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ABSTRACT

The first in a series of guides on the inclusive classroom that offers teachers research-based instructional strategies with real-life examples from Northwest classrooms, this publication focuses on the educational needs of students with learning disabilities in inclusive classrooms. It highlights methods for teaching mathematics and science, and suggests ways to foster collaborative relationships with special education teachers and families of students with learning disabilities. These strategies are drawn from key principles in standards-based reform, inclusion, special education, and multicultural education. Specific sections address: (1) the definition of a learning disability; (2) inclusion and education reform; (3) cultural diversity and the inclusive classroom; and the use of cooperative learning, peer tutors, assessment, special education teachers, and family involvement; (4) science instructional strategies, including inquiry-based science, structured inquiry, vocabulary acquisition, and mnemonics; (5) structured inquiry in an inclusive classroom; (6) mathematics instructional strategies, including problem solving by working backward, simplifying and reducing, recognizing patterns, drawing and modeling, making tables or graphs, acting it out, simulating, and using calculators and computers; and (7) textbook adaptations, including using study guides, graphic organizers, and computerized information organizers. A list of resource organizations is included. (Contains 59 references.) (CR)

The Inclusive Classroom

Mathematics and Science Instruction for Students With Learning Disabilities

IT'S JUST GOOD TEACHING

Northwest Regional Educational Laboratory

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Mathematics and Science Instruction for Students With Learning Disabilities

IT'S JUST GOOD TEACHING

By Denise Jarrett
Mathematics and Science Education Center

March 1999

Northwest Regional Educational Laboratory

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Preface

THE 1998 REAUTHORIZATION OF THE INDIVIDUALS WITH Disabilities Education Act (IDEA) reaffirmed the practice of including students with disabilities in general education classrooms. Increasingly, teachers are seeking multiple strategies to help students of widely varying abilities learn important concepts and skills in mathematics and science.

Students with learning disabilities, like all young people bound for adulthood, need problem-solving and reasoning skills, as well as knowledge of key mathematics and science concepts. Because their disabilities often affect their language or mathematical performance, these students typically benefit from individualized learning supports. In science, for example, students with learning disabilities may need structured inquiry experiences in which the teacher supplies the question and procedures to be followed, but students draw their own conclusions and communicate their reasoning. In mathematics, students might need explicit instruction in methods of solving problems, such as working a problem backward or drawing a model of a mathematical relationship. These and other strategies are highlighted in this publication to help the general education teacher meet the individual needs of students with learning disabilities.

The Inclusive Classroom: Mathematics and Science Instruction for Students with Learning Disabilities is part of the Northwest Regional Educational Laboratory's series, It's Just Good Teaching. This series of publications and videos offers teachers research-based instructional strategies with real-life examples from Northwest classrooms. This is the first of three new publications in the series to address the diverse needs of specific groups of students in inclusive classrooms: students with learning disabilities, gifted students, and students who are English-language learners.

We hope readers will find this publication useful in their efforts to provide all students with high-quality mathematics and science learning experiences.

Kit Peixotto
Director
Mathematics and Science Education Center

Introduction

THIRTY YOUNG SOULS ASSEMBLED IN A CLASSROOM, EACH with his and her own life experiences and ways of learning. Some students have learning gifts or disabilities. Others have physical differences in mobility, hearing, or speaking. In Northwest schools, some students might speak Spanish, Russian, or Japanese. Others might speak Filipino, Korean, or Yup'ik. In the midst of this diverse assemblage, the general education teacher is both privileged and challenged. Her students enrich the learning environment with their knowledge of other languages and cultures and various ways of demonstrating understanding and creativity. They also challenge her to use instructional strategies that respect and address students' differences while helping all of them to learn important concepts and skills in the core curriculum.

> "INCLUSION IS A WAY OF LIFE, A WAY OF LIVING TOGETHER, BASED ON A BELIEF THAT EACH INDIVIDUAL IS VALUED AND DOES BELONG."
>
> —"What is an inclusive school?" (Falvey, Givner, & Kimm, 1995)

This publication focuses on the educational needs of students with learning disabilities in inclusive classrooms. It highlights research-based teaching strategies and suggests ways to foster collaborative relationships with special education teachers and families of students with learning disabilities. These strategies are drawn from key principles in standards-based reform, inclusion, special education, and multicultural education. Together, these principles can empower a teacher to respond effectively to the particular learning needs of today's students.

What is a Learning Disability?

Learning disabilities are by far the most common disability among school-age children—more than half of students with disabilities are learning disabled. About one-third of all secondary mathematics and science classes—and half of all primary grade classes—include students with learning disabilities (National Science Foundation, 1996). Generally, students with learning disabilities have difficulties in listening, speaking, reading, writing, reasoning, or mathematics. They also often have trouble sustaining attention to task; remembering procedures, deadlines, and verbal information; and applying organizational skills (Mastropieri & Scruggs, 1993).

In mathematics and science, students with learning disabilities frequently have difficulty with computation, problem solving, terminology, making inferences, and integrating new and prior knowledge. Memory, motor, and attention deficits are also common and impact students' mathematics and science achievement (Miller & Mercer, 1998; Scruggs & Mastropieri, 1994). Finally, many students have had a frustrating history of school failure, and they struggle with low self-esteem (Mastropieri & Scruggs, 1993).

Like all young people, students with learning disabilities are varied and complex individuals. While they may have learning difficulties in certain areas, such as in language or organizational skills, they may be gifted in other domains, such as in art or performance. These students' talents or intellectual gifts are often overshadowed by their weaknesses. Many times, they are first noticed for what they cannot do, rather than for the specific talent they may have (Baum, 1990). Thus, teachers will want to identify and support students' strengths and interests as well as address their disabilities.

"[Students] require an environment that will nurture their gifts, attend to the learning disability and provide the emotional support to deal with their inconsistent abilities," writes Susan Baum (1990).

When a teacher recognizes and supports the intellectual and personal strengths of a student with a learning disability, he will likely raise that child's self-confidence and heighten her determination to persevere (Baum, 1990). Working with these students can be a particularly rewarding experience, says Suzanne Moe, science teacher at North Eugene High School in Oregon.

"They think of things in a different way, they're more creative," she says. "A lot of students who get high grades go down a straight and narrow track. They want to know, 'What do I need to do to get my A?' Kids with learning disabilities like to get off the beaten track. And they can surprise you with what they really know."

Jimmy, for instance, was a ninth-grader who hung out with a group of "scallywags," recalls Moe. "This little kid didn't do well on tests, didn't do a lot of work in class. But one week, I invited a guy from the local planetarium to come in and make several presentations with his portable planetarium. At the end of the week, I asked the students to write down all of the things they had learned from the presentations. Well, the high-ability students immediately asked, 'How many do we have to have to get an A?' I said, 'Oh, about 100.'

"The next day, Jimmy came back with a list of 300 facts that he had learned! He was so excited. This kid never passed a test before that, but because it was all generated from him, he was able to show me that he

was learning and that he was interested in the topic. The kids are learning a lot, often times much more than we can assess, and much more than even *we* realize they are learning."

Inclusion and Education Reform

Since 1975, when Congress passed the Education of the Handicapped Act (now called the Individuals with Disabilities Education Act, or IDEA), the law has mandated that disabled students be placed in the "least restrictive" educational environment in which they can learn successfully (Thornton & Bley, 1994). Increasingly, this is interpreted to mean the general education classroom. Until recently, students with learning disabilities were typically "pulled out" of the regular classroom for a better part of each day to receive special instruction in mathematics, reading, and other core subjects. However, today's movement toward full inclusion means that students are increasingly remaining in the regular classroom for most if not all of the day (Winzer, 1993). They receive the bulk of their instruction from the general education teacher with periodic assistance from a special education teacher or aide who visits the classroom at intervals. The general education teacher is responsible for ensuring that students with learning disabilities learn the same core content and concepts as all other students in the class.

Today's standards reform and inclusion movements mean that expectations for all students have risen sharply. In the last decade, educational and professional organizations in mathematics and science have identified higher standards for students, and they emphasize teaching strategies that place students in a more active and self-directed role in their own learning. These organizations urge more connections within and between disciplines, as well as links to students' life experiences. They promote greater use of calculators and computer-based tools such as spreadsheets and graphing programs. These standards also call for earlier instruction in advanced subjects, such as algebra, geometry, chemistry, and physics (National Council of Teachers of Mathematics [NCTM], 1989; American Association for the Advancement of Science [AAAS], 1990; National Research Council [NRC], 1995).

The influence of these recommendations has been significant. Many states now require high school seniors to pass minimum competency exams before they can graduate. Increasingly, students are required to take more mathematics and science classes, including higher-level courses. Newer textbooks often require a higher level of reading ability and place a greater emphasis on problem solving (Miller & Mercer, 1998). At the same time, the inclusion movement not only places students with learning disabilities in the general education classroom but also demands that they are engaged in a meaningful way in the same curriculum and activities as their classmates. These higher expectations have significant implications for students with learning disabilities.

Some educators and parents are wary of aspects of the new standards and inclusion practices, which they see as potentially placing higher expectations on students without providing necessary support (Goldman, Hasselbring, & The Cognition and Technology Group at Vanderbilt, 1998; Jorgensen, 1997; Scruggs & Mastropieri, 1994). Nevertheless, many others, including special education experts, do embrace standards-based teaching methods, such as inquiry and problem solving (Goldman et al., 1998). Most, however, recommend that these strategies be modified for students with learning disabilities, by providing students with explicit instruction, structured activities, and practice in basic skills, such as vocabulary acquisition and problem-solving procedures. Indeed, early research into the efficacy of standards-based teaching methods for students with learning disabilities indicates that students can benefit from activities-based and hands-on learning, as well as from mathematical reasoning and problem-solving experiences (Goldman et al., 1998; Mastropieri & Scruggs, 1993; Miller & Mercer, 1998; Scruggs & Mastropieri, 1994; Winzer, 1993).

Cultural Diversity and the Inclusive Classroom

STUDENTS LEARN BEST IN CHALLENGING ENVIRONMENTS IN which individual differences are respected and supported (Baum, 1990). The principles of inclusion, multiculturalism, and special education can be powerful coagents, creating environments in which each child can flourish. These principles focus on identifying and responding to the individual learning needs of young people; ensuring that all students learn important concepts and skills in the core academic content; and conducting equitable and authentic assessments of students' knowledge.

> "THE MOST CONCRETE FORM OF THE LINK BETWEEN MULTICULTURAL EDUCATION AND SPECIAL EDUCATION IS SEEN IN INCLUSIVE SCHOOLING."
>
> —*Special Education in Multicultural Contexts* (Winzer & Mazurek, 1998)

Nationally, about one-third of students in special education are from culturally diverse backgrounds, particularly African American, Native American, and Hispanic children. There is concern among educators and parents that children from these and other groups may be overrepresented in special education—their cultural or language differences being mislabeled as learning deficits (Artiles & Zamora-Duran, 1997; Downs, Matthew, & McKinney, 1994; Winzer & Mazurek, 1998). Teachers must be aware of this issue when considering whether to refer a child for special education. For all students—including those children who are currently in a special education program—teachers need to understand their cultural and language differences as well as their learning differences. When teachers are aware of the roles culture and language play in the learning styles and needs of students, they will likely perceive students' abilities and disabilities more accurately and respond more effectively.

Classroom Arrangement

The physical arrangement of the classroom can influence the learning environment. Teachers will want to be sure that students with learning disabilities are seated in ways that do not distance them from the teacher or the primary locus of learning (for example, make sure that students with learning disabilities don't all sit in the back of the room while high-ability students sit in the front or closest to the teacher). Though group-ing students of similar abilities together can be appropriate to achieve some learning goals, students should frequently be paired or grouped with students of mixed abilities. Also, students with learning disabilities should share in meaningful tasks and take their turn at leadership roles (Winzer & Mazurek, 1998).

Cooperative Learning

According to the writers of *Special Education in Multicultural Contexts* (Winzer & Mazurek, 1998), cooperative learning is a cornerstone of inclusive education because it can accommodate students' varied skill abilities. Each student can complete a necessary task that calls on his or her particular talent, skill, or learning style, while contributing to the success of the group (though, over time, it is important for students to function in various roles that not only call on their natural abilities but also help them to develop additional skills). For students whose home culture involves working closely with other family members, cooperative learning can be an effective classroom practice. For example, many Native American, Alaska Native, African American, Asian, and Hispanic young people often respond well in small, cooperative-learning situations (Winzer & Mazurek, 1998), especially when tasks focus on whole concepts, or big ideas, in culturally relevant contexts (Oakes, 1990).

The effectiveness of cooperative learning in mathematics and science is well established by research (Secada, 1992; Pressley & McCormick, 1995; Tobin, Tippins, & Gallard, 1994). When coupled with high expectations, cooperative learning can improve students' academic achievement and help them to develop greater self-confidence, more cross-cultural understanding, and enhanced social skills (Kober, 1991). In mathematics, students often improve their problem-solving abilities and solve more abstract mathematical problems when studying cooperatively (Leikin & Zaslavsky, 1999; Pressley & McCormick, 1995). In science, cooperative learning tends to raise the level of discourse. Students gain skills in clarifying, defending, elaborating, evaluating, and arguing with one another about concepts and scientific methods (Tobin et al., 1994).

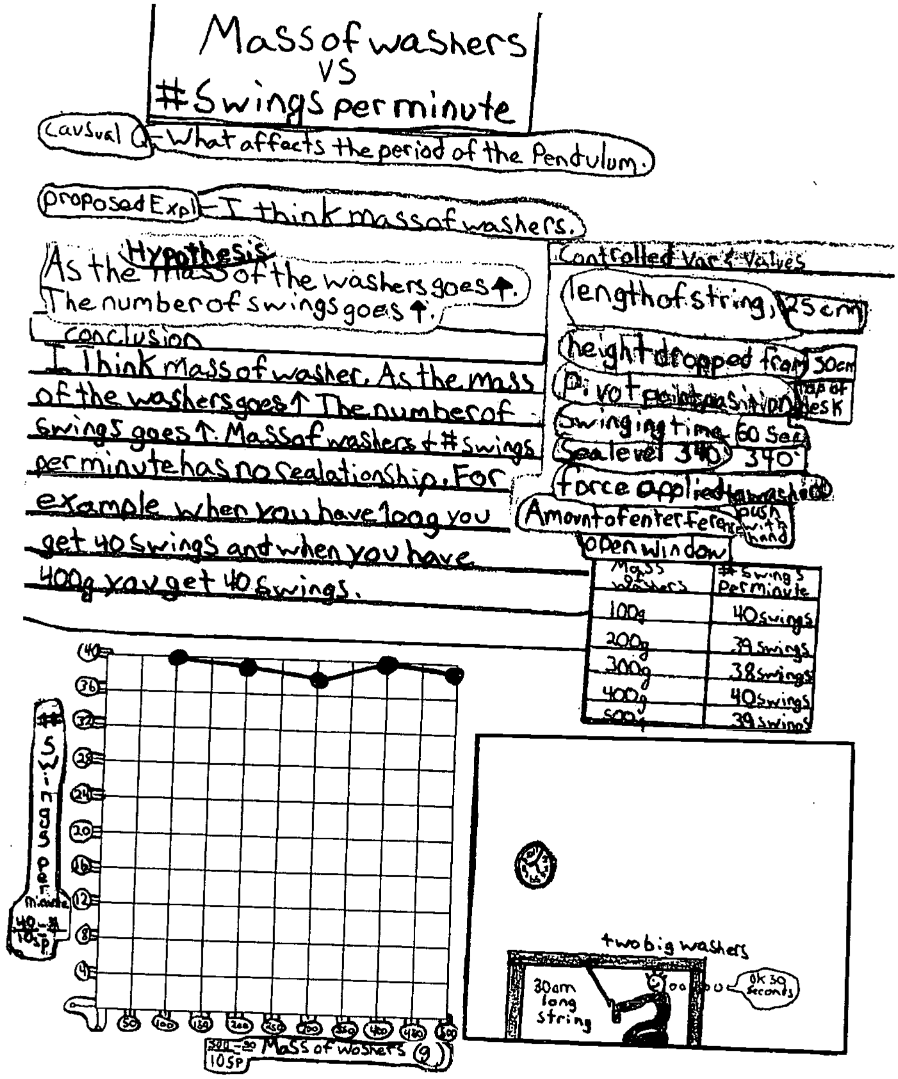
"Students with learning disabilities should be full participants in a cooperative group, bringing their unique experiences and strengths to the team," says Jolene Hinrichsen, science associate for the Northwest Regional Educational Laboratory (NWREL) in Portland, Oregon. "Often, a weakness in mathematical reasoning is counterbalanced with a strength in spatial or interpersonal intelligences. Respect for diverse intelligences must be apparent to all persons in a classroom if students with disabilities are to be given support to succeed."

Hinrichsen recalls a former student who demonstrated a "hidden" talent when the opportunity arose: "Michael, an eighth-grader who was following a severely modified program for written language, became the outspoken expert when the science lab moved into the field. His personal interest in and love of nature made him a keen observer capable of describing relationships other kids missed."

There are many models for cooperative learning. One strategy that can be effective in the inclusive classroom is the **jigsaw** model. Each member of a group takes responsibility for mastering a portion of the material to be learned and teaches the other members of the group. Mastropieri and Scruggs (1993) also point to the **FOSS** (Full Option Science System) model for science activities involving students with mixed abilities. This cooperative-learning model, developed at the Lawrence Hall of Science at the University of California, Berkeley, involves four students working together and taking turns with different roles to complete particular science activities. In the FOSS model, one student is the **reader** who reads all print instructions; one student is the **recorder** who records data, observations, predictions, and estimations; one student is the **getter** who assembles all of the necessary materials; and one student is the **starter** who oversees manipulations of the materials and ensures that all members have equal opportunity at using the hands-on materials.

Peer Tutors

Mastropieri and Scruggs (1993) also suggest that peer tutors can be helpful for students with learning disabilities. In peer tutoring, a student with a learning disability is paired with a student who does not have a learning disability. Typically, the student without disabilities will function as tutor, helping the tutee with tasks which require additional practice. Teachers will want to ensure that tutors understand their role and responsibilities, and understand the task to be used during tutoring. Teachers should demonstrate effective interpersonal skills, including how to provide corrective feedback. Learning objectives for the tutoring session should be clearly specified, and a formative assessment component can be put in place to monitor the student's progress. Peer tutoring



This drawing is by an eighth-grade boy who was following a program modified for mathematics. It was kept in the boy's portfolio and helped the teacher to identify where he needed additional guidance. As the report indicates, the student worked through his hypothesis regarding a variable that might affect the period of a pendulum. Through his written descriptions and tables, his teacher could see the boy's reluctance to let go of his initial hypothesis and trust his data to say something different. Later, she saw in his conclusion that the boy matched the evidence with a new and consistent hypothesis.

typically benefits the tutor as well as the tutee. Research indicates that giving help to others is related to improvement in achievement (Winzer & Mazurek, 1998).

Assessment

Teachers will want to monitor and assess students' progress throughout instruction, not just at the end of a unit. According to the NWREL publication, *Assessment Strategies to Inform Science and Mathematics Instruction* (Stepanek & Jarrett, 1997), formative assessments, which occur prior to, during, and after instruction, are especially critical in the inclusive classroom. Formative assessments enable diverse learners to show their knowledge in various ways, for example, by writing, demonstrating, modeling, or by representing their ideas orally or graphically. This provides teachers with valuable insight into students' prior knowledge, academic progress, and thinking processes. Formative assessments also document the effectiveness of the curriculum and instructional strategies. Thus, teachers can use formative assessments to inform their future classroom practices (Jorgensen, 1997; Montague, 1997).

As the illustration on page 9 shows, **portfolio assessments** can provide an overall picture of a student's learning, reflecting his or her conceptual understanding, problem solving, reasoning abilities, and communication skills (Stepanek & Jarrett, 1997). They also facilitate student self-evaluation and goal setting. In the process of deciding what to include in portfolios, teachers will reflect on curricular and instructional issues that influence their practice: What is valuable for students to learn? What activities are most worthwhile?

Students can also demonstrate their reasoning by drawing **concept maps**. Students place their ideas in a diagram and link them by lines and words that indicate relationships between concepts. This helps students to organize and represent concepts in a personally meaningful way, while providing an opportunity for students and teachers to exchange ideas about the validity of links or links that are missing. Concept maps also help teachers to identify and address students' misconceptions and to identify areas for new learning (Stepanek & Jarrett, 1997; Tippins & Dana, 1993).

Performance assessments also provide teachers with insight into students' reasoning and thinking processes. These assessments focus on the process of solving problems or completing complex tasks, emphasizing what students can do, not just what they know. Performance assessments allow students to show how they reach their solutions, explain their answers, and demonstrate their ability to synthesize information. In performance assessment, teachers typically observe students as they work, interview students about their work, and examine products that students have produced. Paper-and-pencil tasks that require students to show their work or describe their procedures will also give teachers insights into students' problem-solving strategies (Spinelli, 1998; Stepanek & Jarrett, 1997).

Rubrics also can be used to assess the achievement of students with learning disabilities. A rubric, such as the one shown on page 11, is a guide teachers can follow when scoring assessments or activities. Rubrics are standards against which a student's work is compared and judged. There are two types of rubrics, analytic and holistic. Holistic rubrics focus on the total performance or final product rather than the individual steps taken to arrive at the final product. Therefore, analytic rubrics may be most appropriate for use with students with learning disabilities because they are more process oriented. With analytic rubrics, students with learning disabilities can receive credit for the process skills required

Strategies and Reasoning

Emerging	Developing	Proficient	Exemplary
1. Your strategy was not appropriate for the problem. 2. You didn't seem to know where to begin. 3. Your reasoning did not support your work. 4. There was no apparent relation between your representations and the task. 5. There was no apparent logic to your solution. 6. Your approach to the problem would not lead to a correct solution.	1. You used an oversimplified approach to the problem. 2. You offered little or no explanation of your strategies. 3. Some of your representations accurately depicted aspects of the problem. 4. You sometimes made leaps in your logic that were hard to follow. 5. Your process lead to a partially complete solution.	1. You chose an appropriate, efficient strategy for solving the problem. 2. You justified each step of your work. 3. Your representation(s) fit the task. 4. The logic of your solution was apparent. 5. Your process would lead to a complete, correct solution of the problem.	1. You chose an innovative or unusual and insightful strategy for solving the problem. 2. You *proved* that your solution was correct and that your approach was valid. 3. You provided examples and/or counterexamples to support your solution. 4. You used a sophisticated approach to solve the problem.

to complete the task rather than being scored only on the final product (Finson & Ormsbee, 1998).

Special Education Teachers

Eileen Houser is a special education teacher at River Mill Elementary in Estacada, Oregon. She suggests that frequent collaboration between the special education teacher and the general education teacher often results in a rewarding professional relationship that benefits teachers as well as students. The special education teacher can support the efforts of the general education teacher by briefing him on students' developing histories, students' academic strengths and weaknesses, and education plans that have been most successful. The special education teacher can help brainstorm curriculum ideas or modify an assignment for an individual student. She can provide appropriate materials, teach part of a lesson, and arrange for additional support in the classroom or in a separate location.

Family Involvement

Teachers and families need to be united in their efforts to assist children in developing to their fullest. Teachers can foster collaborative relationships with families by being aware of the challenges families face and how these challenges impact parents' involvement in their children's

This portion of a mathematical problem-solving scoring guide, or rubric, developed by the Northwest Regional Educational Laboratory's Mathematics and Science Education Center, illustrates how rubrics can help teachers to assess student understanding and process skills. This example illustrating the problem-solving trait, "Strategies and Reasoning," is one trait out of five presented in the rubric; the other problem solving traits are conceptual understanding, computation and execution, insights, and communication. The scoring guide is available online (www.nwrel.org/msec/mpm/index.html).

education. For example, some parents of students with learning disabilities share their child's disability and may have had negative experiences in school that make them reluctant to talk to school officials. The stress of personal circumstances can thwart parents' desire to be active in their child's education. Illness, single parenthood, poverty, or "the sheer mental and physical exhaustion that many parents deal with on a daily basis" impact parent involvement (Spinelli, 1998).

Teachers will want to establish trust and respect with families early in the school year by contacting parents and asking them about their child's academic, social, and emotional needs. Teachers can explain the learning goals and objectives for the upcoming school year. They can encourage parents to contact the school whenever they want to discuss something. Parents need to know that the teacher welcomes their child into the class, and that she sees their child's capabilities and strengths rather than only his or her weaknesses (Spinelli, 1998).

Parents as well as other significant family members or support persons should be invited to meetings. Some families have an extended family network whose members may play an important role in the child's development. These individuals may help parents to retain key information from school meetings when parents are feeling overwhelmed and may play a key role in implementing intervention strategies (Spinelli, 1998).

Cultural responsiveness begins with careful listening and personal reflection, note the writers of, "Creating Conversation: Reflections on Cultural Sensitivity in Family Interviewing" (Dennis & Giangreco, 1996). An essential element of being responsive to cultural differences is appreciating the environment in which people live. Knowing this can help teachers to understand what the family's priorities are for the child, not only in education but in community involvement, and in social, recreational, and vocational pursuits.

Below are some suggestions proposed by Dennis and Giangreco (1996) for communicating effectively with families from diverse backgrounds:

- Recognize that being responsive to cultural differences is an essential aspect of meeting the needs of students with learning disabilities
- Appreciate the uniqueness in each student and his or her family
- Be aware of how families may perceive your role as an authority figure
- Acknowledge your own cultural biases
- Seek new understandings and knowledge of cultures
- Be open to different belief systems

- Remember that culture is not static and many variables can have an influence on a family, such as social class, education, and geographic region

- Consult with the special education teacher, who can provide valuable insight into the child's background and home environment

Students, too, should be involved in the collaborative process. They can be encouraged to participate in the planning of their individualized education program, to ask questions, to contribute to their own goals and objectives, and to share their concerns and feelings about their future. Students who are involved in the decisionmaking about their own education are more likely to commit to the plan. Students also learn how to advocate for themselves, an essential life skill.

Science Instructional Strategies

ORGANIZING CURRICULUM AND INSTRUCTION AROUND BIG ideas and interdisciplinary themes can facilitate the science achievement of students with learning disabilities. Big ideas are important concepts or principles that help students to organize, connect, and apply component facts and ideas. When students learn scientific facts, ideas, and processes as part of an overarching theme, or big idea, they are more likely to see meaningful relationships between science and other disciplines, as well as with their own lives (Salend, 1998).

Interdisciplinary themes can link various science disciplines—such as biology, chemistry, earth science, and physics—or relate science to other subject areas, such as mathematics, English, social studies, and art. When selecting themes around which to organize instruction, teachers will want to consider several factors: the alignment of curriculum to content standards; the relevance of the themes to students' lives; whether the themes will provide sufficient opportunities to teach fundamental and higher-level content and skills; the length of time it will take to complete the unit; and availability of materials and resources (Salend, 1998).

"ALL STUDENTS WITH DISABILITIES DO HAVE POTENTIAL IN SCIENCE."

—*Blueprints for Reform* (American Association for the Advancement of Science, 1998)

The design of theme-based science lessons should not only integrate key unifying concepts from multiple disciplines, but should also involve various teaching strategies such as direct instruction, inquiry-based activities, and performance assessment opportunities. Interdisciplinary thematic units should culminate with students completing a presentation that allows them to summarize and show what they have learned (Salend, 1998). This variety in instructional techniques will create multiple opportunities for diverse learners to learn and demonstrate their knowledge.

Inquiry-Based Science

Inquiry-based teaching practices can provide an effective strategy for thematic learning. The active and self-directed nature of inquiry learning allows students to make personally meaningful connections between themes and disciplines. Some teachers worry that students with learning disabilities will not have the reasoning ability or prior knowledge necessary to learn effectively in an inquiry-based environment, say Scruggs and Mastropieri (1994). They found that some students with learning disabilities do have difficulty sorting and classifying, making predictions and inferences based on prior knowledge, and drawing conclusions. However, they found that these students were stronger at observing and describing scientific phenomena. Additional research indicates that students with learning disabilities can benefit from activities-based and hands-on science instruction (Dalton, Morocco, Tivnan, & Mead, 1997; Scruggs & Mastropieri, 1994; Mastropieri & Scruggs, 1992, 1993). Supported inquiry-based teaching provides students with concrete learning experiences in a structured environment, increasing the meaningfulness of the information being learned while reducing language and literacy demands (Dalton et al., 1997).

What is Inquiry?

In an inquiry-based classroom, students are active participants in their own learning. The teacher spends minimal time lecturing and a maximum amount of time facilitating discussions and small-group activities. While moving about the room to observe students' work, the teacher often stops to talk with students one-on-one. Instead of giving answers, he asks questions to prompt and guide students' critical thinking and understanding.

Students also contribute to the decisionmaking process. For example, during a brainstorming session, they might identify aspects of photosynthesis that most intrigue them and pose questions for further study. After conducting investigations, students communicate their findings through written reports and journals, and through oral and multimedia presentations.

To assess students'understanding of important concepts, the teacher conducts formal and informal assessments throughout the learning process. In addition to traditional exams, the teacher might ask students to keep written journals and to draw concept maps to illustrate their thinking. While students demonstrate a task, the teacher records his observations of the students' understanding. During student interviews, he asks students for their own assessment of their progress, and offers strategies for improving their performance.

—*Inquiry Strategies for Science and Mathematics Learning: It's Just Good Teaching* (Jarrett, 1997a)

Science reform standards call for all students to take an active role in their own learning by contributing ideas, designing investigations, and constructing their own understanding of science (NRC, 1995; AAAS, 1990, 1993, 1998). However, no single teaching method is appropriate in all situations, for all students. Teachers will want to know how and when to use a variety of strategies within an inquiry-based pedagogy to increase students' understanding of core concepts and to enhance their reasoning and problem-solving skills.

The inquiry continuum. In practice, inquiry-based teaching typically occurs on a continuum. Depending on the teaching goal, teachers will move along the continuum, choosing strategies and activities that are most appropriate for the content. At one end of the continuum is **structured inquiry,** where students might engage in a hands-on activity and draw conclusions, but follow precise instructions from the teacher. In the middle is **guided inquiry,** where students might determine a procedure for the investigation, but the teacher chooses the question to

be investigated and the materials to be used. Farther along the continuum is **student-directed inquiry,** in which students generate their own questions concerning a topic selected by the teacher, and design their own investigation (Jarrett, 1997a, 1997b).

Structured inquiry. In all inquiry, students are actively engaged in making observations, discussing, and interpreting data. But along the inquiry continuum, the degree of student autonomy changes. Students with learning disabilities often find success with structured inquiry teaching methods. At the start of an inquiry-based lesson, teachers will want to determine all students' **prior knowledge** and possible misconceptions about the topic to be investigated. If students are not familiar with the subject, teachers can provide general information or engage students in introductory experiences with the material prior to the activity. Relevant concepts that have been previously taught should be reviewed. Teachers will want to be sure that students know what they're looking for in a structured inquiry activity. For example, to ensure that students are looking at pertinent objects in a microscope activity, teachers can provide a drawing or photograph of the object to be viewed, or ask students to draw what they see through the lens (Mastropieri & Scruggs, 1993).

"In a brief interview, teachers can determine the appropriate 'entrance' for a student," says NWREL science associate Jolene Hinrichsen. "A teacher might ask, 'Can you tell me where you have seen something like this before?' Or, 'Perhaps you can draw and label a picture of something that behaves in a similar way.' After considering the student's response, the teacher can better guide and challenge him."

Students with learning disabilities, as well as many other students, frequently need structured **questioning** to help them make inferences and construct knowledge. Teachers will want to structure questioning so that students cannot simply guess what the teacher is thinking. When asked an open-ended question, say Scruggs and Mastropieri (1994), students with learning disabilities will often focus on cues from teachers and other students rather than on the present activity. Students are more likely to make meaningful responses to open-ended questions, they say, when the relevant method and outcomes are apparent to the student, such as when a teacher says, "Drop the seltzer tablet in the solution and tell me what you observe." Direct questioning can help students to refine their observations. When the method of the activity is not provided, students may need specific prompting, for example, "Find a way to make the bridge hold this weight," prompted by, "What would happen if you connected the braces this way?" (Mastropieri & Scruggs, 1993).

During questioning, teachers will want to be sure to call on students with learning disabilities as often as they call on students without disabilities. Students should be given ample time to respond to questions and teachers should not interrupt or redirect too soon, but work to improve students' responses by prompting students or rephrasing the question. Teachers should respond to questions or statements from students with learning disabilities as thoroughly and with as much positive affect as they would respond to other students. In this way, teachers model respect for the dignity and diversity of all learners.

Before materials are put away at the end of the day's inquiry lesson, teachers will want to **review** with students the nature of the problem and the thinking that led to a solution or consensus. The class can discuss previous problem-solving activities in the context of the present one. Individual students should share their thinking out loud so that others can consider the ideas and respond, either by elaborating on the idea or offering constructive criticism. This reinforces student learning and will help teachers to monitor students' level of engagement and critical thinking (Mastropieri & Scruggs, 1993).

Special education teacher Eileen Houser suggests that, after the lesson, teachers reflect on the success of the activity and students' level of engagement, and note any modifications that might be necessary for future lessons.

"At the completion of a unit or theme, teachers could identify the students who did not successfully engage in the inquiry activity," says Houser. "These students can become the new target population, and teachers can identify which 'entrances' might work for them in the next area of study."

Vocabulary Acquisition

Science activities alone may not be enough to help students with learning disabilities learn essential vocabulary. Though vocabulary learning is sometimes minimized in hands-on science activities, students must still master key vocabulary used in classroom discussion. "Students who don't master the essential language of science may find their ability to share experiences and participate in class discussions impeded," write Scruggs and Mastropieri (1994).

Tips on Structuring Inquiry Lessons for Students with Learning Disabilities

- Post an outline for each day's lesson and activity
- Review previously learned concepts prior to the activity
- State learning objectives clearly for the present activity
- Present information explicitly and directly
- Invite all children into discussions, especially during review
- Sanction creative or unorthodox examples, hypotheses, and procedures
- Guide interaction during hands-on group activities
- Demonstrate high enthusiasm during instruction
- Adapt curricula to provide for a slower pace, repeated coverage of concepts, ample practice in vocabulary acquisition, and graphic supports

—Adapted from "The Construction of Scientific Knowledge by Students with Mild Disabilities" (Scruggs & Mastropieri, 1994)

Teachers may want to preteach new vocabulary prior to assigning reading or an activity. Vocabulary words can be presented by the teacher or practiced in a peer tutoring format in which students paraphrase or summarize what they have read after each paragraph or page (Munk, Bruckert, Call, Stoehrmann, & Radandt, 1998). Students can be encouraged to write down vocabulary as it is encountered and refer to the glossary of their textbook. They can also create a vocabulary index by writing new words on a separate index card, arranging the cards alphabetically, and placing them on a ring so that new words can be added as needed (Scruggs & Mastropieri, 1994).

However, teachers may prefer to present new vocabulary after students have been involved in a relevant activity. This gives students an opportunity to own an idea before labeling it, says Jolene Hinrichsen.

"There is the school of thought that says you don't 'tag' a thing or idea with a term until students have worked intimately with it," she says. "Lab equipment, ideas, and phenomena often beg for a name *after* the child has been working with it for a period of time."

For example, says Hinrichsen, after an inquiry activity on principles of energy, the teacher can refer to key vocabulary by pointing out, "Remember when you pushed the brick across the sand paper? Well, that push is called a 'force.'"

Mnemonics. Mnemonic (memory-enhancing) techniques can be effective in helping students with learning disabilities to learn scientific vocabulary. These techniques typically employ familiar, concrete, visual, and auditory cues to help students remember words and definitions. For example, write Scruggs and Mastropieri (1994), to help students remember that a euglena is a single-celled organism that contains chlorophyll, students can use the key word "green," which sounds like the second syllable of euglena. This key word helps students remember that the euglena contains green chlorophyll.

Munk and colleagues (1998) offer another example: Students can be taught a key word that is related to the definition of a term, such as the keyword "artery" for tree, or "biomes" for homes. The keywords facilitate recall of both vocabulary and meaning. Mnemonics can also be used to facilitate recall of a list of names, such as "ROY G BIV" to recall the colors in the spectrum (red, orange, yellow, green, blue, indigo, violet).

Structured Inquiry in an Inclusive Classroom

AT THE END OF THE DAY WHEN THE LAST YOUNGSTER HAS COLLECTED his book bag and left the room, fourth-grade teacher Marilyn Jackson sits at her tiny desk making notes into her date book, reminding herself which students need follow-up: Candice—multiplication review; Scott—current electricity. To reinforce students' understanding of division and multiplication, Jackson will repeat or vary a hands-on activity in which students use manipulatives and paper and pencil to create models, such as arrays, to help them work division and multiplication problems.

It is these and other strategies that make the difference for many students in Jackson's classroom at Edwards Elementary in Newberg, Oregon, a working-class town just outside Portland's metropolis. One of Jackson's talents as a teacher is her ability to recognize each child's strengths and, when needed, to modify the curriculum or her instructional approach to help each child advance to the "next step."

For teachers who want to address the learning needs of individual students, this is an essential teaching skill. It helps if teachers understand how mathematics is organized as a discipline, says Jackson. With an understanding of the "big picture," teachers can devise modifications that chart a direct route to important concepts. Before devising modifications to a lesson, teachers should ask themselves: What are the essential concepts students need to know? What are the necessary steps to get there?

Sometimes, modifications need to be made quickly. Teachers can be in the middle of a unit, or even in the middle of a conversation, and realize that some students need extra support or a different approach. While it might feel like lessons progress by "stops and starts," these diversions are teachable moments of great value, says Jackson.

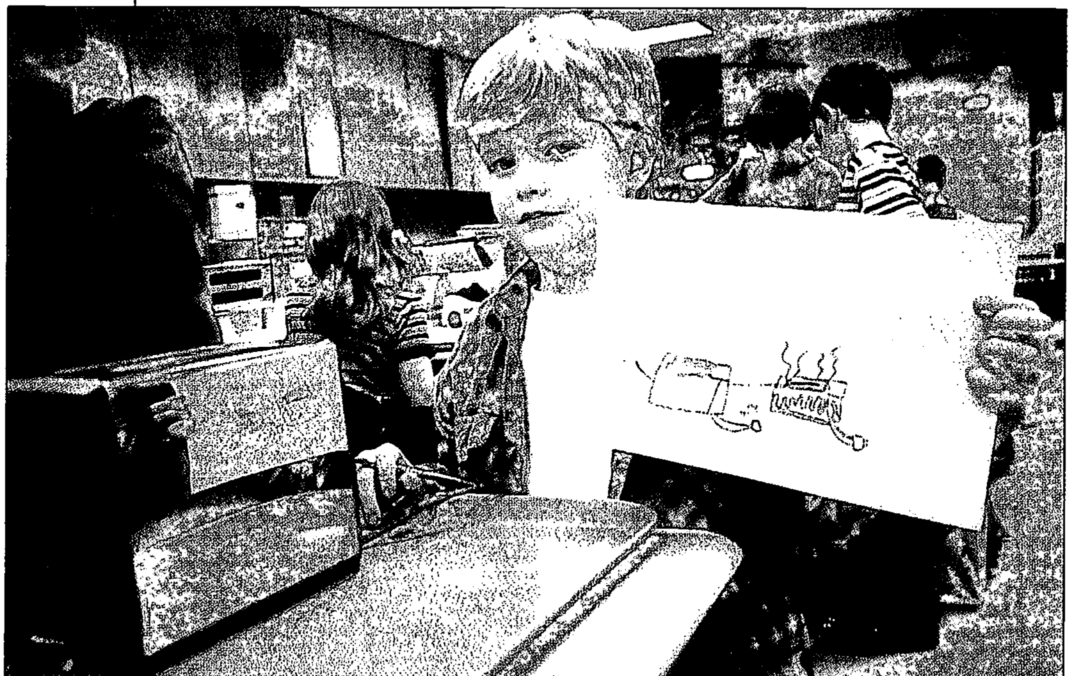
"When I first started teaching, I thought each lesson would have this tidy closure," she says. "But the process is so much messier than we ever acknowledge."

If a teacher suspects that modifications will be necessary for some students, she will want to plan ahead. Study guides and graphic organizers—even problems and experiments—can be prepared in advance and either given

to students at the outset or held in reserve until, and if, students show that they need additional learning supports. At other times, a student's needs will only become evident during a lesson. Jackson says that she can usually tell within the first three days of a new unit if a student needs a different approach or modified materials. But it's not always clear where the problem lies. In many cases, the teacher must identify the point at which a student's understanding of a concept or procedure is faltering before she can adapt a lesson or materials.

"I have to follow the student's thinking process and break it down small enough so that I can see what she 'gets' and what she isn't getting—what's the step that she's missing?" says Jackson.

Usually, Jackson discovers the problem area by talking with the student, asking questions that prompt the student to describe her reasoning. Many times, this one-on-one conversation and Jackson's prompting questions help the student to clarify her thinking. This often leads the student to ask her own question and, with encouragement, undertake a further investigation. In these cases, the student has an opportunity to formulate a deeper understanding of a concept and, in a follow-up interview, explain her reasoning more fully.



When modifications are necessary, Jackson might draw on a number of strategies, such as asking students to complete exercises, problems, or experiments for extra practice in foundational concepts and skills; to work with manipulatives or modeling to provide a concrete link to abstract ideas; or to create graphic organizers, such as concept maps. Often, she consults with the special education teacher who can help modify lessons and work with the student individually—in the class or learning resource room—to reinforce the concepts being taught.

"I don't think there's an assignment on earth that can't be adjusted up or down," says Jackson.

Would her dream class be all high achievers with no need for modifications?

"Absolutely not. Everybody learns better when there's a mix of abilities," she says. "High-ability students have to explain things to someone else. Lower-ability learners come up with different perspectives than high-ability students, who are often more linear in their thinking. Because they are struggling, lower-ability students often come up with different, creative approaches to the material. That kind of mix is really valuable in a classroom."

She pauses a moment, then adds, "There are so many needs to be met in a classroom of 30 students. I know I don't meet everyone's needs everyday, and that's sad, but I can't. You have to find a balance, and sometimes I have a hard time with that—sometimes I just want to sit here and bawl. But when you make a difference, you make a difference for a lifetime."

Investigating the Mystery of Electricity

MARILYN JACKSON'S FOURTH-GRADE STUDENTS ARE IN THE middle of a two-week science unit on electricity. The students are learning about static and current electricity and how electrical energy can be transferred to other forms of energy, such as light, heat, or movement. At the start of the unit, the whole class did several experiments and investigations to develop a basic understanding of the characteristics of magnetic fields and electrical currents. They brainstormed ideas and posed questions, constructing a concept map after each new set of experiments. This helped students to draw on their previous knowledge and begin formulating new concepts and acquiring key vocabulary.

Today, students are in small groups and are preparing to take apart and diagram common household electrical appliances. But before they proceed, Jackson asks them, "What can you expect to see when you take your appliance apart? What's happening in the electrical circuit? Think of three things you'll find in your appliance." Students write down "wires," "wheels," "levers," "screws," and such. Then they set to work unscrewing plastic casings, prying off spigots and metal screens—sketching and labeling as they go.

Finally, each student has disassembled an iron, fan, mixer, coffeemaker, or some other small machine, and is sketching the parts of the appliance, tracing the electrical pathway and its interaction with moving objects, heating elements, and other functional parts of the tool. During all of this, students have their journals open and are jotting down questions as they think of them: "Where do those wires go? How come they are so skinny?" Or, "I wonder if that pokey thing is a switch?" Alongside these reflections, students sketch diagrams with labels and arrows pointing here and there. While they work, Jackson circulates around the room, stopping at each group to ask questions and, when necessary, to guide students' investigations.

After the activity, Jackson collects the student journals. At the end of the day, she studies each child's entries, looking for insights into students' thinking processes and understanding of current electricity. She reaches for her lesson plan book and makes a note to herself to be sure to follow-up with a few students who appear to need further guidance or modifications. Looking up from her desk, she scans the now empty classroom. The students stored their dissected appliances in neatly stacked tubs, but a few stray springs and knobs lie about the floor, and she stoops to pick them up, her mind occupied with the next day's lessons.

Mathematics Instructional Strategies

TO HELP STUDENTS DEVELOP THEIR REASONING AND PROBlem-solving skills, teachers will want to design curriculum around big ideas or central concepts that can facilitate learning of subordinate concepts. Understanding big ideas in mathematics enables students to solve diverse problems which may appear to be unrelated but are, in fact, connected in some way to a larger mathematical concept (Carnine, 1997).

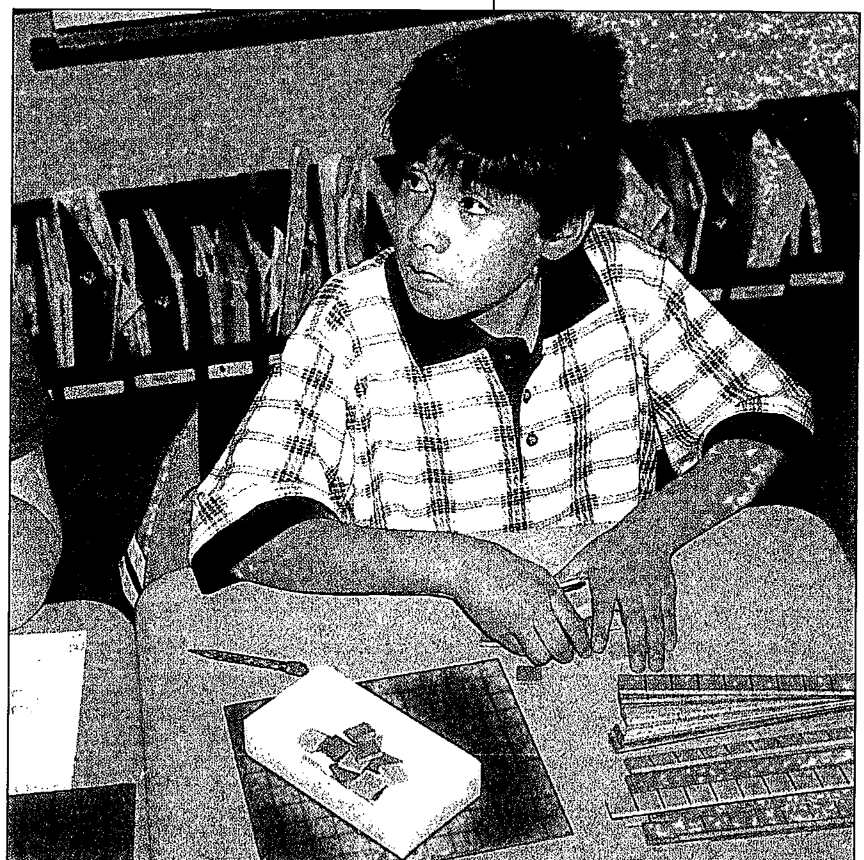
Big ideas in mathematics contain many concepts. Teachers can organize big ideas and subordinate concepts into strands which can be taught over a number of days. Strands make the sequencing of concepts more manageable for many students, especially students with learning disabilities who can be overwhelmed if too many concepts are taught too quickly (Carnine, 1997). Robert McIntosh, mathematics associate for NWREL, suggests, for example, that a lesson on ratio and proportion—big ideas—might be arranged into three strands: probability, scale, and geometric similarity.

> "A MAJOR EDUCATIONAL GOAL FOR ALL STUDENTS, INCLUDING THOSE WITH LEARNING DISABILITIES, IS BETTER PROBLEM-SOLVING PERFORMANCE."
>
> —"Instructional Design in Mathematics for Students with Learning Disabilities" (Carnine, 1997)

On one day, students can explore the concept of probability by using fractions to project, perhaps, the odds of a women's basketball team winning a championship, or the probability of a person genetically inheriting blue or brown eyes. Another day, students might use percentages in scale activities such as mapping geographic formations or adapting recipes. At another time, students can explore the concept of geometric similarity by solving rational equations. For example, students can determine the height of objects which are too tall to measure directly, such as a tree. Knowing their own height—and comparing the length of their shadow to the tree's shadow—students can determine the height of the tree using proportional reasoning or similar triangles.

Problem Solving

A decade ago, the National Council of Teachers of Mathematics (1989) set goals calling for greater emphasis on problem solving at all grade levels. Problem solving can be difficult to teach, yet it is one of the most important areas in mathematics instruction because it affects nearly every aspect of a person's life (Bley & Thornton, 1995). The ability to problem solve is as crucial for students with learning disabilities as it is for all other students. However, students with learning disabilities often need explicit instruction in the strategies of problem solving and guided learning experiences in solving problems in mathematics (Montague, 1997; Pressley & McCormick, 1995).



Most interpretations of problem solving include the notion of confronting a situation that contains novel and challenging elements (McIntosh, in press). When faced with such a situation, a person's problem solving occurs on two levels. One level is metacognitive: Which problem-solving strategy is most appropriate for a given problem situation? This question requires a person to analyze the situation, reflect on his prior knowledge, choose a strategy, apply it, and evaluate its effectiveness. The other level involves applying the strategy—a specific approach to dealing with the problem, such as creating visual representations of problems, noticing patterns, or working a problem backward (Bley & Thornton, 1995; Montague, 1997).

The student with a learning disability will typically try many strategies to solve a problem, but the strategies may be ineffective or inefficient, such as rereading a problem or shifting computations. Even when students learn effective problem-solving strategies, it can be difficult for them to decide when and how to use a particular strategy in a new context. Pressley and McCormick (1995) recommend that teachers instruct students in how to use specific strategies to solve problems. They found that students who receive explicit instruction in problem-solving strategies often become more skilled in solving math problems and representing the world with mathematical expressions.

Karen Scapple, special education teacher at Edwards Elementary in Newberg, Oregon, reinforces students' learning of problem-solving strategies by helping them break down the process into smaller steps.

"Students need to have a lot of practice in problem solving, and they need to have a lot of success," says Scapple. "Therefore, they need to have it in small doses. They can't seem to get it if it's too overwhelming. So we help them to break it down. And while they may not understand the core concepts at the same level as some of the nondisabled students in the class, they're doing the same process (of problem solving), and they're very excited about that."

Teachers can support students' efforts by helping them in decisionmaking, using information, acquiring mathematical vocabulary, and sequencing (Bley & Thornton, 1995). In decisionmaking, students must determine, for example, whether to regroup. They must choose which operation to use or which problem to solve first. The decisionmaking process can be complex, requiring abstract reasoning. Students must draw on previously learned concepts and skills, distinguish among them, and choose the concept or skill that is most appropriate in a given situation (Bley & Thornton, 1995).

Students must also be able to interpret information accurately. They must be able to isolate key information within a problem, sort out irrelevant information, or determine if important information is missing. This requires strong language abilities. For many children, problem solving is difficult because they are unable to understand and use language efficiently, rather than because of the computation or abstract reasoning involved. They often have trouble expressing their ideas and knowledge. Like reading, mathematics has a vocabulary; students must be able to associate words with symbols (Bley & Thornton, 1995).

Problem solving requires choosing and using previously learned information in a sequential and organized way. In one instance, it may be necessary to add first and then multiply. In another, the reverse of the procedure might be required. Patterning is also an important part of problem solving. Students must be able to distinguish similarities and differences between a given problem and those previously worked. Some students with learning disabilities find it easier to express differences, rather than similarities. For students to expand their problem-solving skills, it is often necessary for similarities to be isolated and for students to have ample opportunities to practice recognizing those similarities (Bley & Thornton, 1995).

Keith Hollenbeck, a researcher with the University of Oregon College of Education in Eugene, also notes that "problem-solving problems should not be randomly chosen but be specific to a strategy or big idea that the teacher wants to reinforce."

The following problem-solving strategies can be effective for students of all abilities and grade levels. The techniques can be expanded in complexity and difficulty as students progress mathematically (Bley & Thornton, 1995; Sorenson, Buckmaster, Francis, & Knauf, 1996; Krulik & Rudnick, 1996).

The strategies described below are adapted from the book, *The Power of Problem Solving: Practical Ideas and Teaching Strategies for Any K-8 Subject Area,* by J.S. Sorenson, et al. (1996, Allyn and Bacon).

Tips for Teaching Problem Solving

- Begin problem solving as part of the initial mathematics program. Do not wait.
- Make problem solving the reason for computation.
- Assist students with what they cannot do so that they can solve problems. If a student cannot read the problem, rewrite it. If the computation is too complex, break it down into smaller steps.
- Ask students to write their own problems and to modify existing problems.
- Use familiar and culturally relevant subject matter as the content for the problems.
- Monitor progress and modify problems as necessary.

—*Teaching Mainstreamed, Diverse, and At-Risk Students in the General Education Classroom* (Vaughn, Bos, & Schumm, 1997)

Working backward. This technique can be used when the answer or situation is known. For example, a student can determine what time he must get up in the morning in order to catch the school bus at 7:50 a.m. by estimating (adding) how much time he needs to get ready working backward (subtracting) from the 7:50 deadline. This skill is useful in planning situations whenever the limits of cost, time, distance, and so on are known. With more complex problems, students can write down the amounts or situations so they can be accounted for in an orderly fashion. This way, students won't become frustrated or lost in the process of working from the general to the specific (Sorenson et al., 1996).

Simplifying and reducing. This skill is useful in any situation involving numbers. Large numbers sometimes distract students, but if they reduce the size of the numbers to a smaller or "round" amount, they can see the process more clearly and get a good estimate of what the result or answer will be. For example, if you need nine rose bushes at $1.89 each, how much would they cost? By simplifying $1.89 to $2, you can come up with an estimate of $18 (9 times 2) which is pretty close to the exact amount of $17.01 (9 times $1.89) (Sorenson et al., 1996).

Recognizing patterns. This technique is applicable in a variety of situations involving numbers, words, letters, shapes, and forms. Teachers can ask students to extend patterns such as 3, 6, 9, 12 ... 15, 18, 21, 24 ...; or A, B, A, C, A, D, ____, ____, ____, and to state the pattern rule for each. Patterns can also be found in "cryptoquotes," well-known quotations which have been "scrambled" using a coded pattern. Students can "translate" scrambled quotations from mathematics and science to develop skills in recognizing patterns. Patterns can also be found in animal and human footprints, geological formations, cloud arrangements, and outer coverings of living things (Sorenson et al., 1996).

Drawing and modeling. This technique can be useful to younger as well as older students. Drawing a picture or making a model helps students to visualize a situation, explain complex and abstract ideas, relate to hands-on activities, and illustrate relationships (Sorenson et al., 1996).

Making a table or graph. Students can organize and summarize both numerical and verbal data in order to draw inferences and make evaluations of past situations or projections for future actions. Students can organize information into categories and/or sequences to make it easier to see relationships and to interpret data. For example, if students want to estimate and determine how many jelly beans there are of each color in a jar, they can create a three-column table listing the color of the jelly beans, the number estimated, and the number actually counted. This technique helps students learn how to organize by selecting categories that are relevant to the problem then recording data under them. A graph or table can also be used to order data in difficult problems and as a tool to classify information (Sorenson et al., 1996).

Acting it out and simulating. Many students learn best when they can construct a kinesthetic understanding of a concept or fact. For example, students can illustrate basic division by forming a group of 26 students on one side of the room. Then, students can leave the group five at a time. Students can count how many groups of five are left and how many students remain. This is a concrete way of illustrating that 26 divided by 5 equals 5 plus a remainder of 1. Acting out can also be used to teach fractions, decimals, multiplication, addition, and so on (Sorenson et al., 1996). When acting out is impractical, students can simulate the problem situation using manipulatives. For example, they can use bottle caps instead of snowballs or chips to represent people. At the higher grade levels, students can make paper-and-pencil simulations by drawing a picture or making a table (Krulik & Rudnick, 1996).

Problem solving requires a student to analyze a problem situation and choose appropriate strategies. The student will use her prior knowledge of mathematics and reasoning skills to choose a strategy, apply it, and evaluate its effectiveness. The experience will be added to the student's store of knowledge, to be called upon the next time she tackles a novel and challenging problem. These problem-solving experiences are crucial to a young person's development, mathematically as well as personally. Learning how to find solutions to new and difficult problems is one of the most important skills a person can have. Being an effective problem solver is an essential and attainable goal for all students, including those with learning disabilities (Montague, 1997).

Calculators and Computers

Calculators and computer-based tools such as spreadsheets and graphing programs can empower students with learning disabilities to explore important mathematical relationships (Goldman et al., 1998). With standard calculators, students with weak computation skills can still engage in higher-level mathematical thinking and problem solving (Branca, Breedlove, & King, 1992; Pressley & McCormick, 1995). Using a calculator to perform routine computation frees the student to focus on more complex concepts, such as number relationships and variables, or to work with real-life data, such as population or economic figures (Branca et al., 1992). Graphing calculators provide students with a visual bridge between concrete and abstract mathematical concepts. The screen on the graphing calculator displays students' keying sequences and answers to multiple problems, allowing students to compare the results of each problem and reinforcing concepts and processes (Vonder Embse, 1992). Computer spreadsheet programs also provide students with visual representation of mathematical relationships. The spreadsheet format keeps data neat and organized, making it easier for students to see how numerical relationships change when variables are changed. Spreadsheets can help students to learn about place value, decimals, making calculations, seeing relationships, understanding variables, and working with large numbers (Knapp & Glenn, 1996).

Textbook Adaptations

IT IS USUALLY NOT SUFFICIENT TO SIMPLY READ A TEXT IN order to learn its contents. Discourse is an essential component to learning; discussing the ideas and information presented in a textbook or other written source helps students to analyze, understand, and remember key concepts and facts.

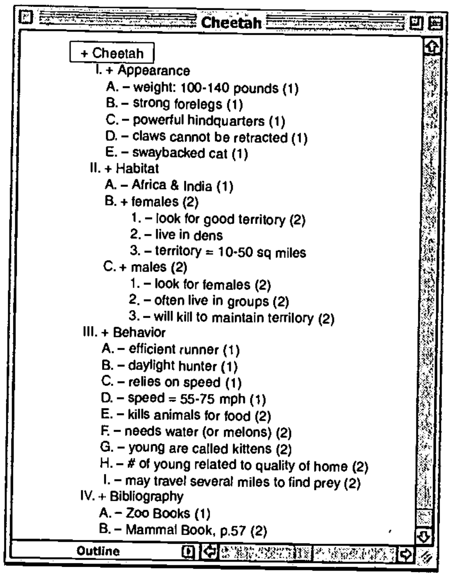
Nevertheless, textbooks remain an integral part of science and mathematics learning in most classrooms—especially at the secondary level. It is often necessary to adapt written materials to facilitate students' reading comprehension. Many science and mathematics textbooks contain numerous facts and details that are poorly organized; vocabulary is dense and technical; and new information is presented too rapidly (Munk et al., 1998; Lovitt & Horton, 1994). Therefore, teachers can consider the following strategies for adapting text-based materials.

"A KEY TO UNDERSTANDING ANY TEXT FOR MANY STUDENTS, INCLUDING STUDENTS WITH LEARNING DISABILITIES, IS USUALLY DISCUSSION—AN INTERACTIVE, CONNECTION-MAKING CONVERSATION."

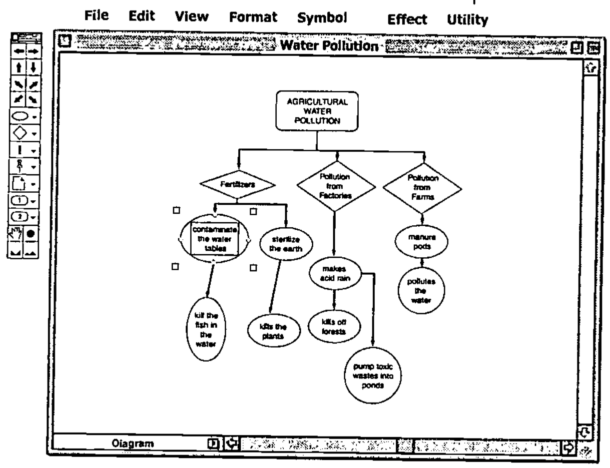
—Jolene Hinrichsen, science associate, Northwest Regional Educational Laboratory

Examples. Students learn a great deal from examples. Unfortunately, the examples presented in many textbooks are inadequate. According to Jones, Wilson, and Bhojwani (1997), teachers will want to provide students with a sufficient number of examples to allow them ample time for practice and mastery. Also, an adequate sampling of the range of examples that define a given concept should be provided. For instance, in the area of fractions, examples should include fractions that are less than one whole unit, such as $1/4$ and $1/2$, as well as improper fractions, such as $6/5$. Otherwise, students can acquire misconceptions, such as believing that all fractions are less than one whole unit.

"Not only should examples be used, non-examples—or negative examples of the concept—must also be used," says University of Oregon researcher Keith Hollenbeck. "While examples communicate to the learner what the concept is, non-examples demonstrate what the concept isn't. These define concepts as discriminations. Defining or using a concept often requires the learner to select and sequence examples and non-examples in a compare-and-contrast strategy."



Note. From *Computer-Based Study Strategies: Empowering Students with Technology* (p. 44), by L. Anderson-Inman, M.A. Horney, C. Knox-Quinn, M. Ditson, and L.A. Ditson. 1997, Eugene, OR: Center for Electronic Studying, University of Oregon. Copyright 1996 by University of Oregon. Adapted with permission.



Note. From "Computer-Based Study Strategies for Students with Learning Disabilities: Individual Differences Associated with Adoption Level," by L. Anderson-Inman, C. Knox-Quinn, and M.A. Horney. 1996, *Journal of Learning Disabilities, 29*(5), p. 461-484. Copyright 1996 by Pro-Ed, Inc. Adapted with permission.

The concept map and outline shown here were produced by students using a computerized information organizer, such as the software program, Inspiration, Inc., to synthesize information from multiple texts.

Study guides. Teachers can prior itize the content of textbooks by placing short-answer questions based on main ideas on a study guide. Students will read the material and fill in their study guides, or, if students need more direct guidance, teachers can place page numbers by each item on the study guide to direct students to the relevant sections in the text. As students scan through their books looking for answers and writing them on the guides, teachers can circulate and assist students who are having trouble (Lovitt & Horton, 1994; Munk et al., 1998).

Graphic organizers. Graphic organizers provide a visual representation of key vocabulary and content information. Using lines and boxes, graphic organizers connect key words and statements in a graphically meaningful way. After reading a passage of text, students can create their own graphic organizer or complete one that has been prepared by the teacher—with all of the boxes and interconnecting lines provided but with much of the subordinate categories left out. A completed graphic organizer can then become a study guide (Lovitt & Horton, 1994).

Boxes, circles, and lines. Sometimes students with learning disabilities have a difficult time differentiating information in mathematics textbooks. For example, they may not be able to locate assigned problems in a textbook because they can't visually separate the problems from each other. With a geometric-shaped template of boxes, circles, and lines, students can organize pages spatially. Problem numbers can be circled, and directions or examples underlined in bright colors or heavy lines. Teachers may need to demonstrate how to box, circle, and underline as needed to isolate and readily locate problems in a book (Bley & Thornton, 1995).

Copying problems. Copying problems from a textbook can be an overwhelming task for students with learning disabilities. Bley and Thornton (1995) offer these suggestions for reducing the need for students to copy problems:

- Assign fewer problems

- Provide students with worksheets

- Allow students to work in pairs; one student copies the problems while both students figure out the answers together

- Provide construction paper "masks" to blot out portions of a page at a time to help students keep their place in a book

- Cut a worksheet into segments and assign only one small section at a time

Computerized information organizers. Computer programs can help students record and structure information. For example, **word processors** have long been effective in helping students with learning disabilities to complete assignments legibly and on time. When used effectively, word processing and writing aids—such as spelling and grammar checkers, and electronic dictionaries and encyclopedias—enable students with learning disabilities to show their strengths to greater advantage (Anderson-Inman, Knox-Quinn, & Horney, 1996).

The Center for Electronic Studying at the University of Oregon, College of Education, in Eugene has developed computer-based study strategies for secondary students with learning disabilities. Students who have access to computers equipped with information-organizing software, such as **electronic outlining** and **concept-mapping** programs, can create visual representations of the interrelationship of ideas. (See illustrations on page 31.) The act of creating outlines or concept maps requires students to organize and synthesize information, reinforcing their learning. Ideally, outlining programs should be integrated with a graphics component (such as Inspiration Software, Inc.), enabling students to change outlines into diagrams and vice versa. The center identified a three-step process for creating outlines and concept maps from text-based materials (Anderson-Inman et al., 1996):

1. Students create an overview of a chapter's major topics by typing in headings and subheadings. (If the original text is not well organized, or headings don't adequately convey content, teachers may want to prepare a study guide for students as an alternative.)

2. Students read each paragraph in the assigned text, then record key words or phrases from the main ideas. When creating an outline, students can insert these ideas under appropriate headings or subheadings. When creating a concept map, they can insert key words as informational nodes linked to a major heading node. The act of summarizing the chapter's content into key words and phrases requires higher-order thinking and helps students to transform information into something that is personally meaningful.

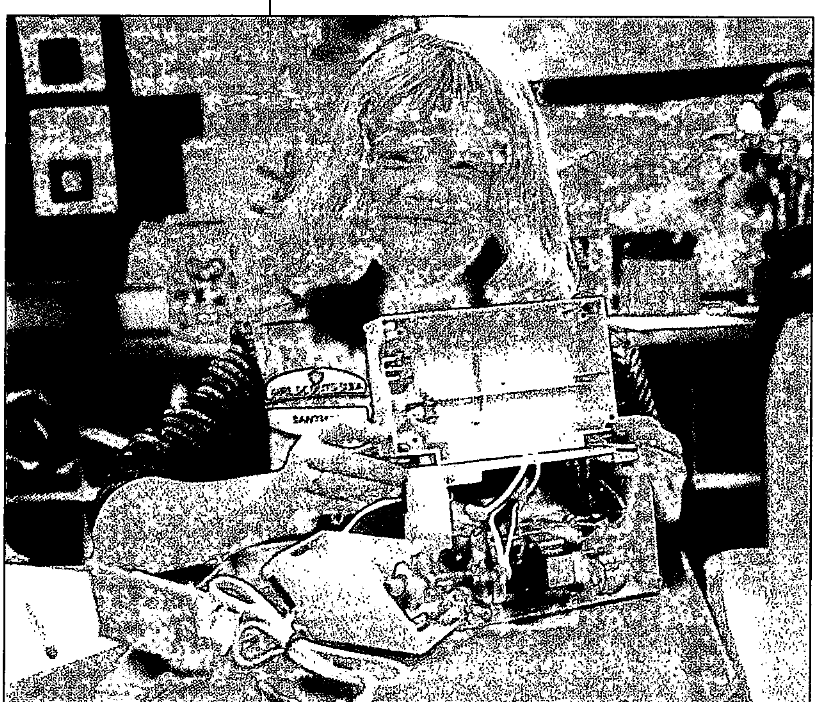
3. Finally, students insert details and examples as subtopics under the main ideas. This three-step process calls for students to go through a section of text multiple times and teaches them to distinguish between key ideas and supporting details.

Students can then use the outline or concept map to **self-test** their knowledge of the information they've recorded. By expanding or contracting portions of the outline to hide or show information under each heading—or opening and closing a window in a concept map—students can assess how well they understand the content. Asking questions such as "How many?" "What are they?" "What more do I know?" can help students to focus and monitor their understanding (Anderson-Inman et al., 1996).

If students have access to portable computers with outlining software, they can **take notes** during discussions, presentations, or taped narration. The software program automatically formats students' entries into an outline which students can later manipulate as needed to distinguish details from main ideas (Anderson-Inman et al., 1996). A manual entitled *Computer-Based Study Strategies: Empowering Students With Technology* (Anderson-Inman, Horney, Knox-Quinn, Ditson, & Ditson, 1997) describes these and other strategies in greater detail. For more information, see the University of Oregon listing in the "Organizations" section at the back of this publication.

Conclusion

TODAY'S CLASSROOMS ARE INCREASINGLY DIVERSE. STUDENTS can have great differences in their abilities, life experiences, cultural backgrounds, and home languages. The general education teacher will want to use instructional strategies that respect and build on these differences while helping all students to learn important concepts and skills in mathematics and science. This publication highlights teaching strategies that draw on key principles of inclusion, special education, multiculturalism, and standards-based reform. These principles can empower teachers to respond effectively to the educational needs of young individuals with learning disabilities. The following pages contain additional resources that may be helpful to teachers in inclusive classrooms.



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Additional Resources

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Organizations

Council for Exceptional Children
Division of Learning Disabilities (DLD)
1920 Association Drive
Reston, VA 20191-1589
Phone: 1-888-CEC-SPED, TTY: (703) 264-9446
Fax: (703) 264-9494
www.edhd.bgsu.edu/DLD/HomePage.html

DLD is an international professional organization that promotes best educational practices concerning people with learning disabilities and recommends professional standards. It also offers forums for discussion and professional development for those concerned with the education of individuals with learning disabilities.

Learning Disabilities Association of America (LDAA)
4156 Library Road
Pittsburgh, PA 15234
Phone: (412) 341-1515
www.ldanatl.org/

LDAA promotes education and training for special and general education teachers. LDA and its state affiliates work directly with school systems in planning and implementing programs for better services for students with learning disabilities. The association produces books and materials and publishes a biannual journal, *Learning Disabilities: A Multidisciplinary Journal.*

National Center for Learning Disabilities (NCLD)
381 Park Avenue South, Suite 1401
New York, NY 10016
Phone: (212) 545-7510
Fax: (212) 545-9665
Toll-free Information and Referral Service: 1-888-575-7373
www.ncld.org/welcome.html

NCLD provides current information on learning disabilities and resources free of charge to parents, professionals, and adults with learning disabilities. NCLD's Information and Referral Service is a computerized resource clearinghouse of information regarding important issues in the learning disabilities field.

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The center provides Northwest K-12 educators with resources and services to support challenging and effective curriculum, instruction, and assessment. Teacher guides and support materials, assessment ideas and samples, research syntheses, and other items are accessible by a searchable database. Northwest educators may borrow material via online requests. The It's Just Good Teaching series includes publications and videos that promote effective instructional strategies. The publications can be ordered or downloaded from the center's Web site.

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ces.uoregon.edu/

The center has developed computer-based study strategies for secondary students with learning disabilities. The manual, *Computer-Based Study Strategies: Empowering Students With Technology,* describes strategies for using the computer as a study tool, including concept mapping, note taking, synthesizing information from multiple sources, and self-testing. Contact the center to purchase a copy of the manual or to obtain information about professional development opportunities.

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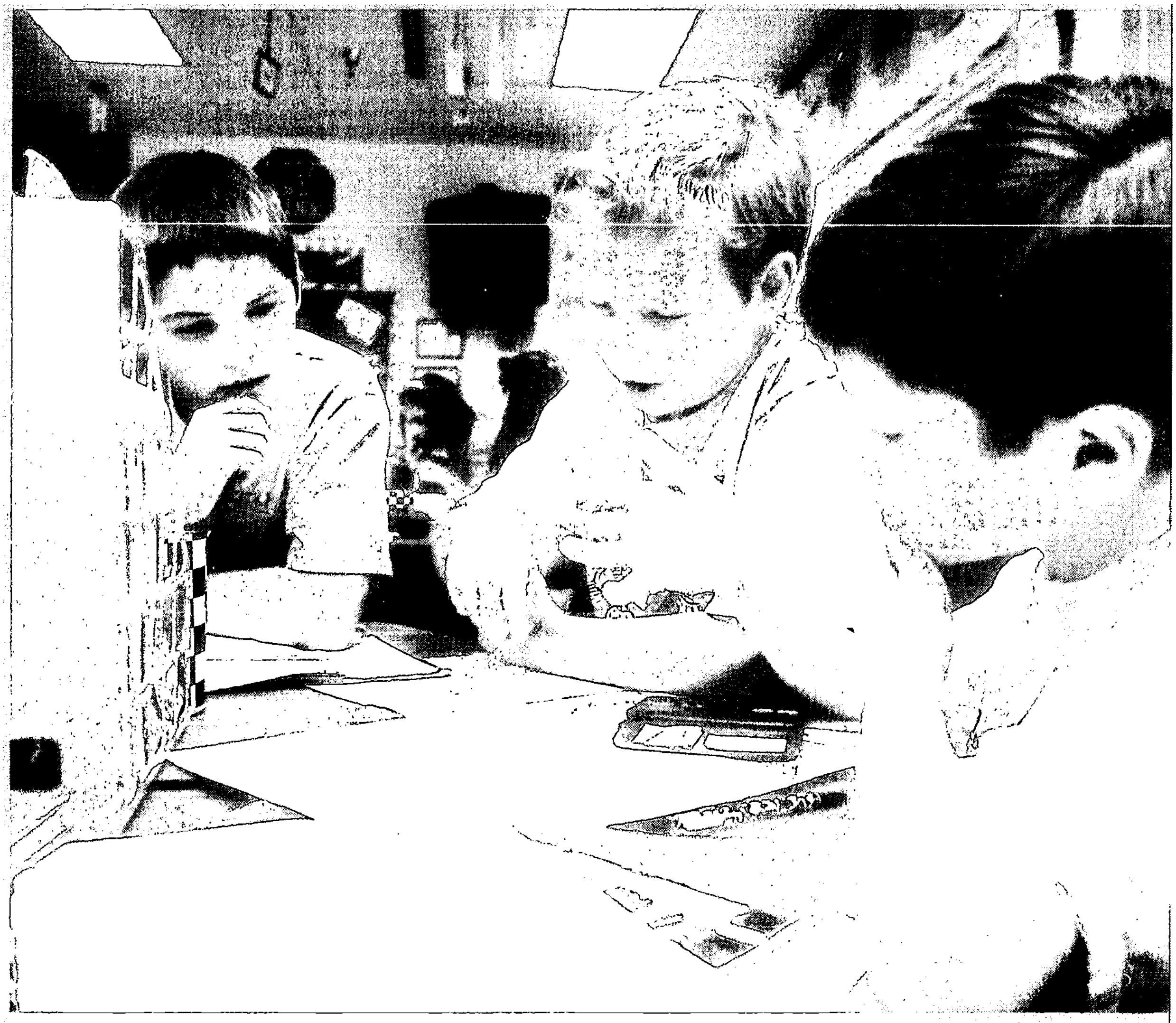
E-mail: doit@u.washington.edu
weber.u.washington.edu/~doit

DO-IT (Disabilities, Opportunities, Internetworking, and Technology) offers high school students with disabilities learning opportunities in mathematics, science, engineering, and technology that will help them succeed in their education and careers. The program also offers science and mathematics teachers workshops, materials, and resources for developing instructional approaches that include students with disabilities in core learning in the classroom and laboratory.



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