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National Science Foundation, Directorate for Education and Human Resources

Breaking Barriers:
PEOPLE WITH DISABILITIES AND SCIENCE AND MATHEMATICS EDUCATION

Harry Lang, a physics professor at the Rochester Institute of Technology in New York, has long been concerned with the quality of U.S. science and mathematics education. He heartily endorses the notion that all students—regardless of gender, race, linguistic background, or physical ability—have access to high-quality teaching and learning opportunities in science and mathematics. And he enthusiastically champions the efforts of the National Science Foundation (NSF) to improve the teaching and learning of those subjects.

Lang, with support from NSF's ***Program for Persons with Disabilities (PPD),*** is especially committed to the task of bettering the opportunities for deaf students to study science and mathematics on a par with their hearing classmates

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> "The capabilities of individuals with disabilities are tremendous... certainly much greater than the popular belief that society holds about them."
>
> — Ken Barner

working together to revitalize science, mathematics, engineering, & technology education

synergy

About Synergy

Synergy is a publication about programs of the National Science Foundation's Directorate for Education and Human Resources (EHR). Each ***Synergy*** issue highlights an EHR activity that is demonstrating progress in reforming the teaching and learning of science, mathematics, engineering, or technology, prekindergarten through career entry. The "synergy" derives from NSF's working in partnership with organizations throughout the United States and in all sectors of the economy to help foster the positive changes in education to which NSF is dedicated. The ingredients of these outcomes-based success stories are unchanging: access to quality science and mathematics education, high expectations for the success of these efforts, proven excellence of materials and their delivery, and measurable gains in learning by all students. Welcome to ***Synergy!***

In this Issue...

Synergy examines the Program for Persons with Disabilities (PPD)—the EHR initiative designed to enhance access, change attitudes, and instill a culture of success in science and mathematics education and careers for students with disabilities. By removing a host of barriers—some more social than physical—and by establishing models for replication, PPD is unleashing exciting forces of change within classrooms, schools, and colleges across the nation. "Synergy" is created among teachers, parents, administrators, and, especially, students, both those with and without disabilities, all of whom benefit from a more dynamic scientific and educational enterprise because of PPD.

PHOTOS CONTRIBUTED BY • DISABILITIES, OPPORTUNITIES, INTERNETWORKING, & TECHNOLOGY (DO-IT), UNIVERSITY OF WASHINGTON • ENABLING SUCCESS, LOUISIANA TECH UNIVERSITY • ENGAGING, RECRUITING, RETAINING STUDENTS WITH DISABILITIES IN SCIENCE, ENGINEERING, AND MATHEMATICS, UNIVERSITY OF DELAWARE • SCIENTIFIC VISUALIZATION USING TACTILE FEEDBACK FOR VISUALLY IMPAIRED STUDENTS, ARIZONA STATE UNIVERSITY •

Program for Persons with Disabilities …

and removing barriers to their entry into science- and mathematics-related occupations. "There are too few deaf professionals in science, math, and engineering," he says, "and I'm on a mission to do something about it."

> "There are far too few deaf professionals in science, math, and engineering—and I'm on a mission to do something about it."
>
> — Harry Lang

Toward that end, Lang and a colleague, linguist John Albertini, have for the past several years headed a PPD project aimed toward enhancing teachers' skills in communicating with deaf students. Among the project goals are to use hands-on and writing activities to enrich science literacy among deaf students and, through what Lang calls "self-esteem activities," to motivate deaf students throughout the United States to consider science as a career.

Like Lang, Karen Gourgey, an administrator at Baruch College of the City University of New York (CUNY), has dedicated the better part of her professional life to efforts on behalf of students with disabilities—in her case, those who are visually impaired. Her work, she says, "seeks to bring people closer to the solutions that will help blind youngsters move forward as they see fit in science and mathematics, whether educationally or in a career." As the director of her school's Computer Center for Visually Impaired People, Gourgey also has been working under a PPD grant to develop and test methodologies and courseware—such as specially developed auditory and tactile materials—that will offer blind and visually impaired students equal access to a basic education in science and mathematics.

Meanwhile, at the Newark campus of the University of Delaware, Kenneth Barner, an electrical engineer by training, is busily working to help students with disabilities gain access to a well-rounded science and mathematics education as well as entree to careers related to those fields. In Barner's case, the focus is on the orthopedically impaired—young men and women who, as the result of illness or injury, are seriously restricted in their physical agility or dexterity and who consequently find themselves without equal access to science and mathematics

Breaking Barriers…

DO-IT!

"I really want to go to college, and now I think maybe I can do it!" Those are the words of one young student participating in the **DO-IT** project at the University of Washington. And his words — especially the last two — are music to the ears of co-principal investigator Sheryl Burgstahler, who conceived the idea for DO-IT while she was completing her doctorate in education at the university and working in the school's computing department. Says Burgstahler: "I saw the potential of emerging adaptive and networking technologies to help students with disabilities increase their levels of independence and find solutions to communication and information-access barriers."

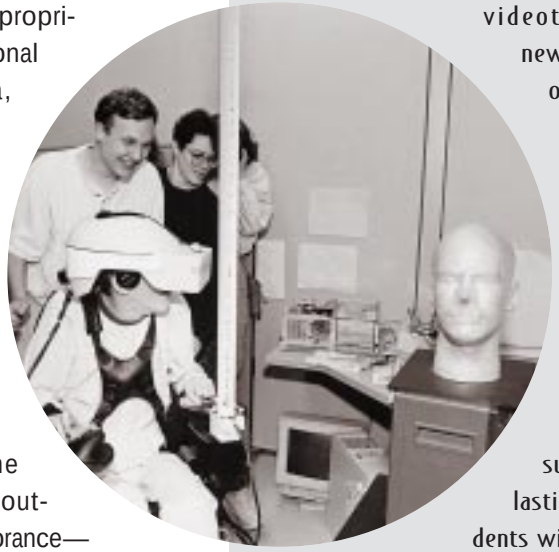
Since 1992, dozens of high school students with disabilities from around the country — about 20 a year — have directly participated in the project (whose appropriate acronym represents the undertaking's formal name, ***Disabilities, Opportunities, Internetworking, & Technology***), although thousands of other young people with disabilities throughout the U.S. have benefited as a result of its ambitious dissemination component. Additionally, the project has recruited more than 50 men and women with disabilities to participate as DO-IT mentors.

The project was the first to be funded by PPD shortly after the NSF program's inception in 1992, and it has received continuing agency support since then. Open to high school juniors and seniors with physical impairments or learning disabilities who are interested in science, mathematics, engineering, or technology and have the learning opportunities and related careers. He, too, is currently working on a PPD project—a multifaceted endeavor to eliminate obstacles by involving students in his efforts, educating parents and teachers about his work, researching information-access tools, and creating a computer-based laboratory that minimizes the physical requirements of students through the use of customized instrumentation and simulation software.

While the devotion of Lang, Gourgey, and Barner to the cause of helping students with various impairments to gain and maximize full, equal opportunities in science and mathematics is laudable indeed, so also is it quite understandable—since all three know first-hand about the challenges facing people with disabilities in our society. Harry Lang has been totally deaf since the age of 15, when he barely survived an attack of meningitis; Karen Gourgey has been functionally blind since birth as the result of congenital and irreversible glaucoma and cataracts; and Ken Barner has been a quadriplegic since fracturing his spine in a diving accident 15 years ago when he was a freshman in college.

The projects now being carried out under the supervision of Lang,

Gourgey, and Barner are among two dozen currently active efforts funded through PPD. Launched in 1992 and administered by NSF's Division of Human Resource Development (HRD)—a branch of the Directorate for Education and Human Resources (EHR)—the program is fostering the changes necessary for people with disabilities to gain full access to both education and the professional world. Among the goals of PPD projects are elevating awareness and recognition of the needs and capabilities of students with disabilities; promoting the accessibility and appropriateness of instructional materials, media, and educational technologies; and broadening the availability of qualified mentoring resources.



That is to say, PPD's fundamental mission is to address the factors—including outright neglect and ignorance—that have contributed historically to stifling the interests of students with disabilities in science and mathematics and impeding those individuals' advancement in science, mathematics, engineering, and

aptitude and desire to attend college, DO-IT relies heavily on computing and networking technologies to connect project participants to their peers and to adult mentors with disabilities.

Through a wide variety of activities—including summer camps, workshops, and rigorous hands-on classes and lab sessions at the University of Washington's Seattle campus—the project aims to foster for its young people what Burgstahler terms "an information-rich and supportive electronic community that will help them in their academic and career aspirations while also developing their confidence and their skills in self-advocacy."

Moreover, the project conducts an extensive public awareness program that widely distributes information in a variety of outreach materials—such as videotapes, periodic reports, and a steady flow of newsletters—describing DO-IT concepts, methodology, outcomes, and other matters. Says Burgstahler: "I believe that if parents, educators, service providers, and others are made aware that these students are successfully meeting academic requirements and are using appropriate accommodations, they are likely to develop more positive attitudes about the potential of youngsters with disabilities and about the accommodations that are available."

So far, says Burgstahler, "it is clear that the project is succeeding in establishing positive, motivational, and lasting interactions between high school and college students with disabilities, high school counselors, special education and science teachers, service providers, university faculty, and practicing engineers and scientists. The long-term objective, of course, is to increase the number of individuals with disabilities in science, engineering, and mathematics professions."

Enabling SUCCESS

Three overall goals are guiding the progress of a PPD-sponsored project at Louisiana Tech University: (1) to work with students with disabilities in middle school (grades six through nine), with their parents, and with their science teachers in an effort to stimulate the youngsters' interest in science, mathematics, engineering, and technology; (2) to heighten the students' awareness of the opportunities and successes in those fields of people with disabilities; and (3) to encourage career exploration among these middle-school students so that they will take appropriate college preparatory courses in high school. Called ***Enabling SUCCESS,*** the project is led by Paul Hale, a faculty member of the university's Center for Rehabilitation Science and Biomedical Engineering with 18 years of experience in providing assistive technology services to college students with disabilities, and in managing a dormitory housing them.

"We've come to recognize," says Hale, "that some of the students we got to know could have pursued a career in a technical field if they had received encouragement and guidance at an earlier age. The middle-school grades are a time when students are either turned on to science and mathematics or the opportunity passes them by." Students participating in the program are called "Science Explorers." Enabling SUCCESS offers five primary activities:

- ***Assistive technology and career workshops*** (attended by teachers and parents as well as students), which are designed to increase awareness of the opportunities and potential of persons with disabilities to succeed in science and engineering careers.

technology occupations. The situation, if perpetuated, will inevitably have sorry implications that extend beyond the confines of science and mathematics, says Lawrence Scadden, PPD's director. He believes that in our increasingly technological society, it is vital that all citizens—including people with disabilities—be sufficiently conversant with science, mathematics, and technology not only in order to take their place in the 21st-century workforce, but also so that they may make informed judgments about the complex social issues bound up in the sciences.

"For far too long," says Scadden, "we've been closing disabled people out of science and math, in the classroom, the laboratory, and the workplace. There is a vast lot of intelligent people who simply don't know how to accommodate the disabled. They don't have any idea how disabled men and women do science—they don't really realize that they can do science. In some instances, students don't want persons with disabilities in their classrooms or labs. They're afraid they'll be slowed down by them. They don't want competition for their time at the lab bench. These attitudes—the myths and the ignorance—have created a major barrier that must be removed."

Scadden's words, and likewise the mission of the PPD program, are buttressed by the results of a 1996 NSF study of students with disabilities who were pursuing majors in science or engineering fields in college. The study found that the students face a host of barriers related to access and retention in these fields beginning in their precollege years but continuing beyond. Consider the implications of a few of the important findings:

- For 42 percent of the students with disabilities who were surveyed, it was not until college that they first developed an interest in their chosen science-related major. In comparison, only 30 percent of students without disabilities developed their interest in college. More typically, these students became interested in science during or before high school.

- Only 46 percent of the students with disabilities felt that high school had prepared them well for college as opposed to 63 percent of their peers who were not disabled.

- And, just 48 percent of the students with disabilities

- ***Classroom and individualized science kits*** that enable students with physical impairments of varying severity to explore science concepts at home as well as in the classroom.

- ***Teacher-awareness seminars*** geared toward sharing information with current and future science and mathematics instructors about the ability of students with disabilities to pursue and become successful in science, engineering, and technology careers.

- ***Study and career-mentoring programs*** in which project staff and qualified college students provide encouragement and advice on a one-on-one basis to the Science Explorers.

- ***"Science Showcases,"*** conducted on the Louisiana Tech campus on selected summer days, at which students take part in discussions with science and engineering instructors and participate, along with their parents, in interactive experiments.

Although the project was launched in 1996, Hale says that the response of both the young Science Explorers and their parents to the mentoring, the kits, and the showcases has already been "enthusiastically positive." For the middle-schoolers with disabilities participating in the project, he says, Enabling Success activities "provide a little glimmer in their days — one of the things that make their days exciting."

Breaking Barriers…

Teaching Teachers

At the University of Northern Iowa in Cedar Falls, a PPD project called ***Systemic Assistance for Teaching Science to Students with Disabilities*** is focusing on training teachers—and teachers of teachers—to improve their skills and knowledge in running science classes for students with disabilities.

Under the guidance of principal investigator Gregory Stefanich, the project is predicated on the assumptions that students with disabilities are increasingly included in general education environments and that science classes are among the primary integrated placements of those students. Stefanich's project thus aims to broaden the capability of science educators who provide services to boys and girls in kindergarten through high school in such areas as effective resources, assessment strategies, and pedagogical techniques that are adaptable for teaching students with special needs.

who were surveyed said there was someone in their scholarly life who served as a mentor compared with 60 percent of students without disabilities.

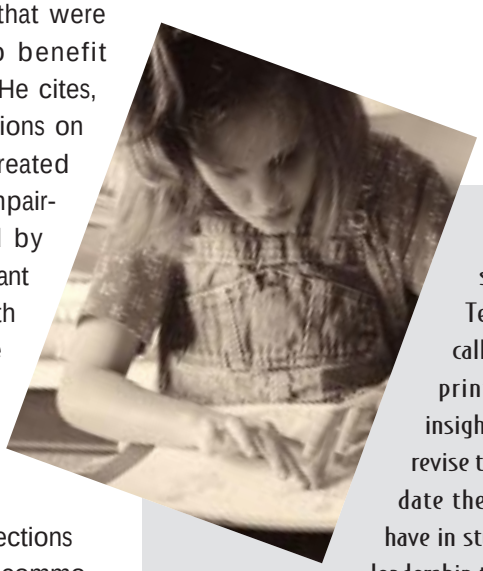
The science and engineering majors with disabilities also indicated that they frequently had problems in communicating with professors, and with their professors' attitudes toward them. They reported similar difficulties in communicating with and relating to their fellow students. And, over 60 percent of the students with disabilities reported that instructional accommodations that they had needed—such as assistance with test taking, library or research support, and note taking—were either rarely or never provided. When science and engineering faculty, however, were asked a similarly worded question, they estimated that these accommodations were supplied in the vast majority of cases. All totaled, these findings suggest that students with disabilities may not have access to peer groups and other support networks that other students do and that there may be a general lack of awareness about disability issues on the part of students and faculty in postsecondary institutions.

It is precisely PPD's mission to dismantle barriers such as these and to remedy the practices that led to these lopsided outcomes in the first place. And, to underscore the point that people with disabilities are eminently capable of doing top-quality work in science and mathematics, Scadden—totally blind himself since early childhood as the result of a household accident—alludes with great pleasure to such historical figures as Galileo (who went blind) and Einstein (who was thought to be dyslexic), as well as to the renowned contemporary physicist Stephen Hawking—whose movement and speech are severely affected by amyotrophic lateral sclerosis, or Lou Gehrig's disease. "And do you realize," he asks, "that 17 of the periodic elements were

discovered by scientists with disabilities?" For its own sake, Scadden points out, society cannot afford to deprive itself of the potential for scientific progress that resides— and all too often remains untapped—in the minds of people with disabilities.

Scadden also notes that society in general tends to benefit from engineering, technology, and architectural innovations that were originally conceived to benefit people with disabilities. He cites, for example, closed captions on television, which were created for people with hearing impairments but are now used by millions of people who want or need to watch TV with the sound turned off. He also mentions sloping curbs—"curb cuts"—intended at first to help wheelchair-using men and women to negotiate intersections but now are a welcome accommodation to the elderly and adults with infants—not to mention, he says with a chuckle, bicyclists, delivery people pushing heavy dollies, and legions of skateboarding youngsters. "Generally," he says, "if you design a product—whether it's a consumer product or a classroom curriculum—in a way that it can be used by

> "Generally, if you design a product... in a way that it can be used by people with disabilities, it will be a better product for everybody."
>
> — Larry Scadden



The general conceptual goals of the project, says Stefanich, are threefold: to develop Teaching Students with Disabilities, a specifically tailored K-12 training module and collateral printed materials and video tapes; to provide insights on how faculty in higher education can best revise their teacher-education programs to accommodate the needs that students with disabilities may have in studying science; and to train approximately 60 leadership teams— each comprising a science teacher and a special-education instructor— who will plan, organize, and conduct local, on-site workshops.

The workshops are intended to train the teams to provide assistance to administrators, teachers, and parents in home districts in such matters as resources for people who are disabled, the improvement of services, and ways in which science instruction for students with disabilities might be improved.

Access Breaks the Silence

According to John Albertini and Harry Lang, co-principal investigators of a PPD-sponsored project called ***AESOP (for Access to English and Science Outreach Project)*** at Rochester Institute of Technology, the number of deaf students entering postsecondary education programs in the U.S. over the past 30 years has increased substantially. Unfortunately, they say, few of those students eventually choose to follow science- or mathematics-related career paths, one reason being the low quality of their secondary-level science and math instruction.

The premise of the AESOP effort is that deaf students will progress more rapidly in science education when they have full access, in high school, to the content and language of science and to information concerning the past accomplishments of deaf people in science professions. The project's primary goal, say Albertini and Lang, is to improve access for deaf students by using all of the best teaching practices in both science and English-language teaching, since — as with hearing students — a major predictor of success in science is competency in the English language.

> "Of all the barriers deaf people and those with other disabilities face, attitudes are the most serious. So our PPD project is critically important."
>
> — Harry Lang

A cornerstone of the AESOP effort is the hosting of regional workshops designed to provide science teachers and deaf students with instructional strategies and materials that take into account the changes,

people with disabilities, it will be a better product for everybody. Because you must have a multi-modality input of information into the design, the product is bound to be easier, more convenient to use."

To a great extent, Scadden says, the PPD initiative is predicated on his distinction between the words *handicapped* and *disabled.* "This is not just a matter of political correctness," he insists. "It has to do with the way people with disabilities view themselves and are viewed by society." The word handicap, he notes, derives from the phrase "hand in cap," and that is an image that serves no productive purpose in relation to men and women with disabilities.

"To me," says Scadden, "a handicap is the absolute inability to participate in an activity. A disability refers to a physical or sensory impairment that limits a function but does not preclude the performance of the activity if approached in an alternative way. I, for instance, have an impairment—I can't see. But this is not a handicap in most situations. I can't drive a car, and that's a disability of sorts. But I can get around, as long as I have friends with cars and as

long as there's public transportation. So, when it comes to moving around in a motor vehicle, I am indeed disabled—but I'm not handicapped. Now, if someone were to exercise a judgment for me, without my knowledge or against my wishes, that I—for my own safety, for example—am not fit to travel in any kind of motor vehicle, then, I certainly would be handicapped in that regard. My blindness could have been a handicap, if I had let it become that. But now I don't regard it even as a serious disability—it's really more of an inconvenience."

Karen Gourgey, who has seen nothing more than random, fleeting flashes of light in her entire life, Kenneth Barner, immobilized if not for a motorized wheelchair, and Harry Lang, who hasn't heard even the sound of his own voice since he was a teenager, concur with Scadden's semantic distinction. "My disability," says Gourgey, "is simply a fact of who I am. As long as I can work and live without hindrance, I don't feel handicapped whatsoever." Says

over time, that have influenced the teaching of science as it pertains to the deaf. The workshops feature visual and interactive presentations of scientific principles with explicit and interactive uses of scientific English. Above all, say Albertini and Lang, the workshops aim to explore the attitude and communication barriers that deaf science students and deaf scientists face and the science teacher's role in contributing to the breaking down of those barriers.

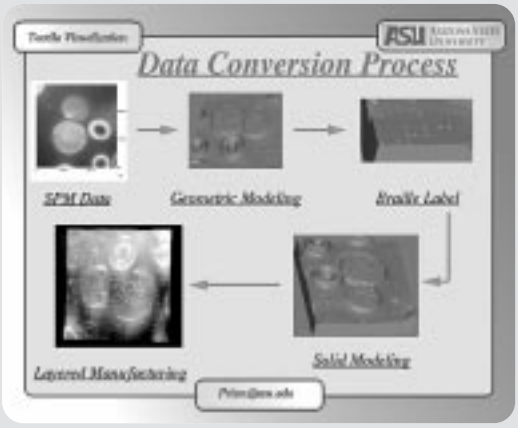
The project's strategic objectives are to develop coherent instructional strategies for teaching science to deaf students; to increase students' access to information about the accomplishments of deaf men and women in scientific professions; and to disseminate an effective model for enhancing learning by deaf students that includes the training of teachers in appropriate hands-on pedagogical methods.

Says Lang: "One of our deepest concerns has to do with teachers' attitudes and how the good teaching methods, once they are identified and developed, can be sustained, since teachers who are well prepared may go on to other positions, and those who replace them will need the same kind of preparation.

"Of all the barriers deaf people and those with other disabilities face, attitudes are the most serious. So our PPD project is critically important. There does not seem to be an easy way other than to have the resources to inform professionals, parents, and students themselves about the need to focus on abilities rather than disabilities."

Breaking Barriers…

A Touching Experience



Thanks to increasingly sophisticated computer technology, three-dimensional scientific visualization has become a valuable tool for scientists and instructors in learning and teaching about the structure of objects that are invisible to the normal human eye. "These days," says Anshuman Razdan, principal investigator of a PPD-sponsored project at Arizona State University, "many courses from K-12 to graduate level make use of and require understanding three-dimensional concepts." However, he points out, the visualization technique, normally entailing the transformation of numerical data into an image that can be viewed on a computer screen, has obvious limitations for people who are visually impaired.

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>
> —Larry Scadden

Barner: "My impairment has no effect on my ability to write articles, reports, and so forth. I feel that the capabilities of individuals with disabilities are tremendous—certainly much greater than the popular belief that society holds about them." And as for Harry Lang, he proclaims, "I have honestly grown to enjoy being deaf in terms of the opportunities it has afforded me to be a role model for deaf youth and in terms of how it has opened doors for me in science education for disabled students."

Plans for the PPD initiative were developed in 1991, shortly after the NSF's appointment of Luther S. Williams as Assistant Director and head of the agency's EHR directorate. Williams, an outspoken advocate of equity—that is, equal access for all students—as a necessary component of comprehensive reform in science and mathematics education, immediately invited Scadden to join the effort. Scadden, who has a doctorate in psychology and some 30 years of experience as

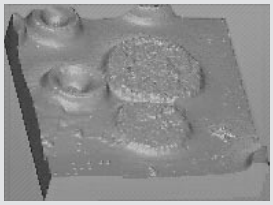
a researcher, teacher, consultant, and government advisor in the field of human sensory perception and the development of technology devices to aid the disabled, jumped at the opportunity.

"At the time," says Scadden, "the focus at NSF was on minorities, especially ethnic groups and women, and there were a lot of good ideas about what should be done for them to get into science." However, although passage of the Americans with Disabilities Act in 1990 had raised national awareness of the challenges faced by people with disabilities, Scadden notes, "virtually nothing was being done for them in terms of science and math access. Luther wanted to fix that, and so did I."

In September 1992, the first PPD award was made, a three-year grant to the University of Washington in Seattle for a project called ***Disabilities, Opportunities, Internetworking, & Technology,*** or ***DO-IT.*** The effort—focusing on high school students—was designed to address the underrepresentation in science, mathematics, engineering, and technology of individuals with disabilities and the specific obstacles young students with impairments face in transitioning to postsecondary studies and careers in those fields. The **DO-IT** project, whose PPD funding has since been renewed and remains vitally active, turned out to be the first of approximately 40 projects supported by the initiative over the past five years.

Currently operating with an annual funding budget of $5 million, PPD continues to center its activities on projects geared to address the

Razdan's project is attempting to remedy the problem by experimenting with a technique that allows data to be displayed in the form of a three-dimensional wax model—a tactile, rather than purely visual, representation of data. According to Razdan, the project, ***Scientific Visualization Using Tactile Feedback for Visually Impaired Students,*** has broad implications for blind students of science and technology who will have a better understanding of such structures as molecules and blood cells because they can hold models of them in their hands.



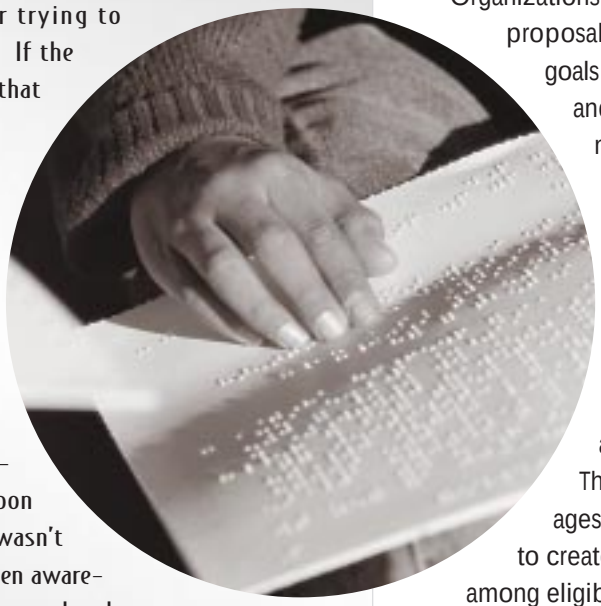
"The idea, conceptually, is very simple. "One can take a 3-D image," says Razdan, "scale it appropriately, convert it into a solid model, create a computer file per the requirement of the manufacturing machine, and, pronto, you have a tactile model. In reality, the process is somewhat more complex, and part of our project involves the development of software to make the process simple to use."

"Our goal," he says, "is to explore methods that bring the concept of scientific visualization to blind students through tactile feedback and then to incorporate this technique into science curricula for them. We believe that this would encourage and enable visually disabled students to pursue science, math, engineering, and technology courses that they otherwise would be unable to do."

A Man with a Mission

Few people inside or outside NSF know PPD director Lawrence Scadden as anything other than "Larry"—a good-humored, articulate, and relentless advocate for the rights of persons with disabilities who, waving his cane before him, negotiates the byzantinely laid-out corridors of the agency's Arlington, Virginia, headquarters with as much assurance as many visioned people can summon up.

Born to a poor family in Los Angeles 58 years ago and blinded at the age of five in a household accident, he is actually thankful that the accident that transformed his life occurred when it did. "By the age of five," he says, "I knew my alphabet and was reading—or trying to read—everything I could lay my hands on. If the accident had happened a year or so earlier, that wouldn't have been the case."



As it happened, the youngster's fascination with letters and love for the printed word spurred him to grasp Braille within an astoundingly short time—and his voracious reading habit soon led to a discovery that would also be a determining factor in his life: "In the school for the blind that I attended," he recalls, "I read everything on the shelves—animal stories, history, everything—but I soon exhausted the Braille collection. There just wasn't very much available at all for blind kids." A keen awareness of the paucity of educational materials for people who are disabled remains with him today. And the desire to correct the situation is, as he sees it, among the core elements of his PPD mission.

His interest in science grew when he was a teenager in the agricultural town of Stockton, California, where his father moved the family to pursue business related to the sale of farm equipment. "I became very interested in ham radio," he says, "and I figured that I would end up doing something in technology." But following high school, his interest turned to political science, largely because

needs of people with hearing, visual, orthopedic, and speech impairments. Increasingly, the initiative also is addressing the needs of young students with such learning disabilities as dyslexia and attention-deficit disorder, and, says Scadden intends to increase its attention to impairments stemming from mental retardation and emotional disturbance.

Organizations eligible to submit proposals to promote PPD goals include universities and colleges; nonprofit, nonacademic institutions such as museums, professional associations, private foundations, and community-based groups; state and local governments; and school districts. The Foundation encourages proposals that serve to create or build alliances among eligible organizations. It favors proposals that include plans for disseminating project findings and carefully reviews the dissemination efforts and achievements of successful projects when evaluating applications for continuing agency support.

Scadden and his PPD associates have awarded grants and invite

proposals for projects in three broad categories:

■ ***Demonstration projects,*** which design, implement, and evaluate innovative intervention strategies to reduce the barriers that inhibit the interest, participation, retention, and advancement in science, mathematics, engineering, and technology educational and career tracks of students with disabilities. These projects address such issues as access to appropriate science and mathematics instructional materials, media, technology, and laboratory experiences; availability of science-enrichment activities through hands-on experiences; interaction with role models and mentors; guidance in course selection; and career counseling. A demonstration project award may be for as long as three years, although requests for one or two years are also acceptable. A budget request of up to $150,000 per year is allowed.

■ ***Research and development projects,*** which address the needs of students with disabilities whose impairments may limit their operation of instrumentation, their access to laboratory experiments, or their access to customary presentation of pictorial, textual, and graphical information and data. These projects cover such issues as the identification

some of his teachers convinced him that because of his total blindness, he would have no future in a science- or math-related field — another salient recollection that continues to influence his work. However, although he had earned a degree in government at the University of Redlands in California and was studying for a master's in political science at USC with the notion of eventually becoming a lawyer, his love of science prevailed — and he began taking courses as a part-time student of psychology at the University of the Pacific. "I was hoping to find something that I could make my mark in," he says, "and then I found human perception."

"Much of the literature at the time was on vision, which was irrelevant to me," he says, "and I kept looking for things in auditory perception and the sense of touch. I suddenly realized that there was, after all, a place for me in science. There was a place for me in this field — there was nothing to block me!" In 1968, Larry received his master's degree in experimental psychology and was offered a position at the Pacific Medical Center in San Francisco, researching the application of technology to relieve the problems of people with visual or auditory impairments. Also, he enrolled in the Center's Ph.D. program, which he completed in 1971.

Soon recognized as an expert in the field, Larry began taking temporary breaks from his job at the center to conduct evaluations of emerging assistive technologies — a role that eventually led to his being appointed, in 1979, as deputy director of a newly created federal agency (now an office within the Department of Education) on disability research. By 1991, when Luther Williams invited Larry to head NSF's PPD initiative, he had not only found his place in science, he had become a nationally recognized authority on the needs of men and women with disabilities and the technologies and curricular advances needed to meet their needs.

Today, Larry Scadden, enormously pleased with the opportunity he has to help others, is quick to voice his appreciation for the people who made a difference in his life: his parents, above all, and the teachers he encountered from time to time who encouraged him by, as he says, "appreciating my ability and, even if they didn't know what to do for me, realized that they must let me advance to my own level."

Mobilizing for Progress

"As an engineer's son," says Ken Barner, "I was always interested in taking things apart, modifying them, and putting them back together. I always wanted to be an engineer." With that in mind, Ken entered Lehigh University in Bethlehem, Pennsylvania, in 1983, confident that he would move fluently through his college days and proceed from there to follow in his father's footsteps. But during his freshman year, a tragic diving accident at a fraternity party threatened to change all of that. The accident left him a C5 quadriplegic, with no use of his lower body and only limited use of his arms.

Ken refused to let his disability interfere with his quest. Only four years after the accident, he received his baccalaureate in electrical engineering—and by 1992, he had earned his doctorate in the field. Today, as a University of Delaware faculty member, he devotes the bulk of his time to a PPD-sponsored project aimed toward reversing the underrepresentation of people with disabilities in science- and math-related education and careers.

"For mobility," he says, "I use a power wheelchair, and I have a modified desk that allows easy access from the wheelchair. To type, I use either a speech recognition system or a special splint that holds a typing stick. For most endeavors, having a disability simply means alternative implementation methods must be developed and utilized."

Ken believes that the constraints experienced by men and women with disabilities are based primarily on the low expectations that others have of them. "Academic and business communities," he says, "often do not expect individuals with disabilities to succeed. As a result, individuals with disabilities are judged on false perceptions rather than on their true and demonstrated abilities."

of a task or information-gathering process that cannot be performed or perceived by students with one or more disabilities; methods by which alternative techniques or technology can be produced; and ways in which innovative techniques or technology can be widely disseminated. Research and development projects may be either one, two, or three years in duration, with funding awarded for as much as $200,000 per year.

- ***Information dissemination projects,*** which support innovative activities designed to disseminate program results and to promote the replication of successful strategies used to increase the recruitment and retention of students with disabilities or to enhance the quality of science and mathematics education. Through a variety of approaches, these projects are expected to reach elementary and secondary teachers and counselors, college and university faculty, and families of students with disabilities. Information dissemination projects are limited to $100,000 per year for two years.

In addition, to further promote information dissemination, PPD has awarded funds to institutions with prior program funding. These

schools have developed effective dissemination strategies to promote the institutionalization of activities and techniques launched during the prior award period that have stimulated increased participation and retention of students with disabilities.

The size, scope, and focus of the two dozen currently funded PPD projects vary widely. For example:

With Kenneth Barner serving as principal investigator, a project at the University of Delaware called ***Engaging, Recruiting, Retaining Students with Disabilities in Science, Engineering and Mathematics*** is striving to reverse the underrepresentation of people with disabilities in technology-related education and careers with a six-part effort: (1) involving families, counselors, and faculty in awareness training and "solution seminars"; (2) updating extracurricular science and mathematics programs on campus to accommodate the special needs of students with disabilities; (3) establishing an electronic mentoring program that allows students, faculty, and professionals with disabilities to exchange ideas via the Internet; (4) designing a virtual laboratory featuring equipment that provides students with disabilities full access to laboratory experiences through the use of instrumentation with simulation software and powerful workstations; (5) developing and testing inquiry-based science and mathematics materials for high schools that demonstrate that students with disabilities can engage in active, hands-on approaches to instruction and learning; and (6) establishing an information dissemination program that will ensure the sharing of the project's achievements with other institutions.

Under the leadership of co-principal investigators Karen Gourgey and Albert Blank, the ***Multisensory Calculus Program for Students with Visual Impairments*** at the City University of New York's College of Staten Island and Baruch College focuses on first-year calculus, using the most effective audio and tactile technology

> "For most endeavors, having a disability simply means alternative implementation methods must be developed and utilized."
>
> — Ken Barner

Inspiring Messages

Stricken with meningitis at the age of 15, Harry Lang was, as he says, "very lucky to come out of a coma—I was not supposed to make it. I was also very fortunate to have loving parents." Although he survived, Harry had become profoundly deaf, and dealing with his impairment was a long struggle for the teenager. His ordeal was significantly eased when his parents decided he should finish his high school education at the Western Pennsylvania School for the Deaf in his hometown of Pittsburgh. It was there, he says, that he "fell in love with science," and, upon graduation, elected to major in physics at West Virginia's Bethany College.

"However," he says, "there were no books at the time about deaf people in science careers, and I was uncertain what the future would be like if I pursued science." Despite his trepidation, Harry persisted, learning sign language and lip reading and "doing a lot of extra studying to keep up with my peers." Shortly after graduating from college, he found a position teaching physics to deaf students at Rochester Institute of Technology's National Technical Institute for the Deaf, where he has remained for the past 27 years, focusing on teaching and, during the past few years, heading a successful PPD project.

to provide visually impaired students access to graphical information. The project is employing such devices as scanners with optical recognition software and Braille printers (or speech-access systems for those who do not read Braille) so that conventional printed or displayed text material can be accessed by blind students. The project also is using enlarged display screens for students with lesser degrees of visual impairment and is developing tactile graphics devices that, combined with the new technology, will permit students to trace calculus-relevant graphics with their fingers while hearing essential information for each point being spoken audibly.

At Oregon State University in Corvallis, principal investigator John Gardner, a high energy physicist, is leading a team of technologists in a PPD project called ***Science, Engineering, Education, and Disabilities—or SEED—***whose goal is the development of computer-based audio systems that allow people with visual and learning disabilities to read, write, manipulate, and understand science, mathematics, and engineering literature. The software creates a hierarchical representation of a document that enables students to control the speed, style, and volume with which the text is

Breaking Barriers…

Independent Energy

Born into a middle-class Brooklyn, New York, family, Karen Gourgey did not allow her congenital blindness (she was born with inoperable glaucoma and cataracts) to keep her from energetically participating as one of six children in a household that she recollects as being "loud and a little crazy, but fun." Nor did she allow her disability to prevent her exercising, from the beginning, a singularly independent nature. "I always relished getting away and being on my own," Karen says. "From the time I was five, overnights were a major draw."

Following her early education in public school settings with itinerant specialized teachers, Karen left home to attend a residential high school for the blind and visually impaired—then took a major step toward independence and self-sufficiency by enrolling in a school far away from family and friends: Oberlin College in Ohio. After getting her bachelor's degree in psychology at Oberlin, she returned to the east to get her master's in English from New York University, and, in 1983, a doctorate in special education from Columbia University's Teachers College. Later that same year, she was appointed director of the Center for Visually Impaired People at Baruch College, a post she has held ever since.

> "My blindness is simply a fact of who I am. As long as I can live and work without hindrance, I don't feel handicapped whatsoever."
>
> — Karen Gourgey

effort leading to the creation of CD-ROM-based science instructional materials that are usable by people with visual disabilities. Headed by principal investigator Larry Goldberg, a computer graphics specialist, the project currently is developing standards for multimedia accessibility and, based on those standards, will develop design guidelines concentrating on CD-ROM instructional materials pertaining to science, mathematics, and engineering instruction, and will establish a program to disseminate their findings.

A project at the University of North Dakota in Grand Forks is implementing an effort headed by principal investigator Sue Schmitt, who has published extensively about disability issues, to increase science and mathematics studies for variously impaired elementary-level Native American students. Called ***Disability Research Encompassing American Indians in Math and Science (DREAMS),*** the project is working to increase the awareness of parents, school personnel, college faculty, and students about the educational and career options available in science- and mathematics-related fields, while also moving to enhance the curriculum, teaching strategies, and counseling options for

youngsters with disabilities. The project also has developed several summer institutes for school personnel, parents, faculty, mentors and role models, and students from schools on or near Native American reservations, with culturally appropriate activities designed to encourage the children's interest in science and mathematics and to reduce the factors that lead to their exclusion from educational and potential career involvement in those fields.

Although director Scadden feels strongly that PPD is making progress, he readily acknowledges that since even the oldest projects have been active for no more than five years, little quantifiable evidence is available at this point to support his optimism.

The author of numerous scholarly papers (including one titled *Mapping New York's Subways: An Adventure in Tactual Graphics),* a frequent lecturer on subjects of concern to the visually impaired, and currently the co-principal investigator of an ambitious PPD project at the center, she continues to work for the most part independently and at an intense pace, disdaining the notion that she is handicapped. "For me," she says, "the idea of handicap comes up only when my progress is stopped."

In some situations, she says, this can occur as a result not of her blindness, but rather from her "simple lack of knowledge in a specific field." To get around, she uses a travel aid—either a cane or a guide dog. In her work—which entails reading, editing, and preparing reports, letters, memos, and budgets—she relies on a wide variety of assistive devices, such as a computer with a speech card and appropriate screen-reading software, scanners that turn text into speech, and a computerized Braille note-taker for meetings.

For all of her independent spirit, Karen shares with other blind and low-vision men and women a sense of frustrating constraint. "We are not part of the general 'we' of society. We are not a significant part of the market. We are regarded as a low-incidence population, so that thoughts regarding access for us are still too often only afterthoughts. Neither our problems nor their solutions make it easily into the marketplace."

Her PPD activities, she hopes, will hasten the day when the world of science and math are made fully accessible to all of the people—including the visually impaired—who should be both the beneficiaries and the practitioners of those disciplines.

Program for Persons with Disabilities…

"There are some convincing numbers indicating that people with disabilities are doing better in science and math," he says, "but I don't think there's a way that you can tie those numbers back directly to the impact of our program. The only thing we can point to is our individual projects. For instance, some of our projects have gotten quite a bit of local coverage in their areas, and we get letters from folks who seem to be waking up. We get questions like 'Do disabled people really work in science?' That encourages us a lot. By the way, we know that there are about 100,000 people with disabilities working as active scientists and engineers in this country right now."

Another indication, he says, has to do with the number and quality of new proposals for PPD grants. "Last year," Scadden recalls, "we had 52 preliminary proposals, and this year about 100—and the quality of the proposals continues to improve." Scadden feels this is evidence that attitudes are changing and awareness within the educational community has been heightened. "That's a significant outcome, I think, and I'm really pleased."

One more sign of progress, he adds, is "the number and quality of students coming out of the projects. The first cohort of disabled kids who were in the University of Washington **DO-IT** program, for example, have graduated from high school now, and almost all of them are going on to college and majoring in science, math, or engineering. And the University of New Mexico graduated the first two of their PPD students, and they're both in high-paying jobs, one at Boeing and one at Hewlett-Packard. Those are the kinds of things we can point to and say 'It's working!'"

But Scadden emphasizes that the thrust of the program, at its current stage, is really more about creating leadership, breaking down barriers, and establishing a series of well-integrated and highly visible models than it is about the actual number of students served at any given time by any one project. The program has been particularly active in showing the way through its emphasis on dissemination of project results. Many of the projects have

established active sites on the World Wide Web, providing information on adaptive resources and identifying those practices that have proved effective. And many of the projects make use of the Internet and the Web to enable students with disabilities to interact with each other and with mentors, and to gain access to scientific and technical information from around the world.

Nevertheless, Scadden feels it is premature to think about expanding the PPD program at present. "For now, my major tasks are clear: To make sure that the phrase 'underrepresented groups' includes persons with disabilities in every document connected with NSF—that persons with disabilities are automatically included in every initiative. And I'm really concerned that we find a way to ensure that, throughout the country, all instructional materials, educational media, and modalities are usable by people with disabilities. If they are, I don't think we'll have the serious problem of helping these kids get the opportunity to compete."

The NSF study referenced on page 7 of this document is Blackorby, Cameto, Lewis, Hebbeler, & Hernandez. (1997). *A case study of persons with disabilities majoring in science, engineering, mathematics, and technology.* Menlo Park, CA: SRI.

> "For its own sake... society cannot afford to deprive itself of the potential for scientific progress that resides—and all too often remains untapped—in the minds of people with disabilities."
>
> — Larry Scadden

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For more information on the Program for Persons with Disabilities and links to projects, please go to http://www.ehr.nsf.gov/EHR/HRD/ or call 703/306-1636.

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