Opening the Doors to Learning: Technology Research for Students with Learning Disabilities (Math Skills)

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The Office of Special Education Programs (OSEP) has primary responsibility for administering programs and projects relating to the free appropriate public education of all children, youth and adults with disabilities, from birth through age 21. For nearly a decade, through its Technology, Development, Demonstration, and Utilization Program, OSEP) has been developing learning tools and instructional practices that help engage the minds and foster the independence of individuals with physical, sensory, intellectual and emotional disabilities. The Technology Program supports research, development, and dissemination activities that advance the availability, quality, use, and effectiveness of tools in educating children and youth with disabilities. Teachers, parents and administrators will be able to use these materials to incorporate research-based practices and technological tools in the classroom to help students with learning disabilities. The video features positive examples of how students and teachers can benefit for the use of technology in their classrooms. The accompanying text offers in-depth information about the technology applications shown in the video.

Accessing challenging math curriculum

Mike's story

Mike Lamoureax is a fifteen-year-old student in a suburban high school outside of Seattle. Since elementary school, Mike has had difficulty mastering basic math facts. He has been unable to concentrate during rote learning exercises involving math computation, and has complained that he finds little application for the skills in real life. During math instruction, he understands best when given multiple representations of symbols and data.

When students reach middle school, teachers and families must make a decision about what is worth knowing and being able to do in math. Like many youngsters with similar skill deficits, Mike has not been exposed to challenging math curriculum, particularly using math to solve real-world problems. Math problem-solving requires conceptual understanding of the data to be analyzed, and the ability to complete calculations--two skills that Mike has not mastered. Yet, even if teachers can motivate students to do drill and practice of basic math facts, it is important to ask if that is the best use of students' time--especially since tools, such as calculators, can replace the need for low level computation. With appropriate support, researcher John Woodward, a professor at the University of Puget Sound, has shown that Mike, and students like him, can be taught to think mathematically and use math to analyze problems.

To ensure access to the curriculum, Woodward has developed a technology application as part of his *Tools for Understanding* program that helps students--particularly those with learning disabilities--understand abstract math concepts and apply them to real-world problem-solving situations. He does this by using commercially available spreadsheet software integrated into math problem-solving lessons to accommodate students' individual learning needs.

Spreadsheets free students, who have difficulty with math, to keep asking questions, to continue analyzing the visual representations of the data, and eventually to use their higher level thinking skills to formulate conclusions. For example, consider this problem: What would happen if a local fast-food chain added just a couple of fries to each package? All of the students agreed that this would make very little difference overall. However, the teacher helped them analyze the problem in greater depth by modeling it on a spreadsheet. If there were 75 fries in each package, the students found that the implications were enormous. Adding just three French fries to a package meant that the fast food chain would be giving away every sixteenth package of fries for free. At $1.09 per basket, their spreadsheet model indicated that this could be as much as a $25,000 loss in revenues per day, nationwide.

As a result of using *Tools for Understanding*, Mike has finally begun to understand and build on the important math skills he will need later in life, and has even taken an interest in math as a subject. The innovative application of this technology tool has provided Mike, and other students with similar needs, with a concrete way of analyzing and manipulating abstract concepts in ways that are understandable and interesting. Mike now speaks proudly of the math skills he has learned and the advances he has made in the past few years.

Features of the technology

Tools for Understanding incorporates standard computer spreadsheet software into classroom instruction. Spreadsheets can be used strategically to connect the visual and the symbolic. For example, students can apply elements of color and manipulate types of presentation format spreadsheets as an aide to visualizing principles of multiplication, division, fractions, percents, and decimals.

Spreadsheets have an advantage of engaging students immediately because they have a game-like quality and are more novel than traditional schoolwork. Spreadsheets organize data--especially problems with multiple steps--naturally without overwhelming youngsters, and thus, can encourage students to handle complex problems. In spreadsheets, all pieces of a complex problem are kept intact--a real plus for students with cognitive learning difficulties. Further, spreadsheets allow teachers to expand the lesson by adding "what if?" problems (e.g., If nine more people come to our party, how many more brownies do we need to make?) which supports students in using higher level thinking skills.

In the service of helping students master problem-solving skills, spreadsheets can model or provide a visual representation of the problem and crunch the calculations. Standard computer spreadsheets can be used to help students understand concepts such as factors and least common multiples; they can create color-coded diagrams and tables that help students understand the meaning behind otherwise incomprehensible math computations. With spreadsheet applications, students, like Mike, who are turned off by tedious calculations and who need multiple representations of data, can now focus their attention on understanding the mathematical operations.

Spreadsheet software is readily available. For many teachers, the issue becomes one of securing the hardware to run it. Even with only one computer in the classroom, Woodward has found that teachers can still use the approach. His solution is an LCD panel connected to a computer and overhead projector. Teachers plan their lessons to be delivered with the entire group. During instruction, students analyze the data and ask questions of it. As each question is posed, the teacher asks the spreadsheet to present the data. Eventually, students will analyze their findings and solve the problem.

Rationale: Using technology to support effective instruction

Students with learning disabilities often struggle with mathematics for a number of reasons. They typically lack the persistence necessary to memorize discreet pieces of information such as multiplication tables. In addition, they have difficulty understanding how abstract mathematical concepts or memorized facts can be applied to everyday situations. As a result, these students often feel like information is being drilled into their heads with little appreciation for how the information can be useful.

Tools for Understanding addresses these difficulties by providing students with a spreadsheet tool that helps them visualize and manipulate math concepts. Spreadsheets make all calculations, so that even students who lack basic skills can be taught to think analytically. The effective instructional practices of anchoring problem-solving instruction in a context familiar to learners and providing ample opportunity for visualization of concepts are core to this approach.

Anchoring instruction. Students need a context for learning higher level concepts to help them link old and new knowledge. When students see the direct connection between something that they have familiarity with and the new concept to be learned, they tend to learn more efficiently. Woodward recommends that teachers develop math problems that relate directly to students' lives. For example, students might be asked to decide how many pieces of each kind of pizza each student would get at a class party. Cost could be manipulated in relation to type of pizza and number of pieces each student received. Or, students might be asked to survey people on their favorite music (e.g., heavy metal, jazz, rap, classical, country). They enter their data into a spreadsheet and analyze results in terms of proportions (e.g., decimals and percentages) to increase their understanding of these concepts.

Anchoring instruction can have an added benefit in that it is often a motivator for students. Students need to see the rationale for learning something--they need to see how they can use these new skills to better their own lives.

Visualization. Particularly useful to students with learning disabilities when learning mathematical concepts is being able to visualize and manipulate otherwise abstract ideas. Visualization is a strategy that helps students link old and new knowledge. For example, representing the equation 7 X 3 = 21 as a set of blocks--three blocks wide and seven high--or as groups of objects--seven groups of three--helps these students understand the underlying arithmetic principles much more than rote learning of multiplication tables.

Tools for Understanding allows for a high level of visualization and manipulation through the spreadsheet software. Students can create color-coded boxes to represent fractions, decimals, or percents; manipulate the boxes to understand the effects of certain changes; and compare one set of boxes with another set to understand how they relate or differ. For example, the video shows students creating colored squares and rectangles on spreadsheets that appear on the computer screen. Creating and manipulating these shapes help students recognize principles of multiplication and division and provide them with visual and dynamic representations of abstract mathematical concepts.

Making it work in the classroom: Suggestions from Cindy Bush, Mike's teacher

Cindy Bush teaches high school math to students who are low achieving. Her students exhibit a variety of problems, including heavy emotional interference with high intellectual ability, limited memory for math, and low motivation to complete math work.

According to Bush, it is important to start with a knowledge of spreadsheets--otherwise, teachers will not be able to take full advantage of the technology. For the next step, Bush selected problems from her math series, *Connected Math*. She stresses

that not all problems lend themselves to spreadsheet application and so it is important to identify only those which do. Problems involving multiple steps are always good choices, because they typically require students to manipulate complex data--something that computers do well and with which students with disabilities have difficulty.

For Bush, classroom management is a major concern when using spreadsheets to teach math. After large group instruction, Bush expects students to pursue their own inquiry and analysis of data. Because she must rely on a computer lab where time is limited, students must do considerable preparation so that they can maximize their time on the computer.

To assist students in preparing for the computer lab, initially Bush gave students grid paper and labeled it like a spread sheet. She directly taught students why grids were fundamental to spreadsheets and how to set one up. As she modeled the process on the classroom computer (aided by an LCD panel and overhead projector), students practiced on their templates. Bush used a similar instructional approach when teaching students how to input formulas into the computer. First Bush wrote the formula on a transparent master sheet. After her demonstration, students practiced the step.

Once in the lab, Bush found that students needed additional help organizing and keeping track of their files. To compensate, Bush assigned a file name to each assignment, to avoid the probability of assigning the same name to different files. A master key was printed in a notebook, to which students had access.

The printer turned out to be one of the greatest distractions for Bush's students. Therefore, Bush found that she needed to structure this task for her students. She found the best way to solve this problem was to print off one "key" copy of the assignment. Bush used the key to monitor students' work as she circulated throughout the class while students were working.

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