EFFECTIVENESS OF EDUCATIONAL COMPUTER SOFTWARE WITH HEARING IMPAIRED STUDENTS

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Abstract

This study addresses the effectiveness of educational microcomputer software with hearing impaired students. A review of the literature revealed a large void in the empirical research on this topic and also indicated that a lack of suitable and appropriate software, was a major hurdle to the successful use of CAI with hearing impaired students.

This study investigated the effectiveness of a specific educational microcomputer program (MECC : Trapezoids and Triangles Areas) with a group of hearing impaired students. The 18 students were randomly divided into two groups. One group viewed the tutorial portion of the software and then worked with the practise section. While the other group worked only with the practise section of the software. This was done to measure and compare the effectiveness of both portions of the program. The students were carefully observed as they interacted with the computer. Problems they encountered with the software, their achievement during exposure to the software and on pre and post tests, were all recorded by the experimenter. These data were used to measure the changes that took place due to microcomputer application, to evaluate the effectiveness of this software, to make recommendations regarding the characteristics required to improve this software, and to set "guidelines" for the development of future educationally effective software for the hearing impaired.

The results revealed the need for software that contains a measured and controlled level of syntax, more advanced diagnostic and remedial capabilities, and a simplified more thorough presentation of the information.

This study demonstrated the need for more research related to identification of the important factors and teaching strategies which make software more educationally effective for use with hearing impaired students.

Table of Contents

List of Tables

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Chapter 1 : Introduction

We are only at the dawn of the educational use of the microcomputer. It is much too early to see clearly what the potential and appropriate applications of the microcomputer are for enhancing the education of our hearing impaired students. None the less, almost every article which discusses hearing impaired students and the use of microcomputers suggests that the microcomputer could be a very valuable addition to a teacher's armamentarium, if it is applied appropriately.

Despite the general prevailing attitude that the microcomputer will be a powerful and versatile tool, there are those who criticize and mistrust the emergence of this relatively new educational aid. They feel that the microcomputer is simply a machine to entertain and on which to play games, and consider that it has little of the educational value that others have suggested. Wright (1980), in her paper, discussed the suspicions of both parents and educators brought about by early attempts with computer instruction. With older main frame computers, there were many breakdowns, responses were slow, the applications were limited and the cost was exorbitant. Wright states that "in short, there is an inherent disbelief that technology can do anything to really promote educational goals of the school" (p.16) and believes that "technology is not a solution it is a resource, which must be manipulated by the teacher for the student's benefit."(p.17)

Originally a key criticism of Computer Assisted Instruction (CAI) and computer use was the initial high cost of the hardware, but now with the development of the microprocessor, much cheaper microcomputers can be manufactured. Indeed, compared with the overall costs of educating a hearing impaired child, the cost of a microcomputer is negligible.

One of the big mistakes made by people is equating the microcomputer with visual aids (Wright, 1981, p.10). The microcomputer requires a great deal of interaction between itself and the student. It is not a passive medium of education because the student is continuously required to interact with it, supplying answers and information. The microcomputer may of course be used solely as a visual aid, but it also has the potential of going far beyond any visual aids of the past.

Now that the low cost of microcomputers has facilitated their use in a very large number of schools, many positive attributes have been associated with their use. Because sound is not generally an important component, they are good machines to use with deaf students. In education of the hearing impaired, teachers generally present information to the students, check for understanding of the presentation, and reward them for correct comprehension. The microcomputer can perform all of these functions. All teachers of the hearing impaired know about the need for redundancy when presenting new concepts (Smaldino, 1983, p.644) and the microcomputer can be used very effectively to give repeated exposure to new topics without the students becoming bored with the routine. Teachers of the hearing impaired who are using computer assisted instruction with microcomputers are now finding that the students really enjoy learning in this fashion. Students find the computer exciting and seldom tire of their task. Many teachers also see a growth in the students' confidence and self-esteem due to successful interactions with the computer. Furthermore, the programs now available for use on microcomputers can be used not only for teaching new concepts, but also for remedial work and reinforcement of basic skills.

Nicolay (1983) in his article on group learning and the computer, discussed what many teachers have already discovered. That is, that time spent interacting academically with the students, giving them new experiences and information is most rewarding. He also suggested that students do better when they are involved in more academic interaction with the instructor, and showed that teacher led group instruction is better than individual seat work. He proposed that the carefully managed use of microcomputer as a teacher's aid in the classroom would in fact afford the teacher more time to interact with students because less time was required to monitor their progress.

Currently there is a great deal of optimism and excitement about the opportunities the microcomputer and CAI will afford our hearing impaired students. The computer as an extension of the teacher's creativity can become one of his/her best motivational tools. The computer is not in competition with the teacher nor will it replace the teacher, but it does replace overheads, flashcards, and chalk. Perhaps the finest aspect of the computer is that it can be used to teach a variety of skills. In brief, modern technology has given us a very powerful educational tool and it is now our task to learn to use it to its fullest potential.

When a neophyte starts to work with and read about computers, the new terminology can at times seem quite extensive and formidable, but in reality only a few basic terms are needed to converse in "computerese". Some of the more common terms are hardware, software, floppy disk, disk drives, memory, input and output devices, printers, modems, interface, terminal, microcomputers, mainframe computers and graphics.

Computer <u>hardware</u> is simply the computer and its components such as the printer, t.v. monitor, disk drive, computer and any other device which can be hooked into the computer. On the other hand when people discuss <u>software</u> they are talking about programs that are used with the computer. Software can take various forms, from computer games to mathematic drills. The software or program controls the actions of the computer and is stored on <u>floppy disks</u> , which are round vinyl disks covered by a protective 5 1/4 inch square of hard plastic. This floppy disk goes into the disk drive which is responsible for writing (saving) information onto the disk and reading information (programs) from the disk and placing it into the computer's memory where all data put into the computer are stored.

Input and output devices are computer components which make it possible to put data into the computer (input), and get data out of the computer (output). Keyboards, laser beam pens, graphics pads, and the human voice are examples of input devices. Output devices are components like monitors (T.V.), printers (many different varieties), coloured plotters (graphs), and sound synthesizers (computer voices). Telephone modems are also considered input-output devices because they allow one microcomputer to commmunicate with other microcomputers or with larger mainframe computers using the telephone system. All of this external hardware (disk drive, input-output devices etc.) is connected to or interfaced with the computer. Each component has an interface card which allows it to be connected to the computer. Once these components are connected to the computer, it has total control over the actions of each component.

Mainframe computers are larger computers which many people can use at the same time. The terminal is another input-output device which allows access to the mainframe computer through a special telephone line. The microcomputer , as the name suggests, is a small computer which is totally self contained. The whole computer fits on the top of a desk in the classroom and there are no telephone lines or indeed any extra costs involved.

Graphics are the pictures that can be produced on the computer's T.V. monitor. These still or moving drawings can be helpful both in explaining concepts on the computer and in making drill work more entertaining for the learner.

The activities of the computer are controlled by an explicit series of instructions. This series of instructions (program) can be written in a variety of languages depending on the required application. Most computers are capable of using several of these languages. Computer languages are broken down into two groups, low level and high level. High level languages are those that closely resemble human language (Basic, Logo, Fortran, Cobol, and Pascale) (McRitchie, 1982). Low level languages are closer to the internal language of the computer (machine language). Basic is the language that most students learn in school because it has a variety of applications and is easier for a beginner to learn . The other high level languages generally used in specific applications are Logo for the production of graphics, Fortran for mathematics and science, Cobol for business and Pascal for the acquisition of programming skills. An example of a low level language and its application is machine or assembly language used in video games and other situations where speed is important.

CAI is an acronym for computer assisted instruction. The computer is used to present drills, practise exercises and tutorial sequences to the student, for the purpose of teaching facts, skills and concepts. In most cases the CAI material is divided into a large number of small steps interspersed with periodic tests designed to test the student's understanding. If the student meets a certain criterion in his performance then he may continue to the next step in the lesson. Using CAI the student's work and progress are monitored and controlled by the computer. Computer hardware plays an important part in CAI, but a more critical role is played by the available and appropriate software.

There are many different kinds of software available for educational use. A list of eight different kinds (Stacy, 1982, p.618-23) with a brief explanation of each is presented below.

(i) Tutorial : This type of software is designed to teach students all or part of a new concept. It starts by giving the student an introduction to the concept and then asks questions. Based on the student's responses, the program will lead the student through a series of lessons to bring about a better understanding of the concept.

(ii) Drill and practice : This type of software is designed to reinforce previously acquired concepts. It can be formatted in many different ways : true or false ; fill the blank ; multiple choice ; or entering correct number/letter (matching). Graphics can also be used to enhance interest and to reinforce a correct response.

(iii) Special purpose software : This type of software is developed and in most cases written by the teacher, to help students better understand a concept. This software is the hardest to obtain, but is usually the most appropriate because, generally, the teacher knows the precise concept and the best way to teach it to particular students. This "tailor made" software is generally preferable to those produced commercially.

(iv) Games : This software is generally used for fun and enjoyment, but at the same time assists in the development of motor skills, eye hand coordination, reading and other thinking skills. Games are also used to entice students to work harder and longer on tutorial, drill and practice types of software.

(v) Simulation : This type of software is used to teach higher level skills which could be difficult in a normal classroom setting. Using graphics and different simulated situations, students are forced to think about an appropriate response. Concepts such as a food web in a lake ecosystem can be taught using a simulation program. Computers have been used frequently by engineers and scientists to simulate the real world; and these same techniques can now be used in the classroom to help teach difficult concepts.

(vi) Teacher utilities : These are programs that help teachers create aids for classroom use. Posters, crossword puzzles, and match games are but a few examples of aids that can readily be created by the teacher with the help of the microcomputer.

(vii) Administration utilities : This type of software is used to help in the administration of a school. Class scheduling, reports and attendance for example can all be dealt with using these programs.

(viii) Programmer utilities : These are programs that help the programmer adapt software to suit his needs. Existing software can be altered so that it is more appropriate to both the teacher's educational goals and the student's individual abilities.

Chapter 2 :

A Condensed History of the use of Microcomputers and CAI with the Deaf.

To obtain a clear understanding of the future potential of the microcomputer as an educational tool, it is important to review its development from the beginning. The history of the educational use of computers with hearing impaired students parallels that of computer use with hearing students. In many smaller schools for the deaf, the computer is a relatively new educational aid. The high costs involved with older computer systems made it economically difficult to have one in every school. For those schools that were large enough to invest in computers during the "pioneer days", a typical scenario follows.

In the early seventies a school would have one or two terminals which were connected to a large mainframe computer by telephone lines. The mainframe computer was located in a central part of the city and the schools would share time on this computer. At that time the software used consisted almost solely of language and math programs. During these initial stages teachers noticed that students were making considerable gains in their computational abilities (Arcanin, 1979, p. 574). The computer also gave the teacher more time to give individual help. Administrators found that computers were reducing the cost of individualized instruction, hence, when a school could afford it and the need arose, more terminals would be added. Indeed some progressive schools went on to hire computer literate people to help design and create appropriate software.

Although teachers at these schools could see the enormous benefits of the computer in their classrooms, there were a few problems involved with mainframe computers. The cost of implementing time-shared computer service was substantial. The initial purchase of hardware such as computer terminals and telephone modems, regular monthly payments for telephone service and routine maintenance on the terminals and mainframe computer proved to be expensive. Limitations also existed. The software could only be used in a mainframe computer and due to the high costs of time sharing the software could not be shared with other schools. There was also the problem of lagtime between entering and receiving information, graphics were very limited, and finally a major problem occurred each time the mainframe computer crashed and no one could access the system. It became obvious that a less expensive delivery system was necessary (Arcanin, 1979, p.575) if CAI was to have more general application.

In 1978/79 a technological breakthrough came with the development of the silicon chip and the microprocessor (essentially a complete computer built into a chip the size of a finger). This advancement made possible the production of microcomputers, which have many advantages for the classroom over the older mainframe system. The microcomputer has a much lower initial cost and this is a one time cost (no more time sharing or communication line rentals). Consequently, the schools could afford more microcomputers and expose more students and teachers to their use. These microcomputers were portable and had much to offer in the areas of colour and graphics. Regional support centres were now established to help with distributing knowledge and software (Arcanin, 1979, p.576). There were no crashes and no downtime to frustrate teachers and students alike. If one microcomputer went down, the others remained working. Now teachers were not limited by the software available through the time sharing system and they could customize software by tailoring it to their own needs.

With the birth of the microcomputer more schools could now afford to get into CAI and computer science studies. This has spawned an incredible growth in the variety and volume of educational software available to today's educators. New software is developed every day and anyone involved in the field of computer science is aware that a great deal of reading is necessary to keep up with the technological advances in the computer industry.

Now with the microcomputer firmly established in our society and in educational systems, it is interesting to assess its impact. What types of software are being used with hearing impaired students? How useful is this software? How are computers being educationally misused? What are some of the new exciting advances in the computer field that could be significant for hearing impaired students and their teachers? Answers to these and other pertinent questions are found in the recent literature.

2.2 Current Developments

Programs that help to teach reading, language, mathematics, spelling, science, social studies, and other content areas are now available and some software programs have been developed especially for use with hearing impaired students. One such program teaches lip reading skills (Hight, 1982). The word being pronounced is shown at the bottom of the monitor and the lip shape and articulation is shown in the space above. Other software packages have been developed to teach sign language (Johnston, 1982). Using microcomputer graphics and animation, this program helps to teach the student new signs and improve reading skills. A further program has been developed to help the teacher of the deaf teach speech and has diagnostic and prescriptive components based on the LING model (Stoker, 1983a). The program prompts information from the teacher and then specifies what is to be taught as a next step. It also provides strategies for achieving the goals and keeps a permanent record of the student's progress. Quigley's Test of Syntactic Abilities is also now available for Apple II computers (Jones, 1982).

Because math is a subject which involves a great deal of drill and practice, it is not unexpected that the most common forms of software are found in this curriculum area. Castle (1982) has found that the software orientated for hearing students is "sometimes just as good or better than mathematics software geared for the hearing impaired" (p.495). There are math programs that allow the student to practise by himself or compete against the computer or another student. The computer not only controls the pace and advancement of the material, but also keeps a record of the student's work and progress. Most of the software utilizes immediate feedback and exciting graphics to heighten interest. One program (Melborp) allows the student to play a short game if he obtains enough correct answers (Bardenstein, 1982).

Although some excellent programs are available, the biggest problem in using CAI with hearing impaired students is the unfortunate lack of appropriate software. Most of the commercially available software is language bound and not always appropriate for hearing impaired students. This lack of software has forced teachers of the deaf to become more resourceful. They must evaluate and critically assess available software and use only those programs which are at an appropriate comprehension level for their students and they must make adaptations to commercially available software, such as revising the directions and simplifying the vocabulary, to make it meet specific learning objectives.

An even better solution to this problem is for teachers to produce the software. Teacher-made software is obviously going to be more appropriate both for the level of the students and for specific learning objectives. The problems with making adaptations to commercial software or creating one's own software are that it takes a long time and demands a great deal of expertise. Most teachers have little of one, other, or both. At the California School for the Deaf at Fremont, they experienced many frustrations trying to fit available software for their students' needs, until they developed a new concept in CAI called "authoring" (Slovick, 1982). These authoring programs allow teachers with little or no computer experience to create and illustrate computerized lesson materials which are specific to their students' instructional needs. Other schools are using a team approach. Teachers design the content and the graphics they want in a program and a programmer takes on the long and difficult task of writing the program. This approach generally is very costly.

One of the major hurdles to the successful use of CAI with hearing impaired students is the lack of suitable software. It is up to both administrators and teachers to develop and aquire software that can be used to obtain specific learning goals with our hearing impaired students. Gallaudet College is presently compiling a catalogue of software used by schools for the deaf in North America and it will include both commercial and teacher made software. The Volta Review (Dec. 1983), in recognition of the potential of the microcomputer and CAI, has started a new section of the journal called, "The Volta Software Review" which according to Stoker (1983b) will "provide an in-depth evaluation of educational computer software that is specifically designed for hearing impaired learners, as well as other software with significant potential application to this population" (p.356). Hopefully initiatives such as these will prove to be the beginning of a cooperative approach toward the solution of this problem.

Although there have been many software programs developed to help teach students, there are also others intended to help teachers prepare learning aids, record students' progress, and assess students' abilities. These teacher utility programs allow teachers to construct crossword puzzles, word finds, computer tests and various other computer generated educational aids. These programs can save teachers a great deal of time, and help to create educational aids that can be used with or without the computer.

The California School for the Deaf at Fremont (Irwin 1982) has developed a computerized lesson planner through which a teacher is able to influence the choice of lessons done by each student on the computer. This program allows a teacher to select the lessons that a student must work through and frees her from the need to direct the student every few minutes.

Many programs help teachers by recording and storing information about a student's performance on a series of lessons. Later the teacher can check the student's scores and make a decision on advancement or remediation.

Computer Assisted Evaluation (CAE) is also being used in many schools to analyse a student's language skills (Riley,1983) and to assess curriculum strengths and weaknesses. Once the student's weaknesses have been discovered, then CAI is provided to strengthen these areas. Another CAE program is used to determine how a student discriminates -- auditorially or visually (Fulton, 1983). A number of visual and auditory stimuli are given to the student and the student's responses are recorded by the computer.

There are many software packages available which help in classroom management and depending on the program, a variety of duties can be handled by the computer. Attendance, grades, progress reports, test evaluation and monitoring the progress of individual students are just a few of the chores that the computer can help the teacher accomplish.

One of the newest and most exciting trends in CAI for the hearing impaired has occurred because of the ability to interface a video tape recorder with a microcomputer. Computer assisted video instruction (CAVI) combines the interaction qualities of the microcomputer with the visual impact of the video terminal (Dillingham, 1982). Most of the instruction comes from the video terminal, but the pacing, reinforcement, review, evaluation and note taking is carried out by the microcomputer. CAVI is much like CAI because the student is presented with information, gives a response to questions and is next provided with feedback depending on his/her response. For example the video tape stops and a question is asked. If an incorrect response occurs the video tape machine rewinds and the material is presented again (Newell, 1983). The big difference between CAI and CAVI is that CAVI is not limited to computer text or simplified graphics. With CAVI, options exist to use computer tests and graphics or video tape scenes or both. When compared with the simpler graphics of the computer, the movie-like quality of the video tape may well have better attention keeping qualities.

The one previous problem with using video tape was that it was a linear sequence and few video tape machines gave the random access feature that is needed to review or reinforce a concept, but by using a microcomputer with the video tape, total flexibility is possible on the tape material presented. CAVI then combines the best qualities of both media.

As with CAI, the heart of CAVI is the software. Software for CAVI is designed much like the Blocks system concept in CAI and allows the teacher to create programs (activities) for the student to use. The teacher is free to choose not only the source and content of the information presented to the student, but also, the questions to be asked. The teacher also puts in the answer options and controls the machine's response to the student's answers (Dillingham, 1982). During the entire development of the software, the teacher can choose to use the computer, the video tape, or both to present material.

Now that our technology has given us the microcomputer and the VCR (video cassette recorder), their marriage as an educational tool may in the immediate future provide the ultimate aid for teachers of the deaf. The mind boggles at the educational value made available through CAVI for the instruction of hearing impaired students. Any concept that one wishes to teach can be brought into the classroom in living colour. Many higher level concepts which either frustrated students or were not attempted, can now be mastered by visually oriented hearing impaired students. The ability to show T.V. sequences to explain a concept will, without doubt, make it much easier to comprehend. Money and software are now needed to give CAVI an opportunity to prove its worth.

2.3 Computer Misuse

As with any machine, there is the potential for appropriate and inappropriate applications. The available literature gives very few examples of computer misuse, however cases do exist. One such example has the computer being used as a recorder of information on an elaborate score sheet for a sign language test (Grosman, 1983). It would have been much simpler and less time consuming if the information had been recorded on paper and then remediation discussed with the student afterwards. Instead, a recorder watched the student's performance only to enter the data with great detail into the computer. At the end of this lengthy process the computer tells the student which areas needed improvement. This whole procedure would have been more productive if there had been less time spent entering copious quantities of data into the computer and more time given to remediation immediately after each trial.

Many people will be caught up in the excitement of using the microcomputer with their students, but this enthusiasm should not lead down the "software" garden path. The value of software should be examined before money is spent because there are some software packages that should stay behind when purchases are made. It is important to ensure that the software chosen is multifunctional and has several levels of difficulty (Fleming, 1983). It should also allow teachers to change options for individual students and permit sufficient flexibility to meet a number of educational needs.

Chapter 3 : A Review of the Research

It is revealing to read the various research articles that appear in the journals and papers concerned with education of the deaf. Of the articles uncovered (see attached bibliography), only five dealt at all with any kind of measurement of collected data. Of the five empirical studies, two were completed in 1973, and one each in 1974, 1975, and 1983. As would be expected, the 1973-1975 studies were very general in scope. One (Suppes, 1973) found that CAI did increase math computational skills. The second project (Fletcher, Suppes, 1973) initiated a large scale use of CAI for several subjects (algebra, logic, computer programing, and basic English) in schools for the deaf and showed that CAI could be of benefit for hearing impaired students. The third study (Fletcher, 1974) was similiar in scope and outcome to the Fletcher-Suppes project. The fourth study (Morgan, 1975) evaluated a mathematics and reading CAI program. Morgan, concluded that not only was CAI beneficial for the deaf, but also that teachers, students, and parents reacted favorably towards its use. The final study (Smaldino et al, 1983) was designed to contrast the efficiency of teacher directed and computer based instruction for hearing impaired students. The results showed that microcomputer instruction appeared to increase instructional efficency. The four earlier studies were simple in scope, design, and findings but the later study is a start towards a focus on some of the important problems associated with the use of

CAI. Overall there were few attempts to provide evidence of specific changes that had occurred with hearing impaired learners as a result of microcomputer use. The 79 articles/books found in the bibliography date back to 1969, but the majority were written between 1979 and 1983 (see Table 1). Of the few nonempirical articles that did try to make some kind of judgement on microcomputer use, all found a gain in student ability and were very positive toward microcomputer applications.

Table 1

Distribution of research articles[(1)]

Category	Number
(1) Description of CAI use in a program for the hearing impaired. [13, 23, 26, 31, 38, 41, 42, 44, 45, 49, 52, 53, 62]	13
(2) CAI in general (with hearing impaired students). [15, 18, 21, 24, 25, 35, 36, 46, 47, 48, 50, 54, 63, 65, 68, 69, 72, 73, 75, 76, 77, 78]	22
(3) Software [1, 2, 7, 8, 11, 12, 13, 17, 19, 20, 24, 25, 27, 30, 31, 32, 33, 34, 39, 49, 50, 52, 55, 56, 59, 60, 61, 63, 66, 67, 74, 78]	32
(4) Hardware [1, 4, 13, 17, 21, 28, 47, 52, 67, 78]	10
(5) Empirical research [14, 16, 37, 57, 64]	5
(6) Computer assisted video instruction (CAVI) [5, 10, 22, 40, 43, 55, 79]	7
(7) Computers in general [1, 3, 6, 9, 29, 51, 58, 71, 78]	9

[(1) see articles listed in Appendix A]

The articles discussed a variety of topics, but the most common was an explanation of how people were using computers and the accuring benefits. Others discussed available software, explained how the software worked and outlined the kind of hardware needed to run the software and a few a discussed the establishment of a computer lab in a school. Although most of the articles are helpful and informative, very few researchers have as yet taken up the challenge of measuring the changes that take place through the use of microcomputers, or of looking at how students learn using microcomputers. Without answers to these and other questions, the true potential of the microcomputer may not be fully realized.

The potential for computer use in classrooms for the hearing impaired is indeed great. There is no question but computers will be used both as teaching aids (computer assisted instruction) and for educating our students in programming skills and computer literacy. One needs only to pick up the newspaper to learn of the exciting developments in the computer industry. It is widely held that over the next decade computers will drastically change all of our lives, especially now that computers are becoming more user friendly, with the result that both staff and students can become competent programmers (Stuckless, 1983). Programming is a valuable skill to learn because it enables students to break down problems into parts and analyse and reconstruct that information in a meaningful way.

Computer assisted instruction can and has been used successfully by deaf students (Fletcher, 1973) and many computer systems are now being developed specifically to aid the deaf. Generally improved academic progress has been seen in students who get increased practise time on the computer the potential for the future is very exciting and is only limited by the quality and quantity of appropriate software that is made available. Over the next few years of trial and error we will hopefully determine the characteristics of software which best meet our requirements. Through this learning process we will become more skilled at designing software to meet our needs. Computers will still be here changing and improving, but the teacher will be the one to decide when and how to use the technology. In the future, complementing conventional educational practices with microcomputer support will probably be the teacher's main responsibility.

Software is the crux of the whole system. Once software is developed that meets the educational needs of hearing impaired students, many benefits will undoubtedly result.

Chapter 4 : Research Design and Methodology

4.1 Statement of the Problem

This study addresses a small part of the research issue of the effectiveness of educational microcomputer software with hearing impaired students. It attempts to measure the changes that take place through software application and to uncover characteristics which could make software more suitable for use by hearing impaired students. It is a descriptive and empirical exploratory study to reveal further insights about the use of educational software in hearing impaired classrooms.

The rationale and reasoning for this study are based on the findings in the literature. From a critical review of available literature dealing with CAI and its use with hearing impaired students, a large void in the area of empirical research is apparent. Few studies have accepted the challenge of measuring the changes that take place through microcomputer applications. The literature also points to a major hurdle in the successful use of CAI, namely the lack of suitable and appropriate software. Most commercially available (hearing) programs are language bound either in the text or instructions which may preclude their use by hearing impaired students without the direct intervention of a teacher. Software should be produced that allows the student to interact freely, one on one with the computer, allowing the teacher to attend to other tasks. What characteristics should this software for the hearing impaired exhibit to allow this "utopia" to become a reality?

4.2 Definition of Terms

<u>Hearing impaired</u> is a term used to describe a person who has any degree of hearing loss. It is a generic term which includes both deaf and hard-of-hearing persons.

<u>Deaf person</u> is one whose hearing disability precludes successful processing of linguistic information through audition with or without a hearing aid (Frisina, 1975).

<u>Sign language</u> is the visual language of signs, facial expression, and body language used by deaf people to communicate.

<u>Tutorial software</u> is a computer "program in which the computer acts as a teacher: introducing new concepts, evaluating students reponses, providing exercises and tests, and branching to remediation and enrichment based on the student's success" (PEMC, 1984).

<u>Drill and practice</u> are "programs which enable students to drill and practice concepts previously taught, until they achieve mastery " (PEMC, 1984).

4.3 Subjects

This study involved all of the hearing impaired students (18) attending a secondary off-campus program of the provincial school for the deaf. This off-campus program is located in a regular secondary school which offers grades 8 to 12 for a population of approximately 900 students. The majority of the deaf students take their academic courses in self-contained classes with a teacher of the hearing impaired, and integrate into regular classes or non-academic classes with the assistance of a teacher of the hearing impaired who acts as interpreter-tutor. Six of these students are graduating this year. Four have been accepted into the freshman class at Gallaudet College and the other two accepted into the London, Ontario program (equivalent to prep year at Gallaudet College). The selection of the 18 subjects for this study was based on convenience and accessibility of the subjects and the experimenter, who is one of the teachers of the hearing impaired at this location.

For this study the experimenter ideally wanted two groups which were matched on reading ability, mathematic ability, and experience with educational software. This population had no experience with educational software, but varied greatly in the other two categories. To obtain subjects for this study the experimenter told the students that their services were required to help in a project, in order for the writter to complete his M.A. degree. He also told the students that it would involve learning some new concepts from the computer and would only take up about 30 minutes over a one week period. The experimenter gave all students consent forms for parental approval. Of the 18 forms, all 18 were returned with consent and all the students became involved in the study.

To accommodate for the variability in reading and mathematic ability within the experimental group the 18 students were randomly placed into two groups of 9 each.

4.4 Materials

The design required that there be two experimental groups. One of the groups would work through a tutorial program (TUTORIAL or Treatment group : TG), while the other had no exposure to it (non-TUTORIAL or Control group : NTG). The tutorial software was picked after the experimenter had viewed over 40 different types of tutorial software. The software varied greatly on format, curriculum area or concept, and style of presentation. This specific software was chosen because the instructions were the most straightforward of the programs viewed and the concept would be novel to the students while at the same time important to their education. The other commercially available programs viewed did not satisfy all of these criteria. This software is produced by Minnesota Educational Computing Consortium, a reputable and trusted source and is in wide use in schools across North America. The Ministry of Education in B.C. thinks so highly of the software produced by MECC that, "The British Columbia government has bought the rights to all MECC software so that it can be obtained at a better price and be distributed more easily to all schools in B. C." (Daneliuk, 1985). The floppy disk is titled MECC Mathematics Volume 3. The portion of this software used in the study is "Trapezoid and Triangle Areas".

Trapezoid and Triangle Areas is a tutorial program which attempts to introduce and teach the concept of measuring areas of these two geometric configurations. There is also a practise section involved in the program, where students may practise the newly acquired skills. The tutorial portion of the program was broken down into 25 seperate frames. Each frame was analyzed to discover what tasks were involved for the learner and to establish the time period between the completion of one frame and the entire presentation of the next frame. Most of the frames required an answer to a specific question pertaining to the content of the frame, before the tutorial continued. On a few occasions there were no questions to check the student's compehension. Experience has taught the experimenter that a hearing impaired student presented with data that s/he does not understand, usually continues, ignoring the portions that are not understood. To prevent this from occurring in frames where no checks were provided the experimenter developed his own comprehension checking questions to test the students. Therefore on these few frames alterations were made to make the software more inquisitive.

This program assumes that students can already multiply by point five (.5), divide 2 into odd numbers, and calculate the areas of rectangles and parallelograms. To assure that these prerequisite skills were achieved the experimenter asked that all math classes involving these subjects get instruction on these four concepts before the study commenced. The tutorial program draws on this understanding of area calculation with rectangles and parallelograms to show how the formulae for calculating area in trapezoids and later triangles were derived.

This program is rated by MECC to be at a reading level of grade 5-6 (Dale-Chall analysis). This level was not considered to be critical because the students were permitted to ask questions if they did not understand the language (information) presented in the Tutorial program. In other words any reading problems encountered, could be solved by the student asking for an explanation. Students working on the practise portion of the software would not be exposed to the written text. It is generally acknowledged that the majority of hearing impaired students achieve at a higher grade level in mathematics than in reading. So any commercially available "hearing" software that is at an appropriate grade level in mathematical developement for hearing impaired students, will probably be at a higher reading level than the students are presently achieving. This is one of the main points of interest for this investigation. What type of problems occur when hearing impaired students use "hearing" software that is at an appropriate level of mathematic sophistication? Teachers of the hearing impaired acquiring computer software to help with the instruction of their students have been and will be limited to using this "hearing" curriculum based software due to the lack of other commercial materials on the market.

The more important aspect of this program was its rated grade level, 6-8. The students in this sample were, at the time of testing, working in math classes at half way through the grade 7 level or higher (7 1/2-12). However some students had Sat-Hi (1983) scores which indicated that they were achieving at lower levels than grade 6-8.

The tutorial program affords the student only two opportunities to practise these newly "learned" concepts. Each practice takes the student through the step by step method needed to calculate the desired area. The calculation of area is broken down into its individual components to simplify the task. If a mistake is made during any part of the process the student is told what the correct response should have been and the correct digit appears in the appropriate space.

The practise portion of the program is almost identical to the practice involved in the tutorial. The only difference is that in the practise portion the student is first required to give the area of the geometric shape (initial area question). If this reponse is incorrect then the same step by step method is emphasized again until the area calculation is completed.

The hardware used to run this program consisted of an Apple IIe computer, black and green Apple monitor III , and an Apple disk II drive unit. The program was transfered from a 5 inch floppy disk. Full documentation is available including handouts (#4) used during instruction from MECC. MECC's description of the program is as follows : "Building upon the calculations of the area of parallelograms, this program develops a formula for TRAPEZOID and TRIANGLE areas.

A practice problem option which drills students on the use of these formulas is included." So the instructional strategy implemented in this program is tutorial based learning of a new concept followed by drill and practice.

A more detailed description of this software will be given at the begining of Chapter 5.

4.5 Design

The subjects in each group receive a pre-test consisting of 10 multiple choice questions (8 on area of trapeziod and 2 on the area of triangles). The reason for emphasizing trapezoids on both pre and post tests is because they make up the major portion of both the tutorial and practise sections of the software. This pretest was administered one week before the study commenced. The application of the treatments for both groups was exactly the same except the Tutorial Group (TG) was exposed to the tutorial portion of the program, and the Non-Tutorial Group (NTG) was not. Students in the tutorial group were given a pencil, piece of scrap paper, and handout #4 which had a diagram of a triangle and trapezoid. Near both diagrams was a specific place for the students to write the corresponding formula for each figure. This was a replica of the handout produced by MECC for use with the tutorial program. The TG were told that this program would teach them to calculate the area of trapezoids and triangles. Students were to read carefully the information that appeared on the monitor (T.V.), and if they had any problem with the meaning of a word or portion of the text they could ask the exprimenter for assistance. The scrap paper was for calculations, and the computer would tell them what to do with the other paper (handout #4). The TG students were asked if they had any questions and then the treatment commenced. The experiences of the TG students as they worked through the tutorial were carefully documented. Each question, reaction, and problem encountered by the students was carefully recorded by one assistant while another assistant noted the time spent on each frame of the program, and the experimenter helped to resolve student problems. Once the TG subject had worked through the tutorial portion of the software s/he would receive a short signed (sign language) test to check comprehension of some aspects presented in the tutorial. Then the subject continued onto the practise section where s/he had to reach an efficiency level of 80% (4/5 questions correct on the first attempt). Due to the rigid sequence of questions appearing in the practise portion, the experimenter set the following requirements; at least 2 of the 4 questions must be trapezoids and at least 1 of the questions must be a triangle. If a student had sucessfully answered 3 trapezoids in a row, the experimenter would stop the time and advance to the next triangle. Once they had accomplished this they were asked to do two questions correctly in a row without the aid of the formulae written out before them. Each time the experimenter recorded the elapsed time, the number of trials required to reach 80% efficiency, and the number needed to answer correctly two questions (1 on area of a trapezoid and 1 on the area of a triangle) without the aid of formulae. When this was completed the students were dismissed. One week later the students were retested with a multiple choice test balanced with the pre-test to determine how much of the concept they had retained since the treatment was administered.

The practise group was not exposed to the tutorial section of the program. They learned the concepts through trial and error with the assistance of the practise portion of the program. The questions in the practise portion were presented in exactly the same fashion as the two practise questions in the tutorial portion, except the practise questions first asked the student to give the area of the figure, then if this input was wrong the correct step by step method was outlined as in the tutorial. The NTG did not receive the information given during the tutorial or the practice gained from the two tutorial practise questions. Otherwise their experience was exactly the same as the subjects in the TG.

Students in the non-tutorial group were given a pencil and a sheet of scrap paper and also the same handout #4 that the TG received. However, on this handout the area formulae were already written in the appropriate spots. They were told that this program would teach (show) them how to calculate the area of trapezoids and triangles. They did not know how to calculate area yet, so they would need to guess at the first few questions. Soon they would see the pattern (plan) and discover the correct method of calculating area. The scrap paper was for calculations and handout #4 displayed the correct formulae needed to calculate the area of both figures. The NTG worked with the practise portion of the program until they displayed an 80% efficiency level. Then they were asked to answer two questions correctly without having the formulae displayed as it had been during the practice. Again the elapsed time and the number of trials required to complete both tests were recorded by the experimenter and the same balanced post-test was given to each individual one week after the treatment was administered.

The experimenter set a time limit for exposure to the practise software of approximately 20 minutes for the TG and 30 minutes for the NTG. If at this time the student appeared unable to reach the 80% efficiency level the treatment was stopped. The TG was limited to a shorter exposure because of the approximately 10 minutes of CAI they had already received during the tutorial. This was done in an attempt to balance the overall computer interaction time of both groups.

4.6 Hypotheses

One hypothesis was that students will receive little benefit from the tutorial section of the software. Students who viewed both the tutorial and practice segments would do no better than those who view only the practice [Null Hypothesis: mean of TG > mean of NTG]. There are three specific times when the impact of the tutorial was measured. Immediately after completion of the tutorial the students were asked a set of questions to test their understanding of its contents. Student's who view the tutorial should be faster to reach the 80% efficiency in practice. Also, due to exposure to the logic behind the derivation of formulae needed to calculate the area of both triangles and trapezoids, these same students should remember the concept (how to calculate the areas) better on a post-test one week after exposure to the software, than those students who just mechanically go through the steps in the practice.

The tutorial portion of the program tries to convey a very difficult and elaborate concept (the derivation of the formulae for area calculation in both trapezoids and triangles), in a very short time. It was felt that few students would grasp this concept from exposure to this software. Hearing impaired students might find the language and methodology used in this segment difficult to understand, thereby adding misunderstanding, confusion and frustration to the task. In addition to these problems the tutorial is also very limited because it only affords the student one practise question to test the newly learned concept.

In the practise portion of the program no language is involved, every mistake is pointed out and corrected, the problems are broken down into their important components, and the correct methods of calculation is re-enforced in a very mechanical way, as they are in the one example during the tutorial.

As stated before, this is a descriptive and empirical study designed to reveal further insights about the use of educational computer software with hearing impaired students. The study attempts to answer the following questions:

1. Can hearing impaired students learn to calculate the area of trapezoids and triangles through the use of educational microcomputer software?

2. What types of problems do hearing impaired students have in working through a tutorial program that contains relatively simple language?

3. What types of problems do hearing impaired students have in working through a drill and practice program which involves no language, when they are introduced to a new concept?

4. Which concepts presented in the tutorial program are not understood by the students?

5. Which concepts presented in the tutorial program are understood by the students?

6. Which areas of this tutorial program could be changed or modified to make its use by hearing impaired students more educationally profitable?

7. Which areas of the practise program could be changed or modified to make its use by hearing impaired students more educationally profitable?

8. Are there any significant differences in the performances of the two groups with respect to the post

tests?

9. What influences does the tutorial program have on student achievement?

It will be enlightening to observe how each individual reacts and learns from exposure to the two different types of computer software. The purpose was to expose the strengths and weaknesses of this software in relation to its use with hearing impaired students and then generalize the findings to make recommendations regarding the characteristics of software which can be used more effectively with hearing impaired students.

Chapter 5 : Results and Discussion

5.1 MECC Mathematics Volume 3 : Trapezoid and Triangle Areas

Before presenting the qualitative data for both the tutorial and non-tutorial groups a brief description of the software is required.

Tutorial Section

The tutorial program opened with the title and a graphic of a trapezoid appearing on the monitor. It discussed and attempted to show via graphics that parallelograms and rectangles have two pair of parrallel sides ("either pair could be used for the base length") while a trapezoid has only one pair of parrallel sides. The graphic for a parallelogram (rectangle) appeared first (frame #2) and then the comparison with the trapezoid graphic happened in frame #3. In frame #4 the text stated "Unlike parallelograms, the parallel sides of a trapezoid have different lengths." It then used graphics to illustrate the three parts of a trapezoid: Base 1 (B1), Base 2 (B2), Height (H). As each part was named and given a numerical value (ie Base 1 (B1) = 4) the value would appear on the graphic to show the student exactly where B1, B2, and H were located on the trapezoid being discussed. In frames #5-#8 this trapezoid (frame #4) was compared to two different rectangles and the student was asked to decide which had the larger area. The first rectangle had sides the same length as the trapezoids larger base (8cm), and it had a larger area than the trapezoid. The second comparison was with a rectangle that had sides the same length as the trapezoids shorter base (4cm), and it had a smaller area than the trapezoid. The students were required to decide which was larger and input their response into the computer. Then the program using animation graphics would move the rectangle over to the trapezoid and visually show which was larger. In frame #9 and #9.5 the text stated "The 8cm rectangle was too large, the 4cm rectangle was too small. Lets try a rectangle with length exactly between 4cm and 8cm. What is an average between 4cm and 8cm? ____cm." The students were permitted two guesses here and if they were not successful the correct method was shown in frame #9.5. In frame #10 the third and last comparison occurred. This time the trapezoid was compared to a rectangle with base lengths equal to the average length of the two bases of the trapezoid (6cm), as calculated in frame 9.5. Animation was again used to show the student that the two figures have the same area. And the text stated "The trapezoid area formula is like the paralleogram formula B(average)xH=A." Below this formula outlined in a large rectangular box appeared the formula [B1+B2/2xH=A]. There was no title above the formula or information in the frame's text, to clearly indicate its appropriate application. In frame #12 the parallelogram formula disappeared and the student was asked to copy the formula (trapezoid) onto handout #4. This method (frames #5-#11) of comparing three different rectangles to the trapezoid was used by the program to illustrate the derivation of the trapezoid formula. In frames #13-#17 the user works through one practise question. The computer gave the value for B1 (B1=7) and asked the user to identify or compute the following in this order: B2, H, B1+B2/2, Area. If the students gave an incorrect answer at B2, H, or B1+B2/2 the computer replaced their answer with the correct one. On the area question the student was given two opportunities to input the correct answer and in frame #17 the correct method was illustrated. In frame #18 the text stated "Here is one last trapezoid. Lets shrink the top base down." In frame #19 the top base shrank and a triangle was formed. The text stated that we can still use the trapezoid formula where one base equals zero. Frame #20 showed the triangle formula inside a large rectangular box, but unlike the trapezoid formula in frame #11 and #12 this formula had a title "triangle formula" above it in the box. This gave the student a little more information about the application of the formula seen inside the box. A triangle practise question appeared in frames #22-#24, where the user was asked to identify B, H, and calculate the area. This practise question did not ask the student to find B/2. In this tutorial practice the problem was not broken down into all of its component parts as it was in the practise portion of the software. The student was not required to compute B/2. He/she was asked to calculate the area without doing this intermediary step, which could make the task more difficult. This was not consistent with the method used in the practise portion of the software.

In frame #25 the correct method for solving this triangle area calculation was shown and the program was then completed.

Practise Section

The method of presentation for each question was identical. A graphic of the trapezoid or triangle to be solved was presented on the right side of the monitor's screen. The base (triangle) or bases (trapezoid) and the height were represented by numeric values which appeared beside the corresponding solid base lines or the dotted height line. The "initial area question" appeared on the left side of the screen, AREA =____. The students should have used the given formula (handout #4) and numerical data on the graphic to solve the area and entered their response. If the correct answer was entered then the student was told "that is correct" and instructed to push the space bar to continue to the next practise question. If he/she failed to calculate the correct answer for this initial area question, "sorry thats not it" appeared and the step by step remedial portion of the practise question was initiated once the student pushed the space bar. First the student was asked to identify the important parts of the figure starting with the base(s), B =____ (triangle) or B1 =____, B2 =____ (trapezoid), appearing on the monitor. The person interacting with the computer was expected to enter the correct value(s) for the base(s). Then the computer user was required to assign the correct value to the height. H =____ appeared on the monitor below the B =____. If the entered value was incorrect, the computer would tell the user that their answer was wrong and replace the incorrect number with the correct digit and the procedure would continue. Next the student was asked to use the base values to calculate either B/2 or B1+B2/2. B/2 =____ or B1+B2/2 =_____ appeared on the monitor. Again if his/her response was incorrect the computer would replace it with the correct answer. The last part of the practice asked the student to try and calculate the area for the second time, using the given formula which appeared above the graphic just before the area question (AREA =____) appeared below B1+B2/2 on the monitor. The student was expected to use the data and the formula to obtain the correct area. If his/her answer was wrong then the computer stated "the correct answer is ____" (the correct answer is given) and the student was told to push the space bar to continue. The next question is presented with its graphic and initial area question (AREA =____) and the same pattern was followed.

A complete description of each students' experience with the software follows. First the tutorial group (TG) then the non-tutorial group (NTG) qualitative data is presented.

5.2 Tutorial Group Case Studies

CASE #1

Student #1 would be placed at or above the 75th percentile in a ranking of overall ability for paticipants involved in this study. This student who was recently accepted into the freshman year at Gallaudet College is presently working midway through the grade 11 algebra curriculum. He reads at a grade level of 6.3 (Sat-Hi June 84). This student scored 0/10 on the pre-test guessing at the area of the trapezoids and consistently using BxH for the area of the triangles.

At the computer the student hesitated after reading the initial instruction "Push space bar to continue", then asked the experimenter if he should push it. He seemed unsure and did not appear to trust himself. He knew that the fiqure on the screen in frame #1 was a trapezoid and also understood the term parallel in frame #2. After reading frame #3 he thought that he was required to answer a question. In fact he asked the experimenter if there was a question on the screen. The experimenter said, "no." At this frame the student showed the first signs of having difficulty with the language presented. The experimenter posed the question, ("What is the difference between a paralellogram and a trapezoid?") that related to information contained in the first sentence of the frame. Even though the student had finished "reading" and "rereading" it several times, he could not answer the question. This was another sign that he understood little of what was being presented. In frame #5 the student was asked to decide which is larger a trapezoid or a rectangle. He carefully read through the text and was uncertain about the task. He read the last line again and then asked for help, but before help was given entered an incorrect response. After entering his answer he waited for a long time while nothing happened. Then he asked the experimenter for instructions and was told to finish entering his response by pushing the return key. Another comprehension problem arose in frame #7. The task was exactly the same as that in frame #5. The student asked for guidance and the experimenter told him to continue. He studied the text and then had no problem with the mechanics of entering his correct choice. He knew how to calculate the average in frame #9. At frame #10 the same task as that found in frame #5 and #7 is given to the student. He was again uncertain and signed, "Not know what to do." The experimenter explained the task and the student signed, "Now I understand", and proceeded to incorrectly push the space bar. The experimenter stopped the student and told him to read it. The student hesitated and then input an incorrect answer and pushed return. This was a further indication that as the student continued he was not comprehending the information presented. Frame #12 requests that the student copy the formula onto handout #4. The experimenter had to stop the student from pushing the space bar to continue. The student had not understood the straight forward instructions to copy the formula. The experimenter pointed to the important data on the screen. Then the student read it again and proceeded to copy the formula onto the appropriate place on handout #4. Frame #13 gives the student a first opportunity to practise with the new formula. It asks the student to enter the appropriate digit for base2. It already displays the value for base1 and the cursor flashes next to the space reserved for the value for base2. The student did not understand the task and asked the experimenter for help. The experimenter explained that he needs to enter a digit that correponds to the base2. Even with the clue of B1=4 on the monitor the student could not figure out the task. The student entered the wrong digit and the correct digit automatically takes its place. At frame #14 he had no problem entering the correct digit for the height. Again at frame #15 the student was puzzled and asked for an explanation of B1+B2/2. The experimenter explained that he must add B1 and B2 then divide the total by 2. The student did this and got the correct answer. Frame #16 proved to be too difficult, it asked for the area of the figure. The experimenter explained the task twice and both times the student did not understand, but he proceeded and made two incorrect guesses. On both guesses the student did not use the formula or other information about B1+B2/2 or H. At frame #17 the student slowly, carefully, and repeatedly examined the correct method for calculating the area. The student understood the word "shrink" in frame #18, and at frame #19 he copied the triangle formula without delay onto the appropriate spot on handout #4. The student had no problem entering the correct data for the triangle practise problem. During frame #24 the student signed, "Dumb math", expressing humorously his difficulty with math. He could not calculate the area for the triangle using the formula or the data right on the screen. He tried to use paper and pencil, but two attempts led to two incorrect and ridiculous answers. In frame #25 the student was shown the correct method and signed, "Now I see how to do it." After completing the tutorial the student was asked a number of questions to measure his understanding of the tutorial section.

He understood most of the vocabulary (isolated words) presented in the tutorial. He did not understand the reasoning behind the comparison of the three different sized rectangles with the trapezoid which attempted to show how the trapezoid formula is derived. He did not understand the term base, but he did know from previous math experience how to calculate an average. He stated that he understood some of the information that the computer taught him and indeed thought that some of it was easy to understand. He enjoyed working with the computer and would like to do it again.

Then this student continued onto the practise section of the software.

Question #1 (trapezoid) : Wrong on his initial guess. Then he correctly answered B1, B2, B1+B2/2, and the area.

Question #2 (triangle) : Wrong on his initial guess. Then he correctly answered B, H, B/2, and the area.

Questions #3,#4,#5,#6,#7,#8,#9 (trapezoids) : The student incorrectly answered each of the initial area questions. And then as in #1 after the problems were broken down into their component parts he was able to correctly calculate each answer. He did not work out the answer on paper. He quickly guessed at the initial area question then carefully worked through the parts. He became annoyed at his inability to answer the initial question correctly. He knew how to do the questions but seemed satisfied to quickly guess and get the initial area question wrong, then work through the problem part by part.

Question #10 (2nd triangle) : For the first time the student went to pencil and paper and quickly got the correct initial answer.

Questions #11,#12 (trapezoids),#13 (triangle) : Working on paper the student correctly calculated the initial area question on all three problems and reached the 80% efficiency level. The elapse time for the session was 10 minutes. He then quickly and accurately calculated the 2 practise questions without the aid of the formula sheet.

Summary:

This student was often tentative and confused when working through the tutorial section of the software. It was obvious from his responses that he did not understand the task although he gave all surface indications that he had read and understood it. However his actions, questions, or pleas for help revealed the extent to which he had not comprehended the information. He understood most of the isolated vocabulary involved in the tutorial but the syntax on numerous occasions proved to be beyond his comprehension. Thus the main concept that the tutorial sets out to explain, (how the formulae for trapezoids and triangles are derived) was totally missed by the student.

After completing the tutorial he still guessed at the initial area questions in the practice, but he could assign the appropriate digits to the symbols for bases, height, and calculate B/2, B1+B2/2, and the areas in the remedial portion of each problem. Once he started to work with pencil and paper and was more careful, he proved that he could readily calculate the initial areas too. The experimenter felt that if the student had gone to pencil and paper earlier he would have reached the 80% efficiency sooner. The student definitely had no problem assigning the bases and heights and easily calculated B/2 or B1+B2/2 in the practise questions. This is probably a direct result of his experience with the tutorial section. Students who did not have tutorial experience had a difficult time assigning appropriate bases and heights on the first few practise questions.

On the post-test this student scored 9/10 demonstrating a dramatic improvement in his ability to calculate these areas. He was also able to remember the correct method of calculation one week after exposure to the computer software.

CASE #2

Student #2 would be ranked in the bottom 25% of participants in this study as far as overall ability is concerned. He is currently working at the beginning of the grade 8 math curriculum. He reads at a grade level of 3.1 (Sat-Hi June 1984). On the pre-test he scored 1/10 guessing at the area of the trapezoids and using BxH for the area of the triangles.

At the computer this student had no problem with the initial instructions without hesitation he pushed the space bar to continue. He also understood that the graphic in frame #1 was a trapezoid. In frame #2 he did not understand the word parallel. The graphics here demonstrating the two parallel lines in a parallelogram did not seem to give him any clues and he could not show the experimenter the two parallel lines in the picture graphic of the parallelogram on the monitor. In frame #3 the student knew which one of the diagrams was the trapezoid, but he could not show the experimenter the parallel sides on the trapezoid. In frame #5 the student 'read' the text, then the experimenter posed the question "How is a parallelogram different from a trapezoid?" The answer to this question was contained in the first sentence of this frame. The student could not answer this question and seemed very confused. This was a fairly clear indication that he was having problems with the language and vocabulary presented in the text. In frame #5 the student is asked to compare an obviously larger parallelogram to a smaller trapezoid and decide which one is larger. The student seemed to understand the task, but then incorrectly decided on the trapezoid. Did he think the trapezoid was bigger or did he misunderstand the task? In frame #6 the student watched the animation but seemed confused. Even after the correct answer was displayed he was not sure if his answer was correct or wrong. In frame #7 he again compared and incorrectly picked the smaller trapezoid thinking that it was larger than the parallelogram. Again as in frame #6 he seemed very confused when the correct answer was revealed in frame #8. In frame #9 when the student was asked to find the average between 4 and 8 he guessed incorrectly on both attempts. In frame #9.5 the text tells and shows the student the correct method for calculating the average. The student quickly looked it over (11 seconds), started to ask a question, but pushed the space bar to continue. In frame #10 the task is similar to the two before where the student must compare a parallelogram and trapezoid and decide if they are the same size or not. The student had no problem entering the data, but gave an incorrect response. In frame #11 the program uses animation to show that the two are in fact the same size and gives the formula used to find the areas for trapezoids. The student seemed confused again, started to ask a question and then decided to continue and pushed the space bar. The task in frame #12 is to copy the formula which appears in a box on the monitor, onto the appropriate spot on handout #4. The student read the text and then started to push the space bar to continue, showing that he had not comprehended the task. The experimenter stopped the student from pushing the space bar and in sign language told him to read it carefully. The student looked over the text again and appeared to be very confused and totally at a loss as to what to do. He asked for guidance signing, "What do?" The experimenter told the student that he should copy the formula. The student did not know where the formula was or where to copy it. After much discussion the experimenter had to show him what to copy and where to copy it. This was another example of this student's inability to read and comprehend the syntax involved in the tutorial program. In frame #13 the student was confused at first, but he did successfully enter the correct digit for B2 and H in frame #14. In frame #15 the B1+B2/2 formula stopped him in his tracks. The experimenter reminded the student of the formula and encouraged him to continue. He quickly entered two incorrect guesses apparently with little thought. In frame #16 the student again quickly guessed twice at the area without much contemplation. In frame #17 the correct method of calculating the area was explained and the student appeared to carefully study this data (31 seconds). He stated he 'now understood the correct way'. In frame #18 he did not understand the word "shrink". At frame #19 the student read about the triangle formula and signed, "Confused." The experimenter signed, "Read again." The student looked at it again and continued without asking for further clarification.

In frame #20 the student concentrated hard, reading he text which gave an example of area computation for triangles. The student asked for help and the experimenter explained how the triangle forumla was used using the example on the monitor. The student was not using the data in the graphic of the triangle and the example formula calculation to help himself understand how the formula was set up and executed. He seemed satisfied after this explanation and continued. The experimenter was forced to stop the student again in frame #21 and ask him to read it again because he attempted to push the space bar to continue before copying the formula onto handout #4. After reading it for a second time the student still had no idea that the task was the same as before in frame #12. The experimenter again explained that he must copy the formula onto the sheet and the student did it. In frame #22 and #23 the student entered the appropriate digits for B and H, but at frame #24 when he is asked to calculate the area, the student could not use the numerical values and the formula to get the correct answer. Instead he quickly guessed twice with little thought. In frame #25 he quickly read over the correct method for triangle area calculation in 12 seconds.

In the signed questioning after the tutorial the student showed in his answers that he had received little benefit from the information presented in the tutorial. The words "base", "parallel", and "average" calculation appeared to mean nothing to him. He also stated that he understood only a little of what the computer had tried to teach him. Although this student seemed to understood a very small part of the content presented in the tutorial, he did say that he enjoyed it and would like to work with the computer again in the future.

On the practise portion of the software this student continued to have problems and consistently tried to do the work in his head, never using paper or pencil.

Question #1 (trapezoid) : He was wrong on his initial answer for the area and he was also wrong on all subsequent initial area questions. He had problems identifying B1, B2, and H and could not correctly calculate B1+B2/2 or the area.

Question #2 (triangle) : He correctly assigned B and H, and correctly calculated B/2 and the area for this triangle.

Question #3,#4 (trapezoids) : He could correctly assign digits to B1, B2, and H, but was unable to get past B1+B2/2 moreover once given the correct answer for B1+B2/2 could not use the formula to calculate the area. He would just quickly guess and make no attempt to use the formula.

Question #5 (trapezoid) : Again he could get B1, B2, H, but was unable to calculate B1+B2/2. Once given the correct answer for B1+B2/2 he did calculate the correct area for the first time. However, this was also his last successful area calculation.

Question #6 (trapezoid) : The student could assign B1, B2, H, but could not calculate B1+B2/2 or the area even given the correct answer for B1+B2/2. He also had computational problems multiplying by .5.

Question #7,#8 (trapezoids) : After assigning B1, B2, H, the student could not calculate B1+B2/2, but given the correct answer for B1+B2/2 he could use B1+B2/2xH and calculate the correct area. At this stage the student was very tired of the work and signed "I don't know how never used this before."

Question #9 (trapezoids) : The student was right on B1, B2, H, and wrong on both B1+B2/2 and area calculations. Again he had problems with .5 in computation, B1+B2/2=6.5.

Question #10 (triangle) : The student had problems with division involving .5 in the quotient, resulting in incorrect answers at B/2 (3.5) and area.

Questions #11,#12,#13,#14 (trapezoids) : The student had no problem assigning B1, B2, and H. But now the student appeared to be more fatigued and frustrated and could not correctly calculate B1+B2/2 for any of these problems and would quickly guess at the areas. Due to the time limit of approximately twenty minutes, the fatigue and frustration of the student, and the feeling that the student would not reach the expected level of efficiency, the treatment was stopped at twenty minutes.

Summary:

This student had a very hard time working through the practise portion of the software. He could readily obtain B1, B2, H, or B, H, but he could not get past the calculation for B1+B2/2 or B/2. He also had problems in computation when

.5 was involved in the quotient. He definitely needed extra help at the point where B1+B2/2 or B/2 was demanded. Unfortunately this program was unable to recognize or provide remediation with these difficulties.

In the tutorial section he rarely asked for clarification of the data presented. At the points where the experimenter could judge his understanding of the text through his actions he inevitably displayed total lack of comprehension. It can be assumed that in the instances where his comprehension could not be judged by actions, that there too he understood little of the material. Although the concepts presented were at his level of math ability, the syntax with which it was presented was beyond his comprehension. The lack of diagnostic and remediation capabilities in the practise portion left him frustrated and unsuccessful.

On the post-test this student scored 2/10 guessing at the area of the trapezoids and using BxH for the area of the triangles.

Case #3

Student #3 would be ranked at or below the 30th percentile for overall ability when compared to the other participants in this study. She is presently working half way through the grade seven math curriculum. She reads at a grade level of 3.0 (this is an estimate : no Sat-Hi data are available on this student). On the pre-test she scored 0/10, summing the digits to find the area for both triangles and trapezoids.

In frame #1 the student did not know what the picture on the monitor represented (trapezoid) and she also did not understand the instruction "press space bar to continue". In frame #2 she could point to the two parallel lines in the parallelogram showing her understanding of the term parallel which she had recently learned in math class. In frame #3 she guessed and identified the trapezoid and could also show the parallel sides on the trapezoid. Later in frame #10 she asked, "What does this word mean -trapezoid?" In frame #4 she could not say how a parallelogram was different from a trapezoid, even after the experimenter had told her that the answer could be found on the screen. The student said, "I don't understand (the task)." This was another obvious example that she could not handle the syntax presented, as the correct answer appeared in the first sentence of the text she was viewing. In frame #5 she thought that she had to pick A or B, but wanted reassurance. She did not understand the word larger and asked for it to be defined. She was very tentative with her answers and actions. She was correct in observing that the parallelogram was larger than the trapezoid. In frame #6 she watched the animation and in frame #7 wasted no time making her choice, but did not push return. Then after waiting, she remembered to push the return key. In frame #8 she was surprised to find out that she had made a wrong choice in frame #7. She understood that she was wrong. In frame #9 she ran into a number of language related problems. In this frame the student is required to give the average of 8 and 4. She did not understand the words "rectangle" or "average" and needed directions on how to enter her two guesses of 5 and 7, both incorrect. The student carefully read frame #9.5 that tells her how to calculate the average of two numbers. In frame #10 the student asked, "What does trapezoid mean?", showing her confusion and apparent misunderstanding of the tasks at hand. In frame #10 she said that the parallelogram and trapezoid were not the same size and in frame #11 she was again surprised that she was wrong but she understood that her response had been incorrect. At frame #11 the experimenter was forced to stop the student from pushing the space bar and signed, "Read it carefully." The student asked about 'formula' and the teacher showed and explained the formula in the box on the screen. The student read the text again and did not understand what to copy. The experimenter explained the task and had to show the student the appropriate spot to copy the formula on handout #4. She copied the formula wrong and the experimenter corrected her mistake (B1+B2=H). She needed reassurance at every step probably because the experimenter was there and also because she was not feeling confident about her comprehension of the text and tasks coming from the text. At frame #13 and #14 the student analyzed the content and entered the correct value for both B2 and H. In frame #15 the student quickly guessed letters for B1+B2/2, first entering H, then A. At this point it was clear that she did not understand the task, but when the correct digit appeared she signed, "I understand now." However, at frame #16 she again entered letters for the area instead of digits on both attempts. She reported, "I don't understand area." The main concept all along had been area and she had not once asked about the term 'area' before. In frame #17 when the correct method for calculating the area appeared she quickly glanced at it and continued onto the next frame. She could not have grasped the concept with such a quick read over the text and calculation. At frame #18 she did not know the word "shrink". She read through the text concerning the area of triangles in frames #18, #19, and #20. In frame #20 she started to push the space bar and then hesitated and then copied the triangle formula onto the appropriate spot on handout #4. She had learned this from her previous experience at frame #12. On the practise triangle question in frames #22, #23, and #24 she guessed incorrectly at B and H and then had no idea on the area question, responding area = H. She obviously did not understand what tasks were involved at this juncture in the program. In frame #25 she quickly (10 seconds) looked over the explanation of the correct method for solving the area of triangles and then pushed the spare bar and was finished.

In the signed questioning after the tutorial it was obvious that she had understood very little of either the vocabulary used or the concepts presented in the tutorial.

She said that she understood a little of what the computer had taught her but although she felt that it was hard to understand the computer, she liked working with it and thought she might like to work with the computer again in the future.

In the practise portion she had difficulty with the first trapezoid assigning the wrong values to B1, B2, and H, but in every trapezoid after that she could easily identify the correct values for these three components. The same happened with the triangles. On question #2 she was way off on the values for B and H, but on question #10 and #13 she had no problem giving the correct values to B and H. She consistently entered a quick guess for the initial area question and at question #9 said that she enjoyed working through the section where the task was broken down into its components. This was probably because in this section she was very successful at assigning the values. However, she did not understand the formula B1+B2/2, or the concept of AREA. She would quickly enter a guess when she came to these parts in the breakdown of the task. In question #10 (triangle) she said B/2=H, showing her continued confusion with this task. She continued to guess at values, not understanding where she was wrong or how to become successful. Due to the time limit of approximately twenty minutes, the fatigue of the student, and the feeling that the student would not reach the expected level of efficiency, the treatment was stopped after twenty minutes (ie. question

#15).

Summary:

This student struggled with the syntax and therefore the information and explanations found in the tutorial. In the practice she quickly picked out the individual components, but when asked to calculate B/2, B1+B2/2, or area, she could not solve these problems. She did not appear to put a great deal of thought into her answers nor use pencil and paper to try to calculate them. She also skimmed over the very important detailed explanations on how to use the formula and values to correctly calculate the areas explained in the tutorial. The syntax in the tutorial was far beyond her ability and the practise portion did not provided her with remediation and help at the B1+B2/2, B/2, or area calculations where she needed extra help. Overall this software proved to be unsatisfactory for the needs and abilities of this individual.

On the post-test she scored 0/10 using the same summation methods as she used in the pre-test. In other words her exposure to this software had no effect on her strategies for solving these problems.

Case #4

This student would be placed in the top 10% in a ranking of overall abilities for participants involved in this study. He was recently accepted into the freshman class at Gallaudet College and is presently working at the mid-point of the grade 12 Algebra curriculum. He reads at a grade level of 6.8 (Sat Hi June 84). This student scored 5/10 on the pre-test. He knew how to get the area of triangles but guessed at all the trapezoids problems.

At the computer this student breezed through the tutorial experiencing only a few difficulties. This student had no trouble with the mechanics of entering data into the computer. He understood most of the vocabulary and could answer all questions posed by the experimenter including the one at frame #4 where he stated from the data in the first sentence of the frame that a parallelogram is differrent from a trapezoid because of the different length of the bases in a trapezoid. At frame #5 he was a little confused. He asked if he should decide which one was larger (trapezoid or rectangle) and the experimenter said, "Yes decide which one is larger." He hesitated, compared the two and entered his correct guess. He went through the next comparison at frame #7 and #8 quickly and easily. On frame #9 he easily calculated and entered the average. At frame #10 he took a long time to compare the parallelogram and trapezoid before incorrectly deciding that they did not have the same area. He laughed when in frame #11 he found that they did have the same area and he read the text and compared the two formulae (trapezoid and parallelogram) carefully. He was embarassed that he had made a mistake. In frame #12 he asked for confirmation of his understanding of the task "Copy formula?" The experimenter said nothing. The student hesitated and signed, "What do I do" to himself, but then copied the formula and added a B and H onto the drawing of the trapezoid on handout #4. He was confused as to the placement of lines B and H on the trapezoid drawing. In frames #13, #14, and #15 he had no problem entering the correct values B2, H, and quickly answered B1+B2/2. In frame #16 he took a little time and correctly calculated the area in his head. At frame #17 he quickly read over the explanation of how to calculate the area. He understood the term "shrink" at frame #18. In frame #19 the student is shown a triangle and an example of an area calculation is worked out for him using the trapezoid formula with B2=0. This student carefully checked the numbers to make sure everything was right. At frame #21 he copied the formula onto the correct place on handout #4. All the students copied it A=B/2xH=A, but this student started this way and then errased the last =A realizing it was the same as the first A. The handout proved to be a little confusing for all the other students that worked through the tutorial. In frames #22 and #23 he quickly entered the correct values for B2 and H. In frame #24 the computer asks the student to calculate the area. This student asked if they 'wanted the answer'. The experimenter said 'yes'. The student correctly worked out the value in his head and entered it. He briefly looked at the correct method for calculation found in frame #25.

In the signed questioning after the tutorial experience the student easily answered all the questions except for the one regarding the comparison of the three different parallelograms and trapezoids. This student understood many of the concepts and vocabulary discussed in the tutorial but he could not decipher the attempt in the tutorial to show how the formula for trapezoids was derived. The student stated that he understood all the information that the computer taught him. He said that it was easy to understand, and he would like to be taught by a computer again in the future.

In the practise section he worked out the initial area question in his head for question #1 (trapezoid), #2 (triangle), #3 and #4 (trapezoids), reaching the 80% efficiency level in one minute and fifty-five seconds. He then easily calculated the correct area for a trapezoid and triangle without viewing the formula.

Summary:

This student had few problems with the content and syntax in the tutorial and breezed through the practise portion of the software thanks to the learning that had happened during his exposure to the tutorial.

On the post-test this student scored 10/10 showing an improvement over his pre-test scores.

Case #5

This student would be ranked about the 50th percentile when comparing her general abilities to other students involved in this study. She is presently working half way through the grade 9 math curriculum in. She reads at a grade level of 7.6 (Sat Hi June 84). On the pre-test she scored 1/10 guessing at the area of trapezoids and using BxH for the area of the triangles.

In frame #1 the student knew that the graphic was a trapezoid and did not hesitate to follow the directions and push the space bar to continue. The student could show the two parallel lines (sides) of the parallelogram, demonstrating that she understood the term parallel in frame #2. In frame #3 she knew which diagram was the trapezoid and could show the pair of parallel sides. In frame #4 the student read the text and when asked for the difference between trapezoids and parallograms said 'parallograms have two pairs of parallel sides, trapeoids only have one pair of parallel sides'. This is correct, but in the frame it stated "in a trapezoid the parallel sides have different lengths". Therefore although the student had a correct answer the information was not from the content of this frame. She asked the experimenter if her answer was right. In comparing the areas of a trapezoid and parallelogram in frame #5, the student did not know what to enter into the computer. She stated, "Think equal" and then decided B was larger and asked, "What do?" The experimenter stated, "Enter B." The student entered B and then waited for a long time while nothing happened. Finally the experimenter told her to push return. In frame #6 the student understood that the trapezoid (B) was not larger and understood that her answer was wrong. Having learned from her experience in frame #5 she quickly entered her choice in frame #7, pushed return and signed, "Hope." The student saw in frame #8 that she had correctly picked the trapezoid as having the larger area. At frame #9 the student read the information about averages and asked for each word to be explained and also asked for more help understanding the concept of average. This was another indication that the syntax was difficult for her. The student guessed 2 first and then thought about it and decided on 6, which was the correct answer for the average between 4 and 8. In frame #9.5 she saw that her second answer was correct and she read over the information on calculating averages. At frame #10 she stated that the rectangle and trapezoid were not the same size and had no problem entering her choice. She was surprised at frame #11 when told that the two are the same size. In frame #12 where she was asked to copy the formula, she asked the experimenter if she should ignore the information on this frame. The experimenter stated, "No." The student then asked, "Should I copy?" and started to copy the formula onto the scrap paper. The experimenter stopped the student and had to show her exactly where on handout #4 to copy the formula. The student copied the formula A= B1+B2/2xH =A, putting in the last '=A' which was not needed and might have been confusing. Here the student understood the task of copying the formula but did not understand that it was to be copied on handout #4, even though it was clearly stated in the frame. At frame #13 the student was confused and hesitated complaining, "Never seen before." She did not understand the task. The experimenter said, "quess." She quickly entered a quess and was told that it was wrong. Then she quessed again and did not push return key until the experimenter prompted her. At frame #14 she got the idea and quickly entered the correct digit for H. Frame #15 asked for the value of B1+B2/2. The student thought about it and then quickly made two incorrect quesses. She did not understand the task here and when the correct answer appeared, she quickly moved onto the next frame without looking at it carefully. Again at frame #16 she did not comprehend the task and quickly guessed twice at the area of the trapezoid. At frame #17 when the correct method for calculation is shown she briefly glanced at it (6 seconds) and then pushed the space bar to continue. The computer should have had a warning here to tell people who made two incorrect guesses to carefully review the correct method of calulation. It should also use a delay loop to force the student to study it studiously. Many students did not realize how important and helpful the data in this frame could be. At frame #18 she understood the word "shrink". During the triangle information in frames #19 and #20 she appeared despondent, frustrated, and confused. Having learned from frame #12, she copied the formula onto the appropriate spot on handout #4 according to the instructions in frame #21. Again she copied without thought A=B/2xH=A duplicating the '=A' portion of the formula. In frame #22 and #23 she had no problem entering the correct values for B and H. However, at frame #25 she entered two wild random guesses for the area, answering first '72' and then '17'. When the correct method was given she quickly glanced at it (4 seconds) and continued to the end by pushing the space bar.

In the signed questioning after the tutorial it was evident that she had understood little of the content of the tutorial. She could not remember how many parallel sides there were on a trapezoid, even though she did answer a similar question posed during the tutorial. She did not understand the concept or the method used to show how the formulae were derived. She did not know how to calculate an average although she was successful at this during the program. She stated that she understood some of the information taught by the computer. She thought that it was hard to understand the computer and she did not like math. She did not think she would like to work with computers again after this experience.

During the practise portion she immediately got B1, B2, and H, but just guessed at B1+B2/2 and area on question #1 (trapezoid).

Question #2 (triangle) : She correctly identified B, H, and B/2, but failed to calculate the area and was angry and confused.

Question #3 (trapezoid) : She entered H for B2 and then carefully and correctly worked out B1+B2/2, but gave the same answer (B1+B2/2) for the area. She did not multiply

B1+B2/2xH to calculate the area.

Question #4 (trapezoid) : She correctly entered B1, B2, and H, and calculated B1+B2/2. When A appeared she asked, "What is this?" The experimenter said, "Follow the formula", and pointed to the sheet. The student then correctly entered the answer.

Question #5 (trapezoid) : Carefully she tried to get the initial question right, but failed. Then using the right numbers and methods, but incorrect computation she got both B1+B2/2 and the area wrong.

Question #6 (trapezoid) : She correctly entered B1, B2, and H, but a computation problem (.5) resulted in an incorrect B1+B2/2. She was successful at the area calculation using the correct B1+B2/2xH. Now she really understood the correct method for calculating the areas using the formula.

Question #7 (trapezoid) : The initial question was wrong, but she had no difficulties working through the rmedial section.

Question #8 (trapezoid) : For the first time she got the initial question right.

Question #9 (trapezoid) : She used the correct methods and values, but due to computational problems she entered incorrect answer to both B1+B2/2 and area.

Question #10 (triangle) : She got the initial area wrong. Then working on paper she correctly answered all the step by step (remedial) questions.

Question #11,#12 (trapezoids) : She was correct on the initial area calculation on both questions.

Questions #13 (triangle) : She made a silly mistake in assigning numbers causing an incorrect B/2, but she did calculate the area using correctly using corrected data.

Question #14,#15 (trapezoids) : Both initial areas were calculated correctly.

Question #16 (triangle) : The initial area was correct.

The student had reached 80% efficiency after 20 minutes and 10 seconds. In the practice without the aid of the formula she calculated both the triangle and trapezoid correctly on the first attempt. She would first find B/2 or B1+B2/2 and then multiply by the height.

Summary:

In the tutorial portion of the program this student would have benefited if she was forced to carefully scrutinize the correct methods of calculation for both trapezoids and triangles. She quickly passed over these two very important frames. She had a difficult time with the syntax, content, and significance of the data in the tutorial, but seemed to understand most of the instructions. The results from the post tutorial questioning showed that she received little benefit from exposure to the tutorial except for the fact that she was able to correctly assign values to B1,B2 or B and H on her first exposure to these in the practise section. She obviously picked up on these concepts during the tutorial. This made her task in the practice easier than for those students who did not recieve tutorial information.

On the post-test she scored 0/10 using a summation method to calculate area for both trapezoids (a+b+c) and triangles (a+b), showing that she had forgotten how to calculate these areas over the one week period between the treatment and the post-test.

Case #6.

Student #6 was ranked in the bottom 5% of participants in this study as far as overall ability is concerned. He is presently working at the mid-point of the grade 7 math curriculum. He reads at a grade level of 2.4 (Sat-Hi June 84). On the pre-test he scored 0/10 guessing at the area of the trapezoids and using BxH for the areas of the triangles.

This student had an extremely difficult time understanding the tutorial information. He did not understand the vocabulary, instructions, questions, or tasks presented to him. He needed a great deal of guidance and even after items were explained to him he did not appear to understand the information. During the tutorial he was incorrect on every response except for the practise sections where he correctly identified B2, H, and B and H; and yet he was the only student who could visually see that the 'average' trapezoid was the same size (area) as the rectangle in frame #10. In frame #12 he needed to be shown what to copy and where to copy the formula. At first he had no concept of the task and the experimenter told him that he must copy the formula. After the experimenter had shown him the formula he started to copy it onto the scrap paper. The second time (frame #21) he was asked to copy the formula, he started to push the space bar to continue and the experimenter stopped him and told him to read it carefully. He then copied the formula by himself.

The syntax and vocabulary used in this tutorial were at a comprehension level beyond this student's ability. Even before this student started the experimenter suspected that this would be a difficult task for him. From time to time the student would however state that he understood when it was clear from his responses that he had no idea about the content of the program. He quickly looked through the text not actually reading the words. Words like "shrink" which he had recently worked with in consumer education were not understood by him. He did not really understand what he was looking for or why. For example when an explanation of the correct method for calculation of the trapezoid area was given, he would not comprehend the signifigance of this and quickly move onto the next frame. He understood the instruction "press space bar to continue" and had only a few problems with the mechanics of entering his responses.

During the oral questions of the tutorial it was clear that he had understood relatively little of the data presented in the tutorial. He could not answer any of the questions replying 'not know'. He said that he understood only a little of the data and that he found it a 'little hard' to comprehend. However he stated that he liked the computer and would enjoy working with it again in the future.

Summary:

In the practise session he could successfully enter B1, B2, or H after the fifth trapezoid and continued to be successful at this step on all subsequent trapezoids up to question #24. On the triangles he was successful right from the first one entering B and H correctly. This was the only part of the practice at which he was successful. Once he arrived at B/2 or B1+B2/2, he would hesitate and then quickly guess with little thought and then guess again quickly at the last area question. He did not once looked carefully at the correct answers to try and see how they were computed. He would say 'it's hard' and then oblivious to the task continue with the parts that he could do successfully while guessing at the others. He could not see any pattern or use the data available to him on the monitor to aid him in the task. The language and concepts involved in this program were well above this student's level of comprehension. He really did not understand the task, nor did he feel concerned that he was unsuccessful. For this student this program would need to be far more detailed, breaking down the task even more and providing diagnostic and remedial help at every step of the way. In a normal situation this type and level of CAI would not be used by a teacher with a student of this ability. However, it was interesting to see how he reacted and what he could comprehend of the information presented to him. Due to the time limit of approximately 20 minutes and the feeling that he would not reach the expected level of efficiency, the treatment was stopped after question #24. The elapsed time was 23 minutes.

He scored 1/10 on the post-test taking less than 2 minutes to complete it randomly guessing at the areas of both trapezoids and triangles.

Case #7

This student would be placed at the 60th percentile based on overall ability, in a ranking of participants involved in this study. He is presently working at the mid-point of the grade 8 math curriculum and reads at a grade level of 3.8 (Sat-Hi June 84). On the pre-test he scored 2/10, guessing at the area of the trapezoids and using B x H for the area of the triangles.

In frame #1 the student stated he did not know what the graphic was on the monitor. Then he used the clue from the title to determine that it was a trapezoid. He waited and then asked if he should continue. The experimenter said 'yes'. The student in frame #2 said that he could not remember what parallel means and could not show the parallel lines in the graphic on the monitor. In frame #3 he could identify the trapezoid, but could not show the parallel sides on it. When asked in frame #4 what the difference was between a parallelogram and a trapezoid he could not extract and comprehend the data in the first sentence of the frame to give an answer. This was the first evidence that although he had read through the data and said that he understood it, he could not indeed comprehend its meaning. In frame #5 when the student had to decide which object was larger, he understood the task and knew that his choice was the rectangle, but he did not know the mechanics required to enter his response. The student asked 'should push A' and the experimenter said 'yes'. The student entered his response and then pushed the space bar and nothing happened. The experimenter stated 'push return'. After reading the text in frame #7 the student saw that the task was similar to that in frame #5 and entered the correct answer and pushed return. In frame #9, the student read and understood the task and stated, "I think 6." The experimenter stated 'put in your answer'. The student asked, "I right?" and the experimenter said, "The computer will tell you if you are right or wrong." The computer told the student in frame #9.5 that he was correct. In frame #10 the student did not understand the task. He read the text again and decided that the two figures were not the same size and entered his answer 'no',but forgot to push return. The experimenter waited 10 seconds and then told the student to push return. The student discovered that he was wrong and that in fact the two figures were the same size. He was a bit surprised and said "So what!" At frame #12 the student read through the text and then reached to push the space bar and the experimenter stopped him, saying 'read carefully'. The student read it again and then asked, "What do I do?" The student did not understand the task. He asked, "What is formula?" The teacher explained that the formula was used to find the area and it was the information inside the box on the monitor. The student read the information again and was still confused. He understood the isolated words 'copy' and 'formula', but could not put them together and did not know what to copy or where to copy it. He was very confused and unable to do the task. He read the text again and still was not sure what to do. He signed all the words in the frame, but he was unable to understand them. The syntax seemed beyond his ability to comprehend. The experimenter showed the student what to copy and where it must be copied on handout #4. At frame #13 the student was asked to enter a value for B2 (the value for B1 was already entered on the monitor). The student said "3" and waited. The experimenter told the student to enter his guess. At frame #14 the student quickly entered 4 for the height (H). In frame #15 the student was asked to calculate B1+B2/2. The student looked at it, worked out the correct answer in his head and said "5" to the experimenter and waited. The experimenter again had to tell the student to enter his answer into the computer. When the computer asked for the area in frame #16 the student looked at it for a long time before signing, "Area don't know, don't understand." The student pointed to the trapezoid and asked, "Area of that?" The experimenter said, "Yes." The student guessed at the area by entering a

5. The computer told him that his response was wrong and he should try again. The student said, "I don't know." The experimenter said "Guess again." The student guessed 7. At this point he did not understand how to use the formula (B1+B2/2 X H) to calculate the area. In frame #17 the student carefully studied the correct method for 20 seconds and then continued. He did not understand the word "shrink", so the experimenter explained it to him. At frame #19 he read it, stated he didn't understand it, looked confused and then said, "Why bother" and pushed the space bar to continue. He was frustrated now and acted as if this was wasting his time because he could not comprehend the meaning of these few sentences. In frame #21 the student read the text, pointed to the triangle formula and signed, "Copy?" and then copied it. In frames #22 and #23 he quickly entered the correct B and H from the triangle graphic. In frame #24 he slowly thought about the answer and then input the correct area. In frame #25 he was very happy that he had calculated the area and briefly looked over the correct method of calculation before continuing to the last frame.

In the signed questioning after the tutorial the student knew how many parallel sides a trapezoid had. He did not understand the tutorial's attempt to show him how the formula for area calculation in trapezoids was calculated. He could explain how to calculate an average for two numbers. He had learned that a trapezoid had two bases while a triangle had only one. He also knew the term "base". He stated that he understood most of what the computer taught him. He said that it was of medium difficulty, "Not easy, not hard." He said that he enjoyed working on the computer and would like to do it again in the future.

In the practise portion of the software this student did very well. At the beginning of the practice he read over the formula sheet #4 and then proceeded to do questions #1, #2, #3, and #4 in his head, quickly reaching the 80% efficiency level in 2 minutes and 25 seconds.

Summary:

In the tutorial practice he could calculate the triangle area, but could not calculate the trapezoid area (frame #16). However he did carefully view the explanation of the correct method to calculate the trapezoid area. Therefore, although he had a number of difficult experiences comprehending the data and instructions in the tutorial, he did learn enough to be successful in using the formula to calculate the correct areas of the first four questions (3 trapezoid and 1 triangle). He also quickly answered the questions on the area of a trapezoid and triangle without the aid of the formula sheet using the formula that he had now committed to memory. In his work on these two questions he showed that he was following the formula (6/2x8 and 5+7=12/2; (B1+B2/2)=6x6=36).

This suggested to the experimenter that a student need not understand all facets of the tutorial program in order to aquire enough insight and information to facilitate their learning of the correct application of the two formulae.

On the post-test this student scored 0/10 and told the experimente, "I forgot a lot." He did not retain what he had learned from his experience during the week between the treatment and post-test. He quessed at both trapezoid and triangle questions on the post test.

Case #8

This student would be ranked at or below the 60th percentile when considering the overall abilities of individuals involved in this study. She reads at a grade level of 4.3 (Sat-Hi June 84) and is presently at the mid-point of the grade 9 math curricululm. On the pre-test she scored 0/10 guessing at the area of the trapezoids and using BxH for the area of the triangles.

In frame #1 the student thought that the graphic was a triangle. She did not know what triangles or trapezoids were. She could show the 2 pairs of parallel lines in the graphic of the parallelogram in frame #2, so she did understand the term parallel. In frame #3 she could now pick out the trapezoid and show the 2 parallel sides on the trapezoid. The student read frame #4 and then mistakenly thought that she was required to perform some task and enter some data. She asked "Add?" The experimenter told her to "Read again." The student read it again and said "Pick area?" Obviously the syntax and vocabulary involved in this frame were beyond the comprehension of this student. The data in this frame discusses the difference between parallelograms and trapezoids, showing the B1, B2, and H on a trapezoid graphic and saying "Let's see how we can use our knowledge of rectangles and parallelograms to find the area of a trapezoid." Nowhere does it ask the student to find the area. This student obviously did not understand the information presented. Other evidence of this was the fact that she could not at this stage explain the difference between a parallelogram and a trapezoid. Yet the answer for this question came from the first sentence of the frame. In frame #5 the student decided that the rectangle was larger and told the experimenter. The experimenter told the student to enter it into the computer. The student entered it and then waited while nothing happened. The student asked, "Push return?" and the experimenter replied, "Yes." In frame #6 the student watched the animation and observed that her response was correct. In frame #7 she picked the trapezoid and had no problem entering the data into the computer. In frame #8 she saw that the trapezoid did have the larger area. In frame #9 the student read the text which stated that the 8cm rectangle was too large and that the 4cm rectangle was too small and what was the average between 4 and 8. After reading this she asked the experimenter "Between ?" ; "Average 6 and 8." The experimenter said "Yes." However, the student was still confused, as to the task involved and asked for help. The teacher explained the language in the frame and told her to find the average of 4 and 8. She was discouraged by her inability to understand the test, but stated the average was 6. The experimenter had to tell her to go on and enter her correct response. The correct method for calculating the average was explained in frame #9.5. The student ignored this because she had entered the correct answer. Later after the tutorial in response to a question from the experimenter she explained that she looked at the keys 4 5 6 7 8, saw that 6 was in the middle and picked it for her answer. She did not use the method illustrated in frame #9.5, nor did she read it because she felt that she knew how to do it as she had already answered it correctly. Her attitude was that it did not matter how she obtained the correct answer as long as it was right. In frame #10 the student said that the rectangle and the trapezoid did not have he same area. In frame #11 she was not surprised that they actually did have the same area. Her response to this information was "Cool." The experimenter had to stop the student from pushing the space bar to continue in frame #12, and instruct her to read it carefully. The student was confused, she had read the text and was proceeding like before. She had not understood the instructions to copy the formula onto handout #4. She asked the experimenter to explain the text. Then she read it again herself, but was still confused. She asked, "What is formula?" The experimenter showed her the formula in the box on the monitor. She said, "Copy?" She was still confused and started to copy the text from the screen onto the scrap paper. The experimenter said "No, copy the formula onto handout #4." She was still totally confused. The experimenter pointed to the words 'handout #4'. She looked at handout #4 and then started to copy the wrong data onto the wrong place on the handout. The experimenter finally showed the student what to copy and where to copy it. The student was completely confused by the task shown on this frame even though she understood the vacabulary 'copy' and 'formula'. The syntax of this section seemed to be beyond her ability to comprehend. At frame #13 the students was told the value for B1 and was asked to enter the value for B2. The student first asked if she should type in the answer, then looked at the diagram and correctly entered a 3. She quickly answered 4 in frame #14 for H (height). In frame #15 she stated, "Must answer add" and then calculated B1+B2/2 without any difficulty. In frame #17 she quickly used the formula to calculate the area of the trapezoid. She was the only student to do all of this correctly during the tutorial portion of the treatment. She was able to assign the correct values for B2 and H, understand the notation and calculate B1+B2/2, and use the formula to calculate the area. The student breezed by frame #17 which explained the correct method because she already had the answer right. In frame #18 she understood the word "shrink" after thinking about it for 20 seconds. Then she read the text and asked, "Copy or what?" She did not understand the task here and said "Confused." The experimenter explained that there was no task here and she only needed to read the information and then continue. She watched the trapezoid shrink to a triangle in frame #19. In frame #21 she copied the triangle formula onto handout #4. She had learned from her first experience in frame #12. Then she quickly worked through the practise question on the triangle. She mistakenly entered the height for the base in frame #22, but again had no problem using the formula to calculate the area correctly. She needed to calculate B/2 herself because this part is not one of the demanded components in the tutorial practice. She ignored the correct method shown in frame #24 and was finished the tutorial.

In the questioning after the tutorial the student demonstrated that she had learned the term parallel and knew that a trapezoid had two parallel sides. She did not understand the complicated explanation that tried to reveal the derivation of the trapezoid formula by comparing different sized rectangles with a trapezoid. She explained that to find the average of two numbers you pick the number in the middle. By using this method, she laboriously picked 8 as the average of 6 and 10. She was not using the accepted method for calculating the average. She understood the term base and knew that a trapezoid had two bases and a triangle had one base. The student said that she understood some of the information that the computer had tried to teach her. She stated that it was not really easy because she 'always made mistakes'. She enjoyed working on the computer but did not know if she would like to work with it again.

Although this student had a tremendously difficult time with the syntax involved in the tutorial she did manage to learn a number of important things. She continued onto the practise portion of the software.

Question #1 (trapezoid) : When the initial area question appeared she asked, "Do they want the answer?" The examiner replied, "Yes." She got the initial question wrong and also had trouble identifying B2, but then correctly calculated B1+B2/2 and the area. She also knew how to do this during the tutorial question.

Question #2 (triangle) : She looked at the formula sheet and correctly calculated the initial area question just as she had done on the tutorial practise question.

Question #3 (trapezoid) : She looked at the formula sheet again and thinking in her head, guessed at the initial area question. She had no problem working through the remedial section of the practice.

Question #4 (trapezoid) : Again the student had problems with the initial question followed by problems with B1+B2/2 because she multiplied B1xB2 instead of summing the two. However she used the correct data and method to calculate the area.

Question #5,#6,#7 (trapezoids) : After guessing at the initial area question she had no problem correctly identifying the rest of the components of these practise questions. She was still guessing at the initial area and not using her experience to solve it straight off. She did not seem to understand what they were asking for with this initial question or she had not had enough practice at this point to be able to do all the steps herself without the computer's guidance. She had no problems with some of the difficult computations that bothered other students.

Question #8 (trapezoid) : Working on paper she almost went off track, but then correctly calculated the initial area for the first time.

Question #9 (trapezoid) : She failed to calculate the initial area and the last area question during the remedial portion due to computational problems.

Question # 10 (triangle) : Her initial answer was incorrect (BxH). She then worked through the step by step remedial section without any difficulties. She signed "Hard!" at the last area question.

Question #11,#12 (trapezoids) : Working on paper and her fingers, she correctly calculated the initlial area question for both trapezoids.

Question #13 (triangle) : Again she used BxH to get an incorrect answer. She then made a mistake assigning height for B. After these problems she was able to use the formula to calculate the area.

Question #14,#15 (trapezoids) : Both initial areas were calculated without error. She now needed to correctly answer a triangle question to reach the 80% efficiency level, so the experimenter moved onto the next triangle question.

Question #16 (triangle) : She calculated the initial area without error, reaching 80% efficiency after 21 minutes. Then she easily calculated the areas of the trapezoid and triangle questions without the aid of the formula sheet.

Summary:

This student could use the correct methods to calculate the area for both trapezoids and triangles in the practise questions of the tutorial section. She knew how to obtain the correct answers right from the start. But she either did not understand the signifigance of the initial area question, or she simply needed more practice with the step by step remedial guidance before she could successfully do it independently during the practise section. Either way, some extra help was needed from the software in the remedial section of the program to explain that the initial area question was the same as the last area question in the step by step process. This would have been beneficial for this student. It may have helped her learn the task more swiftly with less frustration.

Case #9

Student #9 would be placed at or below the 70th percentile of a ranking for all the participants involved in this study. She reads at a grade level of 7.6 (Sat Hi June 84) and is presently working at the start of the grade 9 math curriculum. On the pre-test she scored 0/10 summing the trapezoids (a+b+c) and using BxH for the area of the triangles.

In frame #1 the student signed that she thought the graphic on the monitor was a trapezoid. She had no problems with the instruction "press space bar to continue". In frame #2 the student could point out the 2 pairs of parallel lines on the trapezoid, demonstrating her understanding of the word parallel. She could pick out the trapezoid and show its sides in frame #3. In frame #4 she could logically deduce the difference between a trapezoid and a parallelogram. "A parallelogram had 2 pairs of parallel sides, trapezoid has only 1 pair of parallel sides, others not." This was a correct explanation, but it was not the same as the one given in the text of this frame, "unlike the parallelogram the parallel sides of a trapezoid have different lengths." In comparing the rectangle and trapezoid in frame #5 the student knew what to do but she had problems with the mechanics of entering her responses. She signed, "My answer is A." The experimenter told her to push the 'A' key. Then she waited, nothing happened and the experimenter told her to push the return key. In frame #6 the student saw that she had picked the correct answer. The task at frame #7 was identical to th task at frame #5, pick the shape with the larger area, the rectangle or the trapezoid. The student seemed to have a difficult time making her decision. She compared the two for a long time before deciding. Then she looked to the experimenter for permision to enter the data, asking, "Is it right or wrong?" The experimenter stated, "Enter your data."

In frame #8 she observed that her decision was correct and she was happy. After reading frame #9 (asking for the average of 4 and 8) she signed, "Number in the middle, 6." The experimenter answered, "Yes." She entered her answer and was told it was right and was shown how to calculate the average in frame #9.5. In frame #10 she compared the 2 figures, the rectangle whose sides were the average length of the trapezoid's longer and shorter base and the trapezoid. She decided that they did not have the same area. In frame #11 she was embarrassed to discover that she was wrong. The student did not understand the task in frame #12 and the experimenter had to stop her from pushing the space bar to continue. The experimenter asked, "What does it say?" She answered, "Don't understand." Then she asked, "Copy, what is formula? in box?" The experimenter replied, "Yes this is the formula" and he pointed at the formula. The student was still confused, "What do?" The experimenter answered, "You copy the formula in the box." The student signed, "Copy the formula" and pointed to the scrap paper. "No, what does it say" replied the experimenter. She again signed, "Don't understand" and the experimenter answered "Copy it on handout #4" and pointed to the handout. The student started to copy it on the wrong place on the handout. The experimenter showed her where to copy the formula onto the handout. The student understood some of the individual words in the text, but the syntax seemed beyond her ability to comprehend. Where some students would hide their misunderstanding, she was extremely concise about what she did and did not understand. She was very confused and needed a great deal of direction and guidance from the experimenter to complete the task. In frame #13 where she was asked to enter B2 the student was confused and did not understand the task, "What do?" The experimenter told her to guess. The student again signed that she was confused and did not know the answer. Then she carefully looked over the data on the screen and correctly entered a 3 and quickly entered a 4 for H. At frame #15 the student asked, "Answer?" and worked out the correct answer for B1+B2/2 on paper. She understood the notation and had no problem calculating it even though this was the first time she encountered it. In frame #16 she was asked to calculate the area and again she stated that she did not know what to do. The experimenter encouraged her to try it. The student worked on paper and her hands and computed 4x21=84 and entered 84. Then the computer told her this was wrong and to try again. On her second attempt she added all three numbers together to compute another wrong answer. She did not understand the use of the formula at this point. She carefully looked at the correct method for area calculation in trapezoids shown in frame #17 (25 seconds). In frame #18 she understood the word "shrink", but she did not understand "shrink down". She was confused after reading the text and thought that there was a task for her to do in this frame. She sheepishly asked if she should press the space bar to continue and the experimenter gave her the green light. The student read frame #19 and seemed to understand the concept that a triangle was like a trapezoid with one base that equalled length zero. She read frame #20 and looked to the experimenter before pushing the space bar. In frame #21 she showed that she had learned from her experience at frame #12 and copied the triangle formula onto the appropriate spot on handout #4. In frame #22 she carefully looked at the triangle graphic before picking the value 8 that corresponded to B. In frame #23 she quickly picked H=9. In frame #24 she computed the triangle's area in her head and entered the correct answer. It was obvious she understood the formula here because in the practice the student was not required to give the B/2 value. She had to compute this and then multiply by the height which she did successfully on her first encounter. In frame #25 she quickly looked over the correct method of triangle area calculation.

In the signed questioning after the tutorial the student showed, as was seen in her work on the tutorial, that she understood the word parallel and that she also knew how many sides a trapezoid had. She was unable to see the reasoning for comparing the three different rectangles to the trapezoid. She did not understand the softwares attempt to show her how the trapezoid formula was derived. She could not explain how an average for 2 numbers was calculated, but she could give the average for the numbers 6 and 10. The student thought that a trapezoid and triangle both had one base. She indicated that it was easy to understand what the computer had taught her, and that some parts were simple while others were quite hard. She enjoyed working with the computer, but preferred teachers because they were easier to communicate with.

On the practise portion she had problems assigning the values for B1, B2, and H on question #1 (trapezoid). Then she multiplied B1xB2/2 to get an incorrect value. However, she was able to use the correct value for B1+B2/2 and H to calculate the area. She was able to follow B1+B2/2 on the tutorial practice, but was confused by it here.

Question #2 (triangle) : For the initial area she multiplied BxH. She appeared over these first two practise questions to have forgotten what she did on the tutorial practise questions. She then worked through the remedial portion quickly without error.

Question #3 (trapezoid) : She guessed at the initial area and then had no problem working through the step by step breakdown of the proper method.

Question #4,#5 (trapezoids) : Working with pen and paper, she had no difficulty calculating the initial areas for the first (#4) and second (#5) time.

Question #6 (trapezoid) : She asked about a crooked line on the graphic of the trapezoid. The experimenter told her it did not matter. She had problems computating quotients and products involving .5

Question #7,#8 (trapezoids) : The student had no difficulty calculating the initial areas.

Question #9 (trapezoid) : Again she had computational difficulty involving .5 as both a quotient and product. She understood every aspect needed to solve these problems but had forgotten how to divide yeilding a .5 quotient or how to multiply with .5. If she had received some remedial help here she would have reached 80% efficiency.

Question #10 (triangle) : She made a wild guess at the initial area and then proceeded to correctly work through the remedial section of the program which involved .5 as a quotient and product.

Question #11,#12, (trapezoids) : Working carefully on paper she calculated the initial area for each trapezoid.

Question #13 (triangle) : She had no problem calculating the initial area using the formula.

Question #14 (trapezoid) : She encountered no difficulties while calculating the initial area using the formula.

After 15 minutes and 10 seconds she had reached the 80% efficiency level. Then without the aid of the formula sheet she had no problems using the memorized formulae to answer either question. On the post-test she scored 4/10 guessing at the trapezoid areas, but remembering how to correctly calculate the area for triangles.

Summary:

This student had no problems assigning B1, B2, H, or B and H and could understand and calculate B1+B2/2 and B/2. She could also use the appropriate formula correctly to calculate the area of either figure. The only thing stopping her success was the problem she had dividing two into odd numbers to produce a .5 quotient or multiplying with this .5. If the program was somehow sensitive to this problem and gave her remedial help on this skill, she would have easily reached the 80% efficiency earlier. Her problem with .5 was simply because she had forgotten how to work with it. She needed a little guidance and practice to remind her how these computations were performed.

5.3 Non-Tutorial Group Case Studies

Case #1

Student #1 would be ranked in the bottom 25% of participants in this study as far as overall ability is concerned. She is presently working at the beginning of the grade 8 math curriculum in. On the pre-test she scored 1/10, guessing at the area of the trapezoids and using BxH for the area of the triangles.

Initially on the computer she had difficulty with the required procedure to enter answers and failed to comprehend simple instructions like "press space bar". But after the first trial things went smoothly. Below is a detailed outline of her experience with the practise portion of the software.

Question #1 (trapezoid) : On this and every subsequent question she was unable to correctly answer the initial area question posed at the start of every practise question. She would incorrectly answer the initial question and then continue with the more structured part of the practise session. As expected the student simply guessed at B1, B2, and H. At B1+B2/2 she asked, "Do I add these all together?" The experimenter told her that he could not help. The student multiplied B1xB2 to get an incorrect answer and then incorrectly guessed at the area.

Question #2 (triangle) : The student guessed incorrectly on both B and B/2. When the correct answer for B/2 was given she could not understand how this number was calculated. But once given B/2 and H she was able to compute the correct answer for the area of the triangle.

Question #3 (trapezoid) : On the second trapezoid the student correctly assigned the appropriate numbers to B1, B2, and H. And she continued to correctly assign these on all subsequent trapezoids. She was however very confused when asked to compute B1+B2/2 and indeed added all three digits together. The student after thinking long and hard incorrectly arrived at the area by multiplying B2xH.

Questions #4,#5,#6,#7,#8,#9 (trapezoids) : The student was unable to get past the B1+B2/2 portion on each of these questions. This component of the solution process was a major hurdle to the successful completion of the questions. On question #4 she signed, "I don't know what this means" (B1+B2/2). This seemed to be a very frustrating experience for her. On question #7 she tried to eliminate all possible ways for calculating B1+B2/2 using pencil and paper. But after looking at the formula and other data on the screen for 1.5 minutes she again arrived at an incorrect answer. She appeared to become more frustrated and multiplied B1xB2 to get an incorrect answer for the area.

Question #10 (second triangle) : The student was incorrect in identifying B and calculating B/2, but once given the correct H and B/2 data she was able to calculate the area.

Question #11 (9th trapezoid) : Again the student was stumped by the expression B1+B2/2, but she was able to calculate the correct area once the answer for B1+B2/2 was given. She declared, "But I don't understand B1+B2/2!" The student now understood that B1+B2/2xH gave the correct answer, but she was unable to calculate B1+B2/2.

Question #12 (trapezoid) : The student again could not successfully solve the equation B1+B2/2. Once given the answer to B1+B2/2 (6.5), computational problems (multiplying by .5) resulted in an incorrect answer when she tried to compute the area of the trapezoid. The experimenter could see that the student understood the correct method for solving the problem, but the hurdle of B1+B2/2 still existed.

Question #13 (3rd triangle) : The student could not compute B/2, but once given the correct value for B/2 had no problem calculating the area. Even after being given B/2 she could not see how it was calculated (B=6 B/2=3).

Question #14 (11th trapezoid) : The student realized that B1+B2 was 13 and then correctly proceeded to divide it by 2, but again difficulties with computation (.5) prevented her from being successful. Then she had more computational difficulties resulting in an incorrect area calculation. Due to these difficulties in obtaining the correct answer she was unaware that she had followed the correct method. Unfortunately the computer program gave her no indications that she was on the right track nor could it tell her where she was making computational errors.

Question #15,#16 (trapezoids) : The student successfully calculated B1+B2/2 and the area of these two trapezoids.

Question #17,#18,#19 (trapezoids) : Computational problems possibly due to fatigue and frustration with the exercise resulted in incorrect answers to B1+B2/2 but the student was able to calculate the correct area for all three trapezoids once given the solution to B1+B2/2. Due to a time limit of approximately 30 minutes, the fatigue and frustration of the student, and the feeling that the student would not reach the expected level of efficiency, the treatment was stopped at 31 minutes and 30 seconds.

Summary:

From these observations it was obvious that the student had learned the correct method for solving the problems. From the start she could place the correct values for the bases and heights, but the major hurdle was understanding the task and the steps involved in calculating B/2 or B1+B2/2. If this weakness could have been detected by the program with direction and remediation performed from the onset, this student would have been more successful. The student could not understand the task when presented with these two division procedures. In a classroom situation if these computational errors had been remedied the student could have reached 80% efficiency working one on one with the computer and no teacher intervention would be neccessary. With a slightly more elaborate program this student could have been given more specific help and learned this task from the computer.

On the post-test this student scored 0/10 guessing at the areas for both trapezoids and triangles.

Case #2

This student would be ranked in the bottom 15% of participants in this study as far as overall ability is concerned. He is presently working at the halfway point in the grade 7 math curriculum. On the pre-test he scored 3/10, randomly guessing at the areas of both triangles and trapezoids. He had no difficulties with the mechanics of entering data or following the instruction of "push space bar to continue". This student started to work using pencil and paper right from the start. Normally he is easily distracted and hard to keep on task, but for the whole time he was on the computer he was very studious and concentrated on the task at hand. Below is a detailed outline of his experience while working on the practise portion of the software.

Question #1 (trapezoid) : Having had no previous experience with this material, the student simply guessed incorrectly at the area of the trapezoid. He guessed incorrectly on all subsequent initial area questions during this exercise. He also guessed at B1, B2, and H. At B1+B2/2 he was confused and multiplied two numbers to come up with an incorrect response. Then he guessed at the area.

Question #2 (triangle) : For the initial area question he multiplied BxH to get an incorrect answer. He then correctly assigned B and H. At B/2 he was confused as to the task and entered an incorrect guess. For the area he guessed quickly and again incorrectly.

Question #3 (trapezoid) : For B1 the student gave the value for H. He then went on to get B2 and H correct. At B1+B2/2 he multiplied B1xB2 but once the correct answer appeared he saw his mistake and signed,"I thought multiply." He quickly guessed at the area and was wrong.
Question #4,#5 (trapezoids) : He correctly assigned digits to B1, B2, and H. At B1+B2/2 he quickly guessed apparently without thinking. For the area he again guessed incorrectly on both questions. After completing #5 he signed, "I understand H, but B1+B2/2 times (multiply) ?" The experimenter made no response.
Question #6 (trapezoid) : He correctly assigned digits to B1, B2, and H and also calculated B1+B2/2 (5.5). He then started to divide H into 5.5, but then changed and multipliled. However, due to a computational error he produced an incorrect answer of 25.5 instead of 27.5. Therefore on this question he was successful at calculating both B1+B2/2 and the area for the time. He now had discovered the correct method for solving the questions.
Question #7,#8 (trapezoids) : The student correctly calculated all the answers during the remedial sections and gave the 'thumbs up' sign.
Question #9 (trapezoid) : At B1+B2/2 the student guessed quickly and produced an incorrect response. To calculate the area he used the correct method and values, but made a silly computational error involving .5.
Question 10 (triangle) : The student was at first stuck at

B/2 and then used the right values and methods for the calculation. However, he made a computational error.

Question #11 (trapezoid) : He made a mistake at B2, giving the value for H. He could not calculate B1+B2/2, but used the correct data to calculate the area answer.

Question #12 (trapezoid) : Again the student was stuck at B1+B2/2, perhaps because the value involved .5 (7.5). Then using the correct values and method he calculated an incorrect area due to a simple computational problem.

Question #13 (triangle) : The student stated that B/2=6 when it should have been B/2=3 because B=6. Then without thinking he quickly guessed incorrectly at the area.

Question #14 (trapezoid) : Whitout hesitating the student guessed at B1+B2/2. He appeared to be tired at this point. He used the correct values and method but due to a computational error he entered an incorrect answer.

Question #15 (trapezoid) : He waited and then entered a guess not thinking or using paper and pencil at B1+B2/2. He then used the correct data to solve the area.

Question #16,#17,#18,#19 (trapezoids) : The student correctly calculated answers to all the portions of these 4 questions except for #18 where computational problems resulted in a mistake at B1+B2/2. Due to the time limit of approximately 30 minutes and the feeling that the student would not reach the expected level of efficiency, the treatment was stopped after 32 minutes had elapsed.

Summary:

This student knew the correct method for calculating the area for trapezoids (B1+B2/2xH) after question #6, but he did not get enough practice to learn how to calculate the area for triangles. If he was having computational problems with B1+B2/2, he could still use the given data and find the correct area. On several occassions problems with math computation kept him from being successful. He would occassionally guess at B1+B2/2 or the area, but most of the time he carefully worked out the answer using pencil and paper. The student did not get to the point where he understood the significance of the initial area question. He consistently guessed at the first question and then successfully work through the step by step process where the complete task was broken down. If he had been told that the first (initial) area question was the same as the last area question it may have helped him. However this is a student who also needs a great deal of structural help in his day to day problem solving. If he had received more practice on the triangle questions he would have been able to successfully calculate them. He had a hard time deciphering B/2 and needed some more practice to clear up this misunderstanding.

This student did very well considering his overall ability. If this program had a little more in the way of diagnostics and remediation this student could have been more successful. He certainly enjoyed the experience and stayed on task continuously for longer than he would have in another learning situation.

On the post-test he scored 0/10. On both triangles and trapezoids he would add the height and base or bases to calculate the area.

Case #3

This student would be placed at or below the 30th percentile in a ranking of individuals involved in this study based on overall ability. He is presently three quarters of the way through the grade 9 math curriculum. He scored 2/10 on the pre-test guessing at the area of the trapezoids and using the BxH method to solve the triangle areas. Below is a detailed outline of his experience with the practise portion of the software.

Question #1 (trapezoid) : From question #1 to #20 this student would incorrectly guess at the initial area question and then work through the step by step breakdown of the task. For B1 he was confused and entered 35. After looking over the formula on handout #4 he entered the appropriate values for B2 and H. He was also successful at B1+B2/2 and the area. Right from the begining he knew how to do these calculations.

Question #2 (triangle) : He correctly answered all parts of the remedial section for this problem.

Question #3,#4,#5 (trapezoids) : The student had no difficulty answering these questions after getting the initial area question wrong on each one.

Question #6,#7 (trapezoids) : In both problems he was incorrect on the area calculation due to silly computational errors. He used the correct method to calculate the area, but computational problems kept him from being successful. On the initial area questions he was becomming frustrated singing, "I don't know how to do this part."

Question #8 (trapezoid) : The student made a stupid mistake at H and then apparently working too quickly he made a careless error at B1+B2/2. However, he used the correct data to calculate the area.

Question #9 (trapezoid) : He made a silly error at B1+B2/2, but then again used the correct data to calculate the area.

Question #10 (triangle) : The student had no problems working through the remedial section of this question.

Question #11,#12,(#13 triangle),#14,#15,#16 (trapezoids) : He correctly placed the values and did the calculations on each of these problems after getting the initial area questions wrong. On question #15 he asked, "Where is this AREA = (initial area) from?" The experimenter explained it was the same as the final answer. The student did not seem to understand this explanation.

Question #17 (trapezoid) : The student made computational errors at B1+B2/2 and on the area calculation.

Question #18,#19 (trapezoids) : He had no problems working through the remedial portions for these questions. The experimenter said, "Try to get the first question (initial area) correct now."

Question #20 (triangle) : His answer was wrong on the initial area, but correct on the broken down remedial section.
Questions #21,#22,#23 (triangles) : He was correct on all the initial area question. Now the student had to get two trapezoid questions right to reach the 80% efficiency level.
Question #24,#25 (trapezoids) : The student answered both initial area questions correctly thus reaching the 80% efficiency level.

On the practise questions without the formula, the first and second trapezoids were wrong due to computational mistakes. The third trapezoid and the first triangle areas were correct.

Summary:

This student had the correct method right from the start. He simply could not see that the first (initial) area question was the same as the last area question that he worked out successfully in the remedial section each time. He seemed satisfied getting the initial area question wrong and then working through the problem step by step. Later he became frustrated (#15) and asked about the initial area question, wondering what it meant and where it fit into the overall picture. He did not see the relationship between the first area question and the answer he would get at the end of the computations. The experimenter could see that he had no problem figuring the task out and encouraged him at question #15 to try and get the initial question correct. This student could comprehend the notation B/2 and B1+B2/2 and knew how to use the formulae to correctly calculate the areas. He could have reached the 80% efficiency level much earlier if the experimenter had encouraged him earlier on to get the initial area question correct.

This student was successful because he understood the task at B/2 or B1+B2/2 and he could use the formulae successfully. If the program had been able to help him see the relationship between the questions he worked through step by step and the initial area question, he would have been successful on the initial area questions much sooner. The reason for this problem was because he was confused by the initial notation (AREA=___ _) although he understood the procedure for its calculation from the start. A little more information from the software would have helped him immensely.

On the post-test this student scored 1/10 using the same strategies as those he used on the pre-test. He guessed at the area for the trapezoids and used BxH for the area of the triangles. He had not retained the correct method of calculation that he had learned a week earlier.

Case #4

This student would be ranked at about the 50% level in overall abilities when compared to the other participants in this study. She was recently accepted into the preparatory year at Gallaudet College and is presently working at the beginning of the grade 10 curriculum in math. On the pre-test she scored 1/10 guessing at the area of the trapezoids and using BxH for the area of the triangles. Below is a detailed account of her experience with the practise portion of this software.

Question #1 (trapezoid) : On this and every other question she entered an incorrect guess for the initial area question. Then she would proceed through the step by step remedial procedure showing the appropriate method for calculating the answer. This student had no problems with the mechanics of entering her responses. At B1 she entered 35 as her guess for the area. She was correct at B1 and H, but very confused at B1+B2/2, entering 4B as an answer. Then she quickly guessed at the area and just as quickly moved onto the next question without attempting to see how the answer was derived.

Question #2 (triangle) : For B she entered 12 and then for H and B/2 she entered the appropriate digits. Then for the area she entered 6 which was the value for B or H. She understood the task at B/2, but did not know how to use the formula to calculate the area.

Question #3 (trapezoid) : She was wrong on both B1 and B2, correct on H, but incorrect at B1+B2/2 and area. She was not working the answer out on paper and did not appear to understand the task involved to obtain a correct answer.

Question #4 (trapezoid) : She was getting restless at this point. For the first time she entered the appropriate values for B1, B2, and H, but again she quickly guessed at B1+B2/2 and the area.

Question #5,#6 (trapezoids) : She placed incorrect values at B2, B1+B2/2, and area on both questions. She still appeared to have no understanding of the tasks required to compute B1+B2/2 or area. She just randomly guessed at their value.

Question #7,#8,#9 (trapezoids) : The student had no problem placing the appropriate values on B1, B2, and H. However she was unable to calculate B1+B2/2 and could not see that by following the formula the answer could be calculated by B1+B2/2xH. She appeared to work carefully, but did not comprehend the tasks involved in either of these computations. Sometimes she simply guessed using the numbers present and other times she picked numbers out of the atmosphere. She did not looked at the formula sheet and was becomming frustrated.

Question #10 (triangle) : For the initial area question the student entered TRIANGLE. The experimenter told her that it must be a number. She errased it and quickly entered an incorrect guess for the initial area, other incorrect values for B and B2 and then the area again. She did not look at the correct answers and try to logically deduce how each was calculated. She just quickly entered a guess and when the correct answer appeared she quickly went on to the next part, never pausing to study the problem or solutions presented.

Question #11 (trapezoid) : She made an incorrect entry for B1. Then a breakthrough at B1+B2/2. She added B1+B2=12 and then signed B1+B2=12, forgetting to divide by 2. She also entered an incorrect value for the area.

Question #12 (trapezoid) : She correctly entered values for B1, B2, and H. At B1+B2/2 she added B1+B2 and then divided it by 2, but due to computational problems (15/2=7.1) she entered an incorrect value. Then at the area calculation she used the given value of B1+B2/2 and multiplied it by H, but again due to computational problems she got an incorrect answer. She had figured out the correct method for solving both B1+B2/2 and the area, but the computer had not been able to tell her, because it was not programed to be sensative to these situations.

Question #13 (triangle) : She placed the appropriate value for B and H and successfully computed B/2, but then multiplies BxH to get an incorrect value for the area. She did not see that B/2xH gave the correct answer.

Question #14 (trapezoid) : She was correct on B1, B2, H, and B1+B2/2, but guessed incorrectly at the area instead of trying to work it out. She signed, "Stupid game" showing her frustration at being unsuccessful.

Question #15 (12th trapezoid) : The student placed the appropriate values for B1, B2, H, and succesfully computed B1+B2/2 and then used the correct method to calculate the area. She signed, "I got it!" The student for the first time saw that she was using the correct method and successfully answered the question.

Questions #16,#17,#18,#19,#20 (trapezoids) : The student correctly answered all the components including B1+B2/2 and the area, after guessing incorrectly at the initial area question.

Question #21,#22,#23 (4th,5th,6th triangles) : The student was successful for the first time with triangles. She computed B/2 and then used this value multiplied by the height to get the appropriate answers. Using the data on the screen she had now discovered the correct method for solving areas of triangles. But she was unable to calculate the initial area question for any of these triangles.

Question #24 (trapezoids) : She correctly answered all the components of this question after guessing at the initial area question. Due to the time limit of approximately 30 minutes and the feeling that the student would not reach the expected level of efficiency, the treatment was stopped after 30 minutes.

Summary:

This student could identify the appropriate parts needed for the trapezoid formula after question #7, but could not comprehend the task at either B1+B2/2 or area until question #15. Some diagnostic and remedial help here from the program could have hastened her understanding of this process. The same problem existed with the triangles and the same type of help would have made the program much more helpful and less frustrating for the student.

The student could never do all the work independently to answer the initial question, however she could follow the step by step method and calculate the answer by being lead through the correct procedures by the program. The next step for her was to use the knowledge of this procedure and independent of the computer, work out the answer and enter it as the initial area answer. She never realilzed the signifigance or meaning of this initial area question. If the program had been a little more sensative to the problems encountered by the student and applied appropriate remediation, this student may have reached the 80% efficiency level.

On the post-test she scored 2/10 guessing at the area of the trapezoids and using BxH for the area of the triangles. These were the same strategies she applied on the pre-test.

Case #5

Student #5 would be ranked in the top 25% of the participants in this study based on overall abililtly. She has recently been accepted into the freshman year at Gallaudet College and is presently working at the end of the Algebra 11 math curriculum. Below is a detailed outline of her experience with the practise portion of the software.

Question #1 (trapezoid) : She guessed incorrectly at the initial area question and B1 and H. She understood the notation B1+B2/2 and correctly calculated it. However, she could not calculate the area.

Question #2 (triangle) : She entered the correct values for B, H, and B/2 and then working on paper she incorrectly guessed at the area. After only two trials the student showed the experimenter that she understood the notation B/2 and B1+B2/2, but she had not yet discovered the use of the formulae to calculate the areas.

Question #4,#5 (trapezoids) : She carefully tried to calculate the initial area, but entered a guess each time. Then she studiously worked through the remediation sections and successfully answered all components of both questions.

Question #6,#7 (trapezoids) : On #6, working on paper and using the formula sheet to calculate the initial area, she used the appropriate digits 11/2x5, but had problems with 11/2. When working through the step by step breakdown again she had problems with B1+B2/2 (11/2), but she used the correct data to calculate the area. The exact same scenario happened with question #7. Both with her attempts at the initial area question and the step by step method she was stuck at B1+B2/2 because it involved 7+6/2=13/2 to which she answered 7.5. Therefore a silly computational error caused failure. However, again she had used the correct data to calculate the area.

Question #8 (trapezoid) : Working on paper she successfully calculated the initial area on this the 7th trapezoid.

Question #9 (trapezoid) : Again computational problems involving B1+B2/2 caused failure at the initial area calculation. This problem occured again during the step by step breakdown, but she used the correct value for B1+B2/2 and multiplied it by H to get the right area.

Question #10 (triangle) : Computational problems at B/2 and area made the student unsuccessful at this question. Problems with division and multipication with .5 resulted in an incorrect answer although she was using the correct method. (She knows that B/2xH=Area for a Triangle.)
Question #12 (trapezoid) : She correctly calculated the area involving .5, but entered it as 375 (instead off 37.5) forgetting the decimal. She then had to go through the step by step remedial method.
Question #13 (triangle) : She calculated the right initial area for this triangle.
Question #14 (trapezoid) : Working quickly and carelessly she entered an incorrect initial area and then sped through the remedial part and calculated the area.
Question #15,#16,#17 (trapezoids) : Using paper and pencil, she quickly worked out the correct initial area for each of these trapezoids and reached the 80% efficiency level.

On the practise questions without the aid of the formula sheet she used the correct digits and method but in the final portion B1+B2xH of the first trapezoid she made a silly computational error. On the second trapezoid she correctly calculated the area. Then on the first triangle she had no problems calculating the area.

Summary:

This student understood the notation B1+B2/2 and B/2 right from the start. She also quickly picked up on the appropriate use of the formula for calculating the area (on the second trapezoid and triangle problems). Her biggest problem involved computation when .5 appeared as a quotient or when multiplying with .5. If the computer had been able to detect this problem and provide remediation to correct this misunderstanding, this student would have reached the 80% efficiency level sooner. She did finally overcome this computational problem herself.

Case #6

This student would be ranked in the middle (50%) of the participants involved in this study as far as overall ability is concerned. She is presently working at the halfway point in the grade 9 math curriculum. On the pre-test she scored 1/10 guessing randomly at the area of both trapezoids and triangles. Below is a detailed account of her experience with the practise portion of the software.

Question #1 (trapezoid) : This student went directly to paper to try and solve the problems. She guessed 175 for the initial area and then looking at the formula sheet correctly identified B1, B2, H, and calculated B1+B2/2. However she did not know how to calculate the area and entered 6. She could understand the notation B1+B2/2, but did not understand the appropriate use of the formula.

Question #2 (triangle) : She correctly identified B and H and calculated B/2, but she entered BxH=36 for the area.

Question #3 (trapezoid) : She looked at the figure for a long time and then entered a guess for the initial area. She had problems assigning B1 and B2, giving the value for H to both. She correctly assigned H and also calculated B1+B2/2, but again failed to calculate the area, entering a guess.

Question #4 (trapezoid) : She correctly identified B1, B2, H, and calculated B1+B2/2. Then she almost calculated the area, multiplying B1+B2xH. However she should have divided B1+B2/2 and then multiplied by H.

Question #5 (trapezoid) : She had no problem with B1, B2, H, and B1+B2/2, but could not discover the method required to calculate the area, and entered a guess of 96.

Question #6 (trapezoid) : The student became confused on B1+B2/2 and was also unable to calculate the area. She entered wild guesses for both answers.

Question #7 (trapezoid) : She got the initial area question correct. She did not showed her work so the experimenter was unsure if this was simply a lucky guess.

Question #8 (trapezoid): At B1+B2/2 she multiplied B1xB2 and then divided by 2 for an incorrect answer. However she was able to use the correct answer for B1+B2/2 and for the first time correctly calculate the area of the trapezoid. She now understood how to calculate the area.

Question #9 (trapezoid) : She correcly answered the initial area question.

Question #10 (triangle) : For the initial area question she multiplied the base times the height. Then she worked through the step by step process without any errors.

Question #11,#12 (trapezoids) : Doing the computations in

her head, she calculated both initial area questions.
Question #13 (triangle) : She correctly calculated the initial area for this triangle. After 16 minutes and 10 seconds she had reached the 80% efficiency level. She then quickly answered both the first trapezoid and triangle area questions without the aid of the formula sheet.

Summary:

This student could assign the appropriate values to the individual components of the "solving process" and understood the task at B/2 and B1+B2/2, right from the start. She quickly discovered the correct use of the formulae for calculating the areas. She worked through the practise section, smoothly learning the tasks and reached the 80% efficiency level quickly. She could have attained this level earlier if the program had some diagnostic and remedial abilities to help bring about a better understanding of the proper formula usage. This student immediately understood and could calculate the components. She simply needed some assistance in putting the component parts into the overall formula to successfully attain the areas.

On the post-test she scored 3/10, guessing at the area of the trapezoids and adding B+H to get the triangle areas.

Case #7

This student would be ranked about the 50th percentile when comparing her general abilities to other students involved in this study. She is presently working at the mid-point of the grade 9 math curriculum. On the pre-test she scored 1/10 guessing at the area of the trapezoids and triangles. Below is a detailed account of her experience while working through the practise portion of the software.

Question #1 (trapezoid) : After carefully viewing the problem she guessed at the initial area question. She had difficulty assigning B1 and H, but computed B1+B2/2 and also correctly calculated the area. She understood the notation B1+B2/2 and could compute it right from the beginning. She also understood the significance of the formula and could use it to calulate the area.

Question #2 (triangle) : She had no problem after guessing at the initial area question. She correctly placed the values for B and H and calculated B/2. She was also able to use the formula and calculate the area for the triangle.

Question #3 (trapezoid) : She signed, "I don't understand" what the first (initial) area question meant and then guessed incorrectly at it. She got through the step by step process without making an error and calculated the area.

Question #4,#5,#6 (trapezoids) : She would guess at the initial area question and then continue through the remedial section of the practice without any problems. She had not yet realized that the initial area was the same as the final area answer she got in the remedial section.

Question #7 (trapezoid) : The student quickly guessed at the initial area, then worked correctly through the step by step breakdown of the method, but due to a silly computational mistake she did not calculate the correct area.

Question #8 (trapezoid) : Again she made a quick guess at the initial area, then a mistake at H, forgetting to divide B1+B2 by 2, and then a correct area calculation using the correct value for B1+B2/2.

Question #9 (trapezoid) : For the first time the student worked on paper to try and solve the answer but again she entered a guess for the initial area. She had no problems with the rest of the work except for a careless computational mistake on the area.

Question #10 (triangle) : She calculated a wrong initial area and then had no difficulties working through the remedial portion.

Question #11,#12,(#13 triangle),#14,#15 (trapezoids) : In each case she would quickly guess at the initial area and then quickly and accurately work through the remedial portion of the practice. She was becomming increasingly frustrated with each successive failure on the initial area question. The student was not using the formula sheet or other data displayed on the monitor to help her discover the significance of the initial question. Even the difficult computations involving .5 were no problem for her. However, the initial area was a mystery to her, while all the other components had been simple since the start.

Question #16 (trapezoid) : She looked at the formula sheet #4 and signed, "Stupid me, I understand now." She then quickly used the correct method to calculate the wrong answer because of another careless computational error.

Question #17,#18,#19 (trapezoids) : She correctly calculated the initial area for all 3 trapezoids.

Question #20 (trapezoid) : She quickly calculated and entered the correct answer for the initial area question. She had reached the 80% efficiency level after 20 minutes and 30 seconds. On the two practise questions done without the use of the formula sheet she made a computational error on the first trapezoid, but then correctly computed the next trapezoid and the first triangle area.

Summary:

This student had initial difficulty placing the values for B1, B2, and H, but had no problem on the first attempt at B1+B2/2 or the use of the area formula. She had no problem at all with the first triangle question. Her only downfall was in understanding the significance of the initial area question. If the program could have detected this and provided remedial help or clues, she would have reached the 80% efficiency level after 4 or 5 questions. The only thing holding her back was her inability to understand that the initial area question was the same as the last area calculation in the remedial portion of each practise question. Once she discovered this she expressed her feelings of stupidity over her ineptness. This software gave no help in her only area of misunderstanding and she became frustrated and was on the verge of quitting when she finally unravelled the mystery herself.

On the post-test she scored 4/10, quickly and randomly guessing at both trapezoid and triangle areas.

Case #8

Student #8 would be ranked in the top 10% when comparing her general abilities to those of the other participants in this study. She was recently accepted into the freshman year at Gallaudet college and is presently working at the beginning of the grade 11 Algebra curriculum. This student scored 2/10 on the pre-test, answering both of the triangle area questions correctly and guessing at the area of the trapezoids. Below is a detailed description of her interaction with the practise portion of the software.
Question #1 (trapezoid) : The student signed, "This was a different formula sheet then what I need." She entered a guess for the initial area and then entered B1=10 when there was no 10 in sight. For B2 she entered the value the compute assigned to B1. Then she correctly calculated both B1+B2/2 and the area. She understood the notation B1+B2/2 and could use the area formula right from the start.
Question #2 (triangle) : She tried to work out the initial area on paper but was not successful. Then for B, she tried to enter the B/2 value. She correctly identified H and B/2 and also used the formula to calculate the area. She had no problems with either the notation (B/2) or the calculations involved with the triangle formula.
Question #3,#4,#5,#6,#7,#8,#9 (trapezoids) : In each case

she would look at the formula and then quickly guess at the initial area. Then she would quickly but carefully follow the step by step remediation provided and perform the correct area calulation. At question #6 she asked if the first area meant the area of 'this' (she pointed at the trapezoid). She did not see the relationship between the first AREA=____ and the area of the figure. At question #6 she asked how to enter a decimal for her answer 27.5.

Question #10 (triangle) : She was not using the formula. Instead she tried to measure using her pencil on the screen. She entered an incorrect guess. Then, writing her computations on paper she smoothly worked through the component parts of the practice without making a mistake.

Question #11 (trapezoid) : She looked at the figure for a long time and then entered an incorrect guess. A self confessed "stupid" mistake at B1 was the only problem in solving the question via the step by step process.

Question #12 (trapezoid) : The student's frustration with the initial area question became apparent at this question. "I can't do this part." "I don't know what to do." The experimenter answered her pleas for help by signing, "I can't help you, remember you have this sheet (formula) to help you." She entered an incredible guess of 135 for this initial area and then completed the step by step remediation without a problem. She could do all the steps, but she did not understand the significance of the initial area question. She did not know that the initial area was the same as the final area she calculated after going through the proper procedure. She appeared to think that this initial area was somehow unrelated to the answer she got at the end.

Question #13 (triangle) : She started off incorrectly by dividing 2 into the product of BxH, but then changed her method and got the right initial area for the first time.

Question #14,#15 (trapezoids) : Again a quick guess at the mysterious initial area question followed by a faultless computation through the guided method. At this point she could not understand the significance of the initial area question.

Question #16 (trapezoid) : She looked at the figure on the screen and entered 66 as the initial area. She wanted to give up and was embarrassed by her inability to decipher the meaning of this initial question. She quickly calculated the correct answer step by step.

Questions #17,#18 (trapezoids) : Again she was not looking at the formula sheet, but instead at the numbers on the figure, trying to get over this hurdle of the initial area. In both cases she entered an uncalculated guess and then proceeded to quickly answer the remedial portion step by step.

Question #19 (trapezoid) : She looked at the figure for a long time, pointing to the bases and signing, "base 1, base 2." Then again after performing a strange sequence of computation (12x6=72, 72/2=36), she entered 36 as her answer. Then, as usual, she went on to easily obtain the correct solution by working through the remedial section.

Due to the approximate time limit of 30 minutes, the student's frustration with the task, and the feeling that the student would not reach the expected level of efficiency, the treatment was stopped after 30 minutes.

Summary:

From the very start this student could assign the appropriate values for B, H, or B1, B2, H, and could understand the notation and complete B/2 and B1+B2/2. She could also use the formula to calculate the appropriate areas. Some of the more difficult computations involving .5 gave her no problems. She should have quickly gone through this treatment and easily reached the 80% efficiency level. However, she could not during this treatment discover the meaning of the initial question AREA=____. If this software had the diagnostic capabilities to detect this problem and give the student help in understanding the significance of this initial question, then this student would have successfully attained the 80% efficiency in a very short time.

On the post-test she scored 2/10, getting the triangle areas correct as she had done on the pre-test and guessing at two of the trapezoid questions, while using a summation method (a+b+c) for the areas of the other six trapezoids. She signed "I forgot how to do these."

Case #9

This student would be ranked at or below the 90th percentile when comparing his overall abilities to the other participants involved in this study. He had been recently accepted into the preparatory year at Gallaudet College and is presently working at the mid-point of the Algebra 11 curriculum. This student surprised the experimenter by scoring 9/10 on the pre-test. The experimenter interviewed the student after the pre-test to discover how he was able to compute the correct answers. He stated that he remembered how to do the triangles from previous math experience. With the trapezoids he logically devised a unique method which was similar in purpose but not identical to the appropriate formula for trapezoids. He saw that he could make a rectangle out of the trapezoid by moving one corner (triangle) of the trapezoid over and flipping it up onto the other side. He subtracted half the difference between the smaller and larger base, from the larger base and multiplied this by the height to calculate the area. It worked and he scored 9/10, making one computational mistake which resulted in an incorrect answer. By subtracting half the difference between the larger and smaller bases on the trapezoid from the larger base he was actually calculating the average of the two bases (B1+B2/2) and then multiplying this by the height to arrive at the correct answer. He was making a rectangle out of the trapezoid by moving a part (triangle) over as was done in the animation of frame #11 in the tutorial, and then using the rectangle formula BxH to calculate the area. Below is a detailed outline of his interaction with the practise portion of this software.

Question #1 (trapezoid) : He looked at it and signed, "I forget." He did not look at the formula sheet but in his head calculated the correct initial area.

Question #2 (triangle) : He answered this part correctly on the pre-test, but guessed at the initial area here and then quickly worked through the remediation without any problems.

Question #3,#4 (trapezoids) : He calculated the initial area for these questions in his head without any errors.

Question #5 (triangle) : The experimenter moved ahead to the next triangle because if the student correctly answered it he would have reached the 80% efficiency level. He quickly calculated the correct initial area and was finished. On the two questions done without the aid of the formula sheet this student encountered no difficulties.

Summary:

Student #9 had devised his own method for solving the area and used it successfully on both the pre and post-tests. On the post-test he scored 10/10.

5.4 Quantatative Data for Tutorial and Non-tutorial Groups

The data described in the following tables were collected from the Tutorial and Non-tutorial groups before, during, and after their exposure to the computer software. The students were given a pre-test one to three weeks before being exposed to the software. During their interaction with the practise portion of the software data were collected on the number of trials (practise questions completed), the length of time spent interacting with the computer, and whether they reached the 80% efficiency level on the initial area questions. These data and the scores from the post-tests taken one week after their exposure to the software, are displayed in tables 2 and 3. A more detailed analysis of their experience with the practise portion of the software is given in tables 4 and 5. The information for these tables was obtained by carefully analysing the observations collected by the experimenter as each student worked through the practise section of the software. A heading displays all the individual component parts which made up the remedial section, along with other data that together list all the responses required for the two different types of questions (trapezoid or triangle). The data show the number (1=first, 2=second, etc.) of the triangle or trapzoid at which the student first entered a correct response for each of the component parts.

Table 2

Results from the Tutorial Group

Student Number	Pre-test Score	80% Efficiency Reached (in) : Yes/No	# of Trials	Time	Post-test Score
#1	0/10	Yes	13	10:00	10/10
#2	2/10	No	14	20:00	1/10
#3	0/10	No	15	20:00	0/10
#4	5/10	Yes	4	1:55	10/10
#5	1/10	Yes	16	20:10	0/10
#6	0/10	No	14	20:00	1/10
#7	2/10	Yes	4	2:25	0/10
#8	0/10	Yes	16	21:00	3/10
#9	0/10	Yes	14	15:10	4/10

Table 3

Results from the Non-tutorial Group

Student Number	Pre-test Score	80% Efficiency Reached (in) : Yes/No	# of Trials	Time	Post-test Score
#1	1/10	No	19	31:30	1/10
#2	3/10	No	19	32:00	0/10
#3	2/10	Yes	25	22:05	1/10
#4	1/10	No	24	30:00	2/10
#5	1/10	Yes	17	14:20	3/10
#6	1/10	Yes	13	16:10	3/10
#7	1/10	Yes	20	20:30	4/10
#8	2/10	No	19	30:30	2/10
#9	9/10	Yes	5	3:00	10/10

The two tables above display data collected from the tutorial and non-tutorial groups in this study. These results show the student's number, score on the pre-test, whether she/he sucessfully reached the 80% efficiency rate during the practise portion (Yes/No), the number of trials (practise questions) the student worked through, the time spent on the practise section, and his/her score on the post-test.

On all statistical analysis the null hypothesis was that the difference between the means of the two populations (TG and NTG) is equal to zero, while the alternative hypothesis was that it is different from zero. Statistical tests were performed using an alpha (level of significance) of .05.

$$Ho : u1 - u2 = 0$$
$$H1 : u1 - u2 <> 0$$

Statistical Analysis

Pre-test data showed that the TG had a mean of 1.1 and the NTG had a mean of 2.3. Using a t-test for independent samples this difference was found to be insignificant ($t=1.063$, $df=16$, $p>.05$). Ho is accepted, there is no significant difference between the groups with regard to the pre-test.

The next set of data shows that 5 members of the NTG and 6 members of the TG reached 80% efficiency (Yes/No) while interacting with the practise portion of the software. A Chi square test showed that there was no significant difference between the two populations ($X^2=1.11$, $v=1$, $p>.05$). Ho is accepted, there is no significant difference between the groups on reaching 80% efficiency. Data from these 11 people (5 from the NTG and 6 from the TG) who sucessfully reached 80% efficiency on the practise portion, were used in the next two statistical analysis.

The mean number of trials required to reach 80% efficiency for the TG was 11.17 and for the NTG was 16.4.

This difference proved to be non-significant using a t-test for dependent samples ($t=1.329$, $df=9$, $p>.05$). The null hypothesis is accepted again.

The mean time required to reach 80% efficiency for the TG was 13.28 minutes and for the NTG was 15.67 minutes. This proved to be a non-significant difference when the t-test for dependent samples was used ($t=.561$, $df=9$, $p>.05$). Again the null hypothesis is accepted. There is no significant difference between the two populations with regard to the time required to reach 80% efficiency.

Data collected showed that the TG had a mean of 3.111 while the NTG had a mean of 2.888 on the post-test. This difference again proved to be non-significant when tested using a t-test for dependent samples ($t=.262$, $df=16$, $p>.05$). No significant difference was found between the two groups with regard to the post-test.

Analysis of these data reveals that there was no significant difference between the TG and the NTG on any of this collected information.

Table 4

Results from the Tutorial Group

Student Number	[triangle] B	H	B/2	A	AA	:	[trapezoid] B1	B2	H	B1+B2/2	A	AA	80%
#1	1	1	1	1	2		1	1	1	1	1	9	13
#2	1	1	1	2	N		2	2	2	N	4	N	N
#3	2	2	N	N	N		2	1	2	N	N	N	N
#4	1	1	1	1	1		1	1	1	1	1	1	4
#5	1	1	1	3	4		1	1	1	2	3	7	16
#6	1	1	6	N	N		4	1	1	N	N	N	N
#7	1	1	1	1	1		1	1	1	1	1	1	4
#8	1	1	1	1	1		1	3	1	1	1	7	16
#9	1	1	1	1	3		1	1	1	2	1	3	14

Table 5

Results from the Non-tutorial Group

Student Number	[triangle] B	H	B/2	A	AA	:	[trapezoid] B1	B2	H	B1+B2/2	A	AA	80%
#1	3	1	N	1	N		1	2	1	11	9	N	N
#2	1	1	N	N	N		3	1	1	4	6	N	N
#3	1	1	1	1	5		2	1	1	1	1	18	25
#4	3	1	1	4	N		3	1	1	11	12	N	N
#5	1	1	1	3	3		3	1	2	1	2	7	17
#6	1	1	1	2	3		1	1	1	1	7	7	15
#7	1	1	1	1	4		2	1	2	1	1	14	20
#8	2	1	1	1	3		2	3	1	1	1	N	N
#9	1	1	1	2	2		1	1	1	1	1	1	5

The two tables above display more detailed data about the achievement of both the TG and NTG on the practise portion of the software. These data show the results on the individual component parts of the practise exercise. The digits designate the number of the triangle or trapezoid (ie 1st, 2nd, 3rd, 4th, etc.) where the student first successfully answered the labelled component (ie. B=Base, H=Height). The labelled components found in the first row under the triangle information are: B (base), H (height), B/2, A (area question found at the end of the remedial section), AA (the first time the student got the initial triangle area question right), and 80% (the number of the question at which the student reached the 80% efficiency level). The labelled components under the trapezoid information are: B1 (base1), B2 (base2), H (height), B1+B2/2, A (area question found at the end of the remedial section), AA (the number of the trapezoid question where the student first successfully answered the initial area question), and 80% (the number of the question at which the student reached the 80% efficiency level). The capital (N) signifies that the student never successfully answered this component of the practice or failed to reach the 80% efficiency level.

Statistical tests were performed on this data to see if there were any significant differences between the performance of the TG and the NTG. T-tests for dependent samples were used with an alpha of .05. The TG had a mean of 2 for the first success on the initial area question for triangles, while the NTG had a mean of 3.33. This means that on average TG individuals were successful on the initial triangle questions on their second attempt, while NTG individuals were first successful on their 3.33 attempt. The t-test performed on this data gave significance at the .05 level ($t=1.950$, $df=10$, $p>.05$). There was a statistically significant difference between the TG and the NTG in their first success on the initial area questions for triangles.

A t-test was also performed on the difference between the two groups in successfully calculating the initial area question for trapezoids. The TG had a mean of 4.66 and the NTG had a mean of 9.4. But this proved to be insignificant ($t=1.524$, $df=9$, $p>.05$).

After the completion of statistical tests on these data the only significant result occurred when the TG and NTG were compared on their initial triangle area success. In all other aspects of this study there were no statistically significant differences between the two groups.

Chapter 6 : Summary and Conclusions

6.1 Tutorial Software : Suggested Improvements

As documented in the tutorial group case studies there were many different problems encountered by the students who worked through the tutorial program. Several of these problems were common to most or all of the participants and are used as a basis to make recommendations to improve this software and set some guidelines for the development of future tutorial software for use with the hearing impaired.

The main problem which all students encountered in varying degrees, was with the syntax involved in the tutorial program. Although the math concepts were at or below the appropriate grade level for these hearing impaired students, the syntax used during most of this program was far beyond the reading ability for the majority of them. The individuals in the tutorial group displayed varying degrees of difficulty understanding instructions and text found in the program. On a number of occasions they could comprehend the individual words but were confused by the syntax and unable to understand the task or concept. For example the following sentences were not understood by most students as indicated by their behavior: "Unlike parallelograms, the parallel sides of a trapezoid have different lengths." "Compare the trapezoid with the rectangle whose width is 3 cm and length 8 cm the same as the trapezoids longer base." "Instead of calling the top a base of length 0 just take the base that remains and divide by 2." This is a problem which teachers of the hearing impaired have dealt with in the past, and it will severely limit the amount of potentially useful software available in the future, unless software can be produced specifically with the hearing impaired and other "language limited" populations in mind. The syntax involved in most software programs precludes their successful use by groups like the hearing impaired because they find the text or instructions to be language bound. Software created for the hearing impaired should be carefully scripted and the syntax stringently monitored to ensure the development of high quality, educationally useful software. The computer will not be a useful tool in the classroom if its use requires the constant supervision and aid of a teacher. There is an enormous need for syntatically simple software which also handles advanced concepts. Programs like the one investigated in this study would be more educationally beneficial to groups like the hearing impaired, if the syntax were simplified.

Another major problem with the tutorial program is that it was unsuccessful in teaching one of its main concepts. A large portion (9 out of 25 frames) of the tutorial program was concerned with demonstrating how the formula for trapezoids was derived, but not one of the students in the tutorial group understood this concept after exposure to the software. The student was required to compare a set of three different rectangles to a trapezoid without any explanation as to why this had been done and was expected to see that this explains the derivation of the trapezoid formula. If this concept is deemed to be important then it should be taught more thoroughly with a detailed but clear explanation outlining the reason for each step of the proof. This would require a great deal more discussion and guidance than is presently offered. For hearing impaired students who have difficulty reading and comprehending a straight forward explanation, this section with all of its inferences and lack of detail would be very difficult to understand. However, the fact that this portion of the tutorial was not understood seemed to have no apparent effect on the students ability to learn the correct application of the trapezoid formula.

Software for the hearing impaired should be detailed to explain the concepts put forth, yet in simple language so that it can be understood. This particular software would need to be broken down into more steps (frames) so the concepts could be presented in a more clear, detailed, and understandable fashion.

There were three problems with this tutorial program that probably were not noticed by the students, but showed inconsistency and poor planning by the programmers. The first concerns handout #4. On handout #4 the diagram of the trapezoid and triangle was accompanied by a specific place for the student to copy the formula. The problem was that on the sheet the place for the formula was written like this; A=____________________. While on the computer the formula inside the box that they were to copy was written as follows:

B1+B2/2xH=AREA. All of the tutorial students except one ended up copying the formula to read A= <u>B1+B2/2xH=AREA</u> . This caused some confusion for the students and interfered with their learning of the concept.

The second problem occurred during the triangle area calculation. During the tutorial practice the B/2 step was left out of the step by step teaching of the calculation. While in the practise portion of the software it was used in every case during the remediation procedure. For the sake of consistency the B/2 step should have also appeared in the one practise question in the tutorial. This would have helped students understand the task better once they started the practise section.

The third problem involved a missing title for the trapezoid formula. In frames #21 and #22 the triangle formula appears in a rectangular box clearly titled "TRIANGLE FORMULA" so the students understand its use. But in frames #11 and #12 the trapezoid formula appears in a rectangular box without a clear title to indicate what it was. This appeared to be a source of confusion and misunderstanding for some of the tutorial group students.

It was clear from observing several of the tutorial students that they did not need to understand all facets of the tutorial program in order to aquire enough insight and information to facilitate the learning of the correct formulae application. Several of the students although clearly not understanding information in the tutorial, readily assigned the appropriate digits and could apply the formulae correctly to calculate the initial area questions in the practise portion. Others found it easy to assign the digits to the corresponding parts but had a harder time using the formulae. Even though these students did not understand the derivation of the trapezoid or triangle formulae they did get some useful information from the tutorial that made it easier for them to do the practise problems. One of the frames that the experimenter felt was particularly helpful was frame #4. In this frame a trapezoid is displayed graphically and then as the components Base1, Base2, and Height are given numerical values these same values appear on the graphic, showing the student where the parts are located on the trapezoid. This was an excellent example of the potential power of the computer as a teaching aid. But unfortunately the rest of the program was not quite so illuminating or clear.

One of the interesting observations made during the tutorial was that some students did not understand the significance of an important frame and quickly moved on without carefully reading it. The software should be written so that the computer is more sensitive to errors made by the student. The program should give the computer the capability to point out important information contained in a specific frame where the student has made an error in the past.

A problem with this and other software is the failure to check the user's comprehension of the program's content and provide remediation if required. This program had no questions which directly checked the student's understanding of the ideas discussed. There were only a few questions (four) asking him to enter answers other than the two practise questions. And none of these four questions tested his understanding of the content of the text. It has been the experimenter's experience that if a hearing impaired student "reads" something that he/she does not understand he/she simply ignores it and continues. This actually happened in every case during the tutorial observations. The experimenter added a few comprehension testing questions of his own to this software to try to make it more inquisitive. For the hearing impaired and others, software needs to be written that contains more questions requiring input to test comprehension of the text. If the student makes a mistake or misunderstands a section then remediation can take place to help the student comprehend and learn. For this kind of sophisticated and involved software more time and planning will be required to produce it. This will mean more expense, but the software will be far superior. The software used in this study is fairly typical in that it contains little in the way of diagnostic or remediation capabilities.

Another weakness of this tutorial program was that it only gave the student one opportunity to practise each skill it was attempting to teach. Only 9 of the 25 frames dealt with practice using the formulae to solve questions. Yet this was the only concept tested in the practise section of the software. It would be difficult for any student to learn a concept with only one practice. Teachers of the hearing impaired know about the repetition required when teaching any new concept. One practice is not enough. Many of the students in the tutorial group could have reached the 80% efficiency sooner if the treatment in the tutorial software had been more powerful. By giving the students more practice during the tutorial they would enter the practise portion of the software better prepared to answer the questions. For many students it is unfair to provide only one attempt at the procedure and then throw them into the practice. In any tutorial software for the hearing impaired there should be ample oppourtunity to practise the important skills being taught before the student is left to practise the concept on his own. By providing more practice in a more sophisticated (diagnostic and remedial) tutorial the treatment can be made more powerful and the practise portion would not need to be so involved.

6.2 Practise Software : Suggested Improvements

As outlined in the tutorial and non-tutorial case studies there were many different problems that ocurred while the students worked through the practise portion of the software. As with the problems encountered in the tutorial program several of these were common to many of the students. These problems are used as a basis for recommendations to improve this software and provide guidelines for the future development of drill and practise software for the hearing impaired.

Unlike tutorial software, drill and practise software is not designed to teach new concepts. It was used in this study to teach the use of the formulae so that the effectiveness of the tutorial software could be measured. By doing this the experimenter discovered some very interesting things about how this practise software could be improved for its use with hearing impaired students.

Many of the students in the tutorial group depended on the practise portion to teach them the skills discussed in the tutorial because they did not get enough practice using the formulae during the tutorial to learn its application or they did not comprehend the tutorial information. So these tutorial students were similiar to the practise students because they too were learning the appropriate applications of the formulae during their exposure to the practise software.

The main problem with the practise portion of the software was identical to a problem that occurred during the tutorial portion, the lack of diagnostic and remedial capabilities. Students would make the same errors or get stuck at the same junction in the program which did not have the diagnostic ability to notice the problem or apply remediation to correct it.

None of the students had difficulty assigning the appropriate digits to the component parts of the practice (B1, B2, H or B, H). Within a few trials everyone had learned this part of the concept through repetition and practice. The problems started at the next part of the program when the values for B/2 or B1+B2/2 were demanded. Many students had difficulty understanding the notation and task at this step of the program. Some continued to guess each time they arrived at this portion of the step by step breakdown of the problem without getting any closer to comprehending its solution. Others eventually grasped the concept through simple repetition of the task. If the program could have detected this problem and applied remediation to teach the correct method of calculation the student could have readily learned this and continued onto the next section without becoming frustrated and bored with the task.

Other students could understand the tasks at B/2 and B1+B2/2 but did not see how to use the formulae to calculate the area. Again, some would continue to guess each time they arrived at this point, while others successfully mastered the task after several practices. The program should have a way to detect this problem and show the students how to calculate the area once they have entered their incorrect guess or answer. This program simply told them that they were wrong and supplied them with the correct answer.

One of the most surprising problems encountered by students involved the initial area question. Some students started the practise questions and had no problem working through the remedial portion starting with question #1. They could successfully answer all the component parts including the area calculation without any difficulty. Others had initial difficulties but soon became skilled at answering all of the questions including the area question. Then these same students were not able to comprehend the significance of the initial area question. They could readily solve the area problems but they could not understand the task when presented with the initial area question at the begining of each practise question. If this program had been able to detect this difficulty and explain to the students what this initial question represented, many more would have reached the 80% efficiency level. And others would not have become so frustrated trying repeatedly to discover its significance, only to eventually solve the annoying mystery and express their shame at its simplicity.

Another difficulty which many of the students had was the result of the computations required to solve the problems. Individuals in both groups forgot how to divide 2 into an odd number to get a quotient involving .5, and they also had forgotten how to multiply using this .5 number. Again detection and remediation of this problem by the computer would have saved a great deal of time and frustration and helped some students achieve more success.

Ideally drill and practise software for the hearing impaired should have the capability to detect and remediate problems that the user encounters in his quest to become successful. This will require more complex and detailed branching programs to be written inorder to give the computer these capabilities, but the effort and expense will be worth it.

6.3 Tutorial vs Non-tutorial Acheivement

It was clear in the statistical analysis of the results that the tutorial group did not have a significant advantage over the non-tutorial group in acheivement on the practise section of the program. Students who viewed the tutorial were not able to understand the derivation of the trapezoid formula, and many understood only small parts of its contents. Tutorial students were not significantly faster at acheiving 80% efficiency. Two of the six tutorial students who acheived 80% efficiency remembered the concept on the post test compared to zero out of five for the non-tutorial group. The data reveal that the tutorial was not significantly effective in providing the students who viewed it an advantage in learning the concepts of area calculation for triangles and trapezoids. In other words, the tutorial was not significantly effective in teaching the skills which were required to master the area problems. This was likely due to several different factors previously discussed.

The tutorial did provide some students with skills or understandings that facilitated their progress and achievement on the practice. But overall it appeared to be a weak treatment unable to significantly improve practise acheivement.

6.4 Implications and Suggestions for Future Research

The information compiled in this study leaves the experimenter as a teacher of the hearing impaired interested in CAI, curious about the success of a program which would contain the recommended improvements in software made in this study. Would this type of software with its controlled syntax, more advanced diagnostic and remedial capabilities, and simpler yet detailed presentation be more educationally effective with hearing impaired students than the software used in this project.

Other areas for future information gathering should involve: (a) Research into the advantages of visual vs auditory reward strategies used in CAI with hearing impaired students. (b) How do hearing impaired students best learn from CAI? (c) What types of CAI teaching strategies work best with hearing impaired students? More research is required in areas involving the measurement of changes that occur due to microcomputer (CAI) applications, so that important factors which contribute to better software for hearing impaired students can be identified and programmed into software for the hearing impaired.

Computer Assisted Instruction will likely become a very effective tool for teachers of the deaf. It will be the teacher's responsibility to help educate software producing corporations, so that useful software can be developed to enhance the learning of hearing impaired students. Once an abundant supply of software suitable to the educational needs of hearing impaired students is developed, the computer area will hopefully become a very busy and productive corner of the teacher's classroom.

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Appendix A

Research Articles on CAI with the Deaf

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