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MathPlus ToolBox, a computer application for learning basic math skills

C. Gardner
Linn-Benton Community College
630 N.W. 7th Street
Corvallis, OR 97330
USA
541 757-8944
FAX: 541-757-9537
ckg@dots.physics.orst.edu

R. Lundquist
Oregon State University
Physics Department
Science Access Project
Corvallis, OR 97331-6507
FAX: 541-737-1683
randyl@dots.physics.orst.edu

Abstract

The MathPlus ToolBox, a computer application, has been designed through a collaborative effort of Carolyn Gardner and Randy Lundquist. The goal of the project was to improve accessibility to math for students with disabilities.

Though there are many computer products which are claim to help students learn math, many do not allow universal access. Often these products don't teach students the mathematical processes. The MathPlus ToolBox uses graphics, sound and captioning so that all students have access to the concepts being taught. There is a variety of tools to help a student learn and practice addition, subtraction, multiplication, division, and fractions.

Title of book. Name of Eds.
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Keywords

MATHPLUS TOOLBOX, LEARNING DISABILITIES, TOOLS, MATHEMATICS, COMPUTERS

1 INTRODUCTION

The MathPlusToolBox has been developed in cooperation by Dr. Randy Lundquist with the Oregon State University Science Access Project and Carolyn Gardner at Linn-Benton Community College. It is being developed because of the scarcity of mathematical materials available for students with disabilities. Computers often enable these students to have access to information that is otherwise not available. Though this computer application was developed to help students with disabilities, its universal design makes it appeal to all students learning math.

In this paper, some background will be given about the reasons why the MathPlusToolBox was developed. The tools included in the ToolBox will be described along with some of the reasoning that was behind the design. The development process will be explained along with a look at our plans for the future.

2 BACKGROUND

Persons with disabilities have traditionally been underrepresented in the fields of science, mathematics, engineering, and technology. The future needs of the nation's scientific workforce demand that no group be excluded from participation in education and training that lead to productive careers in the sciences. The National Science Foundation promotes the full inclusion and participation of persons with disabilities in academic studies leading to careers in science and engineering through its Program for Persons with Disabilities. (SRI, 1997) This division of National Science Foundation has funded the development of programs and technologies, and fostered ideas which have improved education for all students.

At this current time, it is especially important not to exclude any group of people from the technical work force. There are jobs which pay well in technology related fields. American companies are unable to find enough qualified people to fill their positions. People with disabilities are often shut out of this job market because of their inability to study mathematics.

One of the reasons that students with disabilities have not studied mathematics is the difficulty of preparing materials for them. This has been particularly true for students who are visually impaired and many students with learning disabilities. For the past several years Mrs. Gardner has been researching the uses of technology to teach mathematics to students with learning disabilities. (Gardner,

C., 1996) The Oregon State University Science Access Project is working on providing access to information for students with visual impairments. (Gardner, J., 1997) When the project presented several of its research projects at the international conference on Technology and Persons with Disabilities, Los Angeles in March 1997, one of these programs, Triangle, attracted many students, parents and educators who were looking for a computer program to do basic mathematics. The MathPlusToolBox should help fill that need.

3 BACKGROUND BEHIND THE DEVELOPMENT OF THE MATHPLUS TOOLBOX

At the beginning of this project, it was planned to use the sound capabilities of AsTeR (Raman, 1997) to provide access to science textbooks for students who had learning disabilities. This approach was abandoned because of the technological difficulties of combining AsTeR"s speaking capabilities with the visual image of mathematical text on the screen, and because the current mathematical textbooks are too highly dependent on graphical images to explain the concepts. The best approach seemed to be to develop a program which could use the computer capabilities to teach the same concepts being presented in textbooks.

Computers have appeal for students of all ages because it is more fun to practice using a computer. It is a nonthreatening environment where the students can easily check their progress and learn from their mistakes. This is particularly important for students with LD because they often need more practice in order to learn and remember a concept. Sound and speaking the text can be combined with visual images. Record keeping features and flexibility allowing a student to progress at his/her own rate can be built into the program. Educational software for mathematics has unfortunately, up to now, been mostly limited to game type programs or drill programs. Most of the sounds that are used are distracting rather than information giving. When well-designed computer-based and video-based instruction is provided on a daily basis, children with learning problems can develop declarative and procedural knowledge in basic math skill equivalent to that of their nondisabled peers. (Goldman, Mertz & Pellegrino, 1989)

Educators have known for years that understanding of mathematical concepts is crucial to long term mastery and use of mathematics. The new NCTM (National Council of Teachers of Mathematics) standards reflect this philosophy. There is a need for *all* students to learn to solve problems, reason, and learn on their own. (Goldman, Hasselbring, & the Cognition and Technology Group at Vanderbilt, 1997). This need for teaching for understanding was one of the crucial ideas behind the development of the MathPlusToolBox.

4 DESCRIPTION OF THE MATHPLUS TOOLBOX FEATURES

- The MathPlusToolBox uses graphics, sound and captioning so that all students have access to the concepts being taught. There are a variety of tools to help a student learn and practice basic math skills. The Toolbox will run on a Windows 95 machine with a SAPI compliant speech engine.

- The MathPlusToolBox has a universal design. One of the major problems with commercial math software is that it is inaccessible to many students. Students with visual impairments can't see the screen. Students with hearing impairments miss all the auditory information. Students with learning disabilities often get confused because they need both auditory and visual display without a lot of extraneous and distracting material.

- Audio is used in several ways. The speech engine reads the highlighted text in the script and in the message boxes, the buttons on the screens, and the problems. It also is used to explain actions being taken in the demonstration boxes. Sounds are also used as reinforcement. When the answer is correct, the sound is different from when the answer is incorrect. The user selects how much or how little auditory feedback he wants to hear.

- Captioning allows the hearing impaired to have access to all the spoken text.

- The screens are relatively uncluttered, and the format is consistent for easy navigation. The graphics are simple and the colors used are consistent throughout the various tools. For example the color green is used for the value of ten's column in the counting tool, and the same color is used for the tens' geometric figures in the demonstration of an addition problem.

- The type and difficulty of problems can be controlled by the user. Practice problems and flashcards can be controlled via the option's button. A script can be written to generate problems and control the sequence of a student's progress.

- Tools to aid authors in writing scripts are included as part of the ToolBox. From a pull down menu, teachers can insert script commands into the text. The text is easily accessible making changes possible within a short time frame.

- Graphics are used to support the development of mathematical

concepts. An example would be the use of the graphical demonstration of an addition problem. In a recent journal, the importance of showing the relationship between fractions and decimals was pointed out. To reach higher level understanding, it is important to include graphics and to have the student accustomed to thinking about understanding. (Stein & Smith, 1998) This concept is the basis for the development of the various tools in the MathPlusToolBox.

5 DESCRIPTION OF THE MATHPLUS TOOLBOX COMPONENTS

Counting Tool

- The counting tool looks like a bar graph with four columns divided into ten sections. Each column represents a number place, ones, tens, hundreds, and thousands. The appropriate number of sections is filled with different colors to match the number written above. A number can be changed by entering a different number in the number box above the graph or by using arrow buttons below the graph to increase or decrease the number of filled spaces and change the number value. The computer will read the entire number upon request.

- It is also possible for a student to see a computerized number line. The number line is used to demonstrate a math problem. When the student moves the number line marker, the problem and its solution change.

Flashcards

- The flashcards have a design similar to the commercially made cardboard product.

- It is possible to generate flashcards for addition, subtraction, multiplication, and division. The type of problem can be changed within the flashcard tool.

- Problems are generated randomly at the level selected. Two digit problems can be generated.

- Students answer in a quick left-to-right manner.

- If a student encounters a problem which is too difficult for them to do in his/her head, it is possible to go directly to one of the

work boxes to solve the problem.

- A score box keeps track of the number of problems completed, the number of problems correct, the number of problems missed, and the time elapsed.

- The problem is read for the student. If the answer is incorrect, the student gets the problem again. The correct answer is read.

Math Work Boxes

- There are work boxes for addition, subtraction, multiplication, division.

- These boxes allow a student to do complicated problems on the computer using sound and graphics as an aid for solving the problem.

- The cursor can be selected to move automatically to the correct space. If the answer is incorrect, the cursor doesn't move. Red numbers are used for carrying and borrowing.

- When the student has completed the problem, it can be checked immediately. If the answer is incorrect, the student is returned to the problem. If it is correct, the problem and the answer are read.

- Students have several options from the Work Boxes. A demonstration can be requested. This allows a student to see a working graphical representation of the problem. The computer will work the problem and show graphically how the solution is reached. Another option is for the computer to work the problem for the student. These options could be turned off in a testing situation.

Fraction Tools

- The fraction tools are just now being developed. The tools that are under development will help the student to better understand fractions in various ways. A simple fraction is written both in its fraction and decimal form as well as illustrated with graphics.

- Other tools help a student to understand equivalent fractions, factoring, and the addition of fractions.

Worksheet Generator

- Random addition, subtraction, multiplication, division, problems can be generated to be printed.

Calculator

- There is a talking calculator available.

Scripts

- Scripts can be used to teach concepts.
- The MathPlusToolBox components can be integrated into the script. Though the boxes are designed to help the student learn the concepts, the scripts allow more detailed explanations to be given when a student is learning a new concept.
- The type, level, and amount of problems can be controlled through the use of scripts.

6 EXPERIENCE WITH USE

Dr. Lundquist has been responsible for the programing, the design, and the implementation of voice into the ToolBox. Mrs. Gardner defined the educational concepts of the ToolBox and has made design suggestions from an educator's viewpoint. Several of her adult basic education students have used various components of the workbook. Changes to the program have been based on the input and discoveries made during its use. Several scripts have been written to help students with specific needs. Since, at this time, the MathPlusToolBox is under development, no official testing has yet been done. All students have found using the MathPlusToolBox to be an interesting way to work on math concepts which previously they found difficult to learn. Using the computer flashcards is less demeaning and more fun than using the old fashion cardboard ones. The graphics and the tools help all students to better understand mathematical concepts. The MathPlusToolBox seems to appeal to all age and ability groups.

7 FUTURE PLANS

The work on the MathPlusToolBox has just begun. It will become an even more powerful tool as it evolves. More tools for teaching and working with fractions, and tools for teaching decimals, and percents will be developed. Word problems

will be included. As the MathPlusToolBox is being used, feedback from students and teachers will be incorporated into the product. There is a need to integrate a braille display or tactile pad so that demonstrations have more meaning for students who are visually impaired.

8 ACKNOWLEDGEMENTS

This project was funded in part by the National Science Foundation grant HRD - 9554453 (CG) and grant HRD - 9452881 (RL).

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10 BIOGRAPHY

For the past five years, Carolyn Gardner has been researching the uses of technology for students with learning disabilities. She has presented at several conferences and written several papers on this subject. For the past twelve years, she has taught adult basic education at Linn-Benton Community College.

After receiving his PhD in 1993, Randy Lundquist joined the Science Access Project at Oregon State University. He is the author of Triangle, a computer program that permits blind people to read, write, and manipulate scientific information.