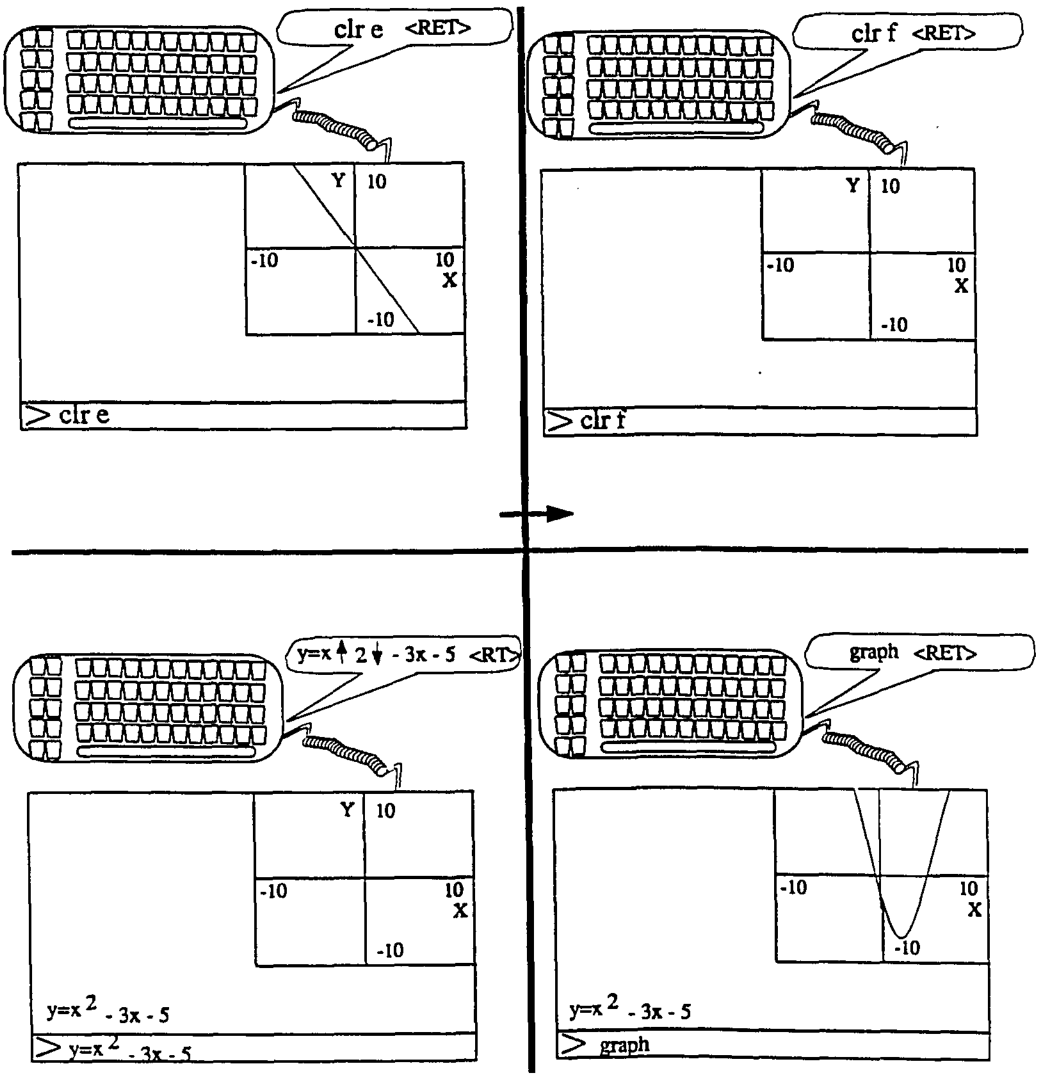
(Try these or make up your own equations.)



APPENDIX C

Examples of MET Commands

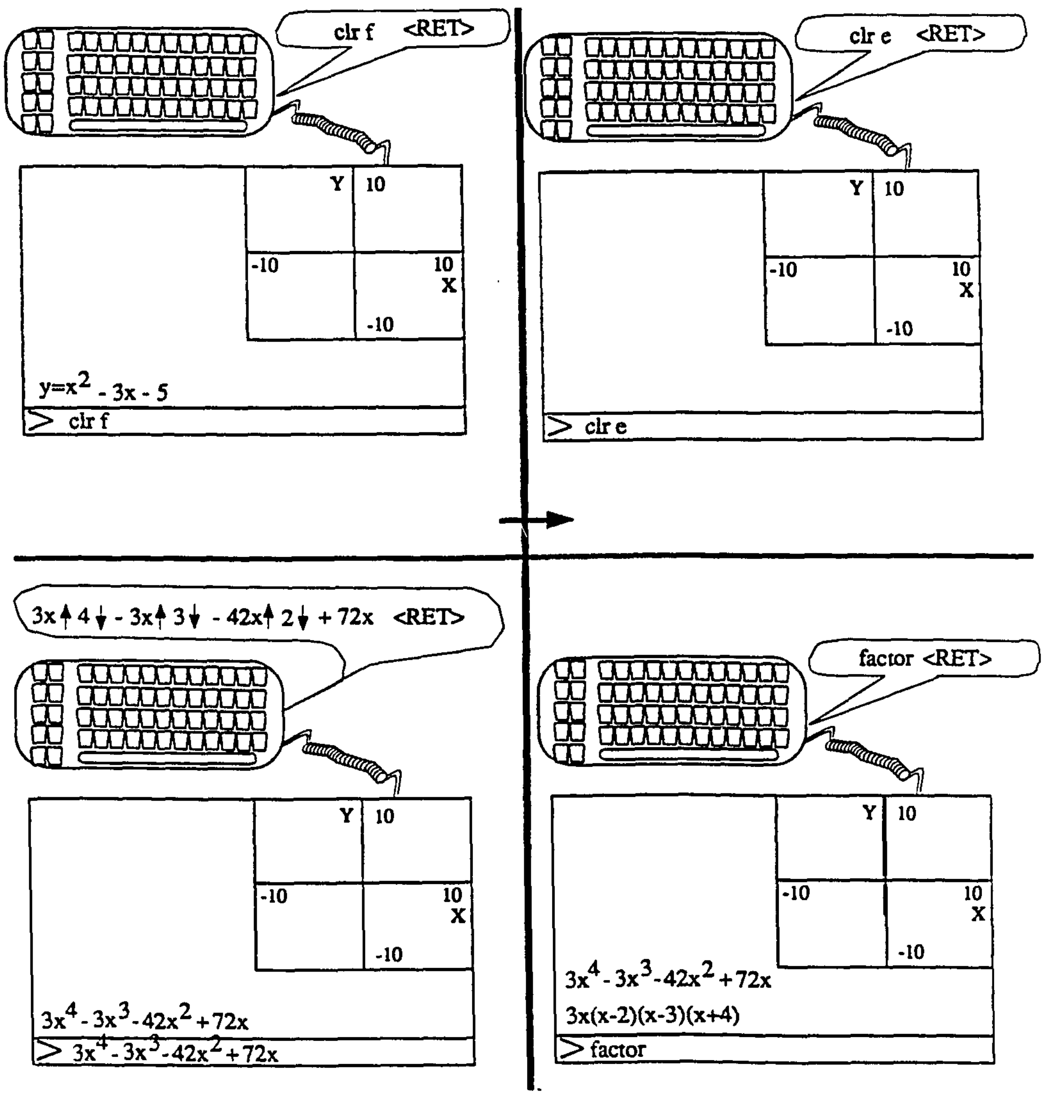
(Try these or make up your own equations.)



APPENDIX C

Examples of MET Commands

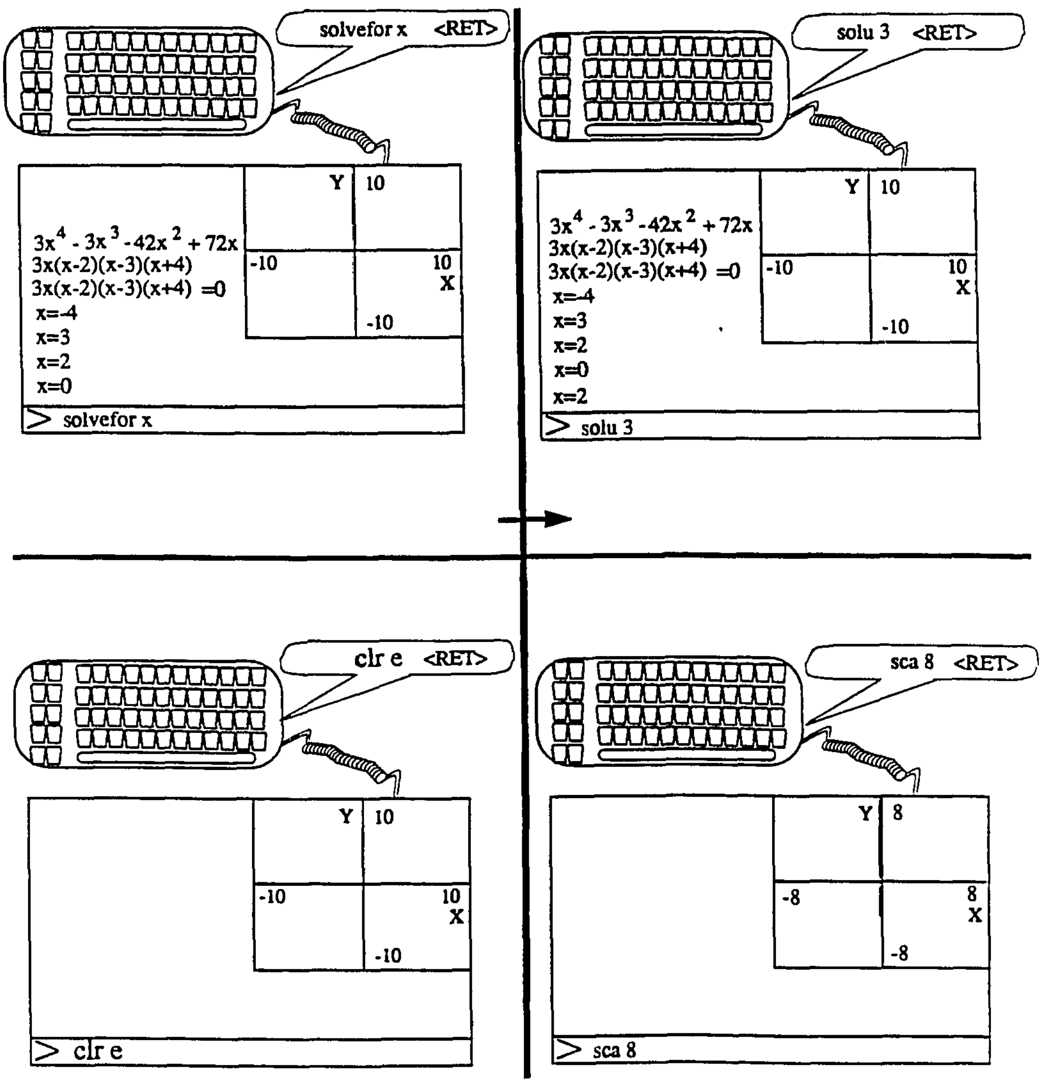
(Try these or make up your own equations.)



APPENDIX C

Examples of MET Commands

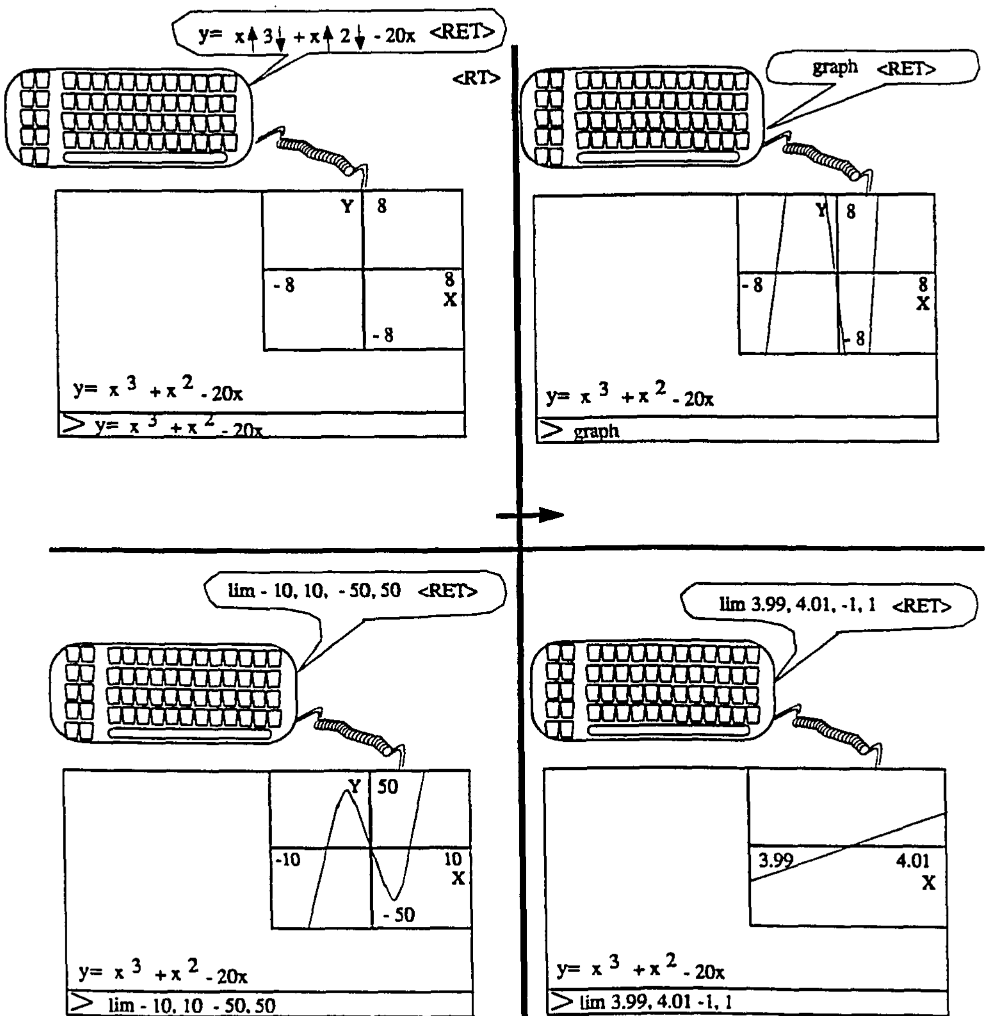
(Try these or make up your own equations.)



APPENDIX C

Examples of MET Commands

(Try these or make up your own equations.)



Limits can range from 1/1,000,000 to 1,000,000.
Notice that when limits are not equal the graph is distorted.

Notice that an axis is not visable when the limits on the other axis are both positive or both negative.

APPENDIX D

Introduction

Please do not turn this page or touch your computer until you are told to do so.

Thank you for participating in this experiment. During this experiment you will be introduced to IBM's Mathematics Exploration Toolkit (MET), a computer software program that can assist in teaching arithmetic, algebra, trigonometry, and calculus. Your participation will help identify effective presentation styles for documentation for this type of computer software.

This book contains one of two types of instructions for a small portion of the MET. Please do not write in this book. There will be enough information in the instructions to enable you to use the MET to complete the Answer Sheet. The software is installed and ready to use.

Once the introduction is read, please begin learning the operations of the MET by following the instructions; then use what you have learned to fill in the Answer Sheet. You will be timed from the end of this introduction until you hand in the Answer Sheet. After you turn in your answers, you will be asked to complete a short survey. The experiment ends when the surveys are turned in. Any questions you have will be answered at that point.

Because you are beginning in the middle of the MET instructions, a few fundamentals are given below.

1. The instruction "enter 2+8" means to type "2+8 <RET>" where <RET> or <RT> represents the RETURN key.
2. The RETURN key may be labeled "RETURN," "Enter," or ↵.
3. Before typing the RETURN key you may undo typing mistakes with the Backspace key. The Backspace key is sometimes represented by <--- on the keyboard.
4. After typing the RETURN key you may back up to the last command by entering "undo" (type "undo <RET>").
5. Some commands take time. The > symbol at the bottom left of the MET screen tells you that the MET is ready to receive the next input.
6. Please do not play with graphing trigonometric equations during the experiment. Some of them can take up to ten minutes to graph.

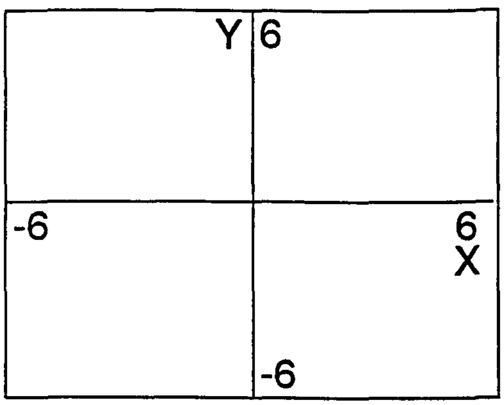
The next few pages are instructions to help you use the MET. The Answer Sheet is loose behind the last page. As soon as you have filled in your answers, please hand them to the examiner. Please wait until you are told to begin.

APPENDIX E

Answer Sheet

Sketch

$Y = 6X^3 - 25X^2 + 32X - 12$



Solve

$6X^3 - 25X^2 + 32X - 12 = 0$

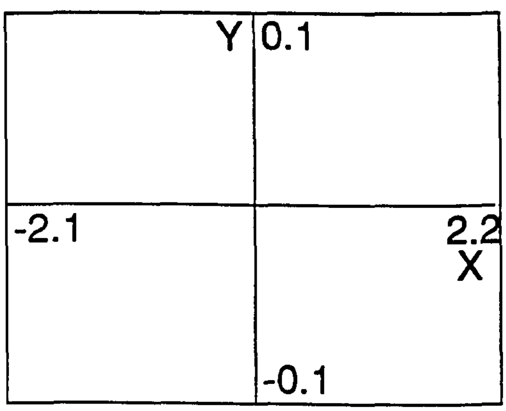
$X_1 =$

$X_2 =$

$X_3 =$

Sketch (Note X, Y limits)

$Y = 6X^3 - 25X^2 + 31X - 11$



Estimate one solution for

$6X^3 - 25X^2 + 31X - 11 = 0$

to the nearest 1/100

$X_1 =$

APPENDIX F

Survey

Please answer the questions below with regard to the documentation you used during this exercise by circling the appropriate choice.

How easy was it to coordinate your attention between the instructions and the screen?

Very difficult	Difficult	Relatively easy	Easy

How easy was it for you to perform arithmetic commands?

Very difficult	Difficult	Relatively easy	Easy

How easy was it for you to factor polynomials?

Very difficult	Difficult	Relatively easy	Easy

How easy was it for you to graph equations?

Very difficult	Difficult	Relatively easy	Easy

How easy was it for you to change limits on a graph?

Very difficult	Difficult	Relatively easy	Easy

How easy was it for you to use a graph to estimate a solution to a polynomial equation?

Very difficult	Difficult	Relatively easy	Easy

How do these instructions compare to other computer instructions you have used in the past?

Much better	Better	About the same	Worse

Please note any observations you have concerning the documentation you used during this exercise.

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APPENDIX G

Pretest Survey

Name ______________________________________

Teacher ____________________Class time ____________________

Circle: Male - or - Female__________Age __________

Please indicate your experience with computers by circling the best answer.

In the past two years my average time spent working with computers (not games)

1-2 hrs/wk   2-5 hrs/wk   5-8 hrs/wk   8-12 hrs/wk

This year I have used computers to teach or learn mathematics

less than 10%   10-30%   30-70%   more than 70%

Have you ever used IBM's Mathematics Exploration Toolkit before?

Yes   No