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ABSTRACT

This book includes four papers presented at a conference on teaching science to students with disabilities. The first paper, "Science Education for Motor/Orthopedically-Impaired Students" (E. C. Keller, Jr.), covers: (1) categories of motor/orthopedic-impairments, (2) life function assessment, (3) formal and informal science teaching methods and experiences for students with disabilities, and (4) past work on science education for students with disabilities. The second paper, "Science Education for Students with Disabilities: The Visually-Impaired Student in Chemistry" (H. David Wohlers), addresses challenges that students with blindness face, based on personal experience in acquiring a doctoral degree in chemistry and working as a chemistry professor. Challenges include attitude barriers, laboratory safety, access to theoretical and experimental data graphics, and adaptations of computers and lab equipment. The third paper, "Learning Disabilities" (Helenmarie Hofman), discusses: general education settings for students with learning disabilities; science education opportunities for such children; and strategies for teaching students with learning disabilities. The fourth paper, "Science for Deaf Students: Looking into the Next Millennium" (Harry G. Lang), provides recommendations on: 1) teacher training, (2) science materials, (3) scientific societies, (4) professional collaboration, and (5) involvement in national science standards efforts. Critical responses follow each paper. Appendices provide a summary of the recommendations of the conference working groups, a list of conference participants, and conference evaluation information. Each paper contains references. (CR)

A Futures Agenda:

Proceedings of a Working Conference on Science for Persons With Disabilities

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Supporting Associations

Science Association for Persons With Disabilities
American Association for the Advancement of Science
Association for the Education of Teachers in Science
National Science Teachers Association

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Table of Contents

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Introduction

A two day, invitational working conference on Science Education for Students with Disabilities, was held in Kansas City by the Science Association for Persons with Disabilities, a National Science Teacher Association associated group. The conference, funded through the Program for Persons with Disabilities of the National Science Foundation, was held on March 30-31, 1993.

Leadership for science literacy such as the NSTA's Scope, Sequence and Coordination Project with the motto, "every student, every science, every year," the American Association for the Advancement of Science's Project 2061 and its document, *Science for All Americans*, and the National Standards theme, " Science for All" provides a focus for full inclusion.

Seventy-three science teachers, special educators, administrators, curriculum developers and others representing 29 states, the District of Columbia, and Canada met with scientists and educators with disabilities to assess needs illustrating problems and issues confronting students with disabilities as students in science. Conference participants discussed the strengths, weaknesses, opportunities, threats, and relative value of science education for disabled students.

The enactment of the Americans With Disabilities Act in the summer of 1990 opened many doors for career-minded disabled persons. We must take full advantage of this legislation by making sure that students with disabilities are given the best education possible.

The population of practicing scientists today reflects a serious under representation of individuals who have had physical disabilities before or during adolescence. Studies indicate that frequently this situation is not due to a lack of ability or interest on the part of the students, but rather to inadequate science preparation in both elementary and secondary schools.

It has been suggested by Whitmore (1981) that as many as 540,000 students are gifted and have disabilities in the United States. In the past, services for these students have been primarily in the area of remediation resulting from their limiting conditions, not in the development of their talents and gifts. Special educators often do not have sufficient training in science to assist a disabled child with above average intelligence in the regular classroom. At the same time many science teachers tend to overlook attention to the learner with disabilities assuming that their needs will be responded to by special education personnel.

Redden (1978) investigated nationwide science opportunities for physically disabled youth. Results indicated that disabled students receive little science instruction, and what they do receive is not academically adequate to allow them to pursue science education or instruction in science-related fields as possible careers. The absence of appropriate science education for the disabled is further evidenced by the dearth of disabled persons within scientific fields.

The United States Department of Education(1990) Digest of Educational Statistics reports that 10.97% of all students in 1986-87 had a disabling condition, reflecting a population of 4,374,000 individuals receiving special services in schools. At the post-secondary level, the percentage of disabled students enrolled is reported at 10.5%, deriving a population of 1,319,229 students.

Weld (1990) states that lab designers and facilitators give a great deal of thought to the rich rewards to be gleaned from hands-on science at the high school level. Unfortunately, consideration is seldom accorded the physically disabled, and consequently, society loses all potential benefits it might have gained from their participation in lab work. For this reason, many students with physical disabilities often shy away from science.

The result of this lack of support is that many students become disenchanted with the system and many drop out academically and/or physically, or show recurring misbehavior. Paradoxically, many students simply may become compliant with the system and suppress their talents and gifts. One cannot just be concerned with the student's disability. It is important to view each as a whole person with emotional, social, and physical needs. When a disabled student arrives in a science classroom, it is important to remember that the intellectual growth of this student may have been compromised at some point due to the disability. Care must be taken to nurture the social skills of disabled students. Many special students need support to combat feelings of loneliness and to cope with low self-concepts. Although the great majority are well adjusted socially, there may be some who need to be eased into group lab work or other social situations. There may be a facet of learning that may be lagging whether is be writing skills, manipulation of equipment, or communicative skills. This requires a more acute sensitivity to the disabled student and a discreet flexibility until the goals for the course and the capabilities of the student are clearly delineated and understood.

The active collaboration of a team of educators, each lending his or her special expertise, is critical if we are to serve the disabled student in the science classroom effectively. When one looks at today's secondary schools with their departmentalization, administrative hierarchies, and large physical plants, it is easy to assume that someone else is responsible. Teachers who "excuse" disabled students from lab participation because of their disability are making an implicit statement that the student is incapable of doing something, even though there may be a number of adaptive solutions available (Weld, 1990). Many of the special adaptations are subject-specific, requiring cooperation of the classroom teacher and other specialists.

The importance of communication between teachers and students was also made clear. Teachers do not teach groups, they teach individuals, and each individual deserves their teacher's best effort. Teachers must be able to talk to their students and adapt to their special needs. For example, teachers should be flexible about their testing format; no one should argue that "enforcing the same time restrictions (or testing conditions) for all is the only way to be fair to the group." In no way should orally administering a test to a blind or quadriplegic student compromise any other person in the class.

Many students, including disabled ones, like to think that as adults they will be able to lead productive lives. They need to learn from their teachers that, in the sciences, they can earn professional recognition, be paid good salaries, and provide service to others. They also need to understand the intrinsic reward, such as enjoying problems that have baffled others. There are two ways teachers can help promote these ideas: (a) by mentioning relevant scientific developments and current scientists when teaching science topics, and (b) by being a exemplar mentor themselves (Weisgerber, 1990).

A failure to respond is a severe loss to both society and the individual. Many disabled individuals find themselves trapped in occupations which are totally inappropriate for their talents and abilities. We have a human and constitutional responsibility to all of our citizens. The authors of this monograph wish to enlist the participation of all teachers of science in meeting their responsibilities to accommodate instruction to enable all students to be active participants in all facets of learning.

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Science Education for Motor/Orthopedically-Impaired Students

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Science Education For Motor/Orthopedically Impaired Students by

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Introduction

Over the past two decades there have been several pieces of legislation, essentially starting with the Rehabilitation Act of 1973, which have, in part, been designed to eliminate the biases of ignorance, stereotyping, incompetence, and overt discrimination in education and career access against disabled individuals. These biases are deeply rooted and currently, for each developmentally disabled individual, begin in the early years of human development and, in our present society, can continue to death. People with later-onset disabilities have the shock of confronting discrimination just a few minutes, days, or weeks after the onset of their disability. The intervention and alteration of such bias can effectively be modified only by changing of behaviors and attitudes of the disabled child, his/her gate keepers, and all individuals in the general population. Legislation against such biased behavior is a good starting point, but it is not in itself the far reaching solution. Some fifteen percent of the United States population and a somewhat smaller portion of school children are disabled. There exists a significant fraction of disabled students of the school age population that need to be educated, as completely as possible, in the contemporary aspects of science, regardless of whether their interest lies in a science or technology career. Disabled students will get an equal chance at a good education, including science, only by having their teachers use the appropriate delivery systems and science learning environments in concert with the type and degree of disability that each of these disabled students possesses.

Legislative milestones are important as a reflection of public pressure and legislative response, as we have seen from the The Education for All Handicapped Children Act of 1975, the 504 regulations of the Rehabilitation Act (1977) and the recently passed Americans with Disabilities Act of 1992. However, what really matters is the non-stereotypic, broad understanding of the public, personnel at all levels of government, and the personnel of the education community as to the needs and the enormous potential of disabled individuals, and societal benefits of having a well educated and subsequently highly productive population of disabled individuals.

The mainstream education of motor/orthopedically-impaired students is usually a very effective way of providing science education to disabled students. Less severely disabled students are, most of the time, on a par in achievement with their non-disabled peers. It is a reality that the more severely impaired a student is, there is, on average, a corresponding decrease in the quantity and quality of science education presented to and accessed by the student. This unfortunate circumstance is primarily due to the elements of time, teacher knowledge, community concern and resources, and educational environment. By time, I refer to the greater amount of time that the teacher needs to give to a more severely impaired student than to a moderately impaired student or a non-disabled student. By teacher knowledge, I refer to the knowledge that the teacher has about the adequate delivery of appropriate and relevant mitigative strategies for that specific disabled student. By community concern and resources, I mean the community focus on their disabled sub-populations and the infrastructure to support such a focus. By educational environment, I refer to the facilities, atmosphere, and appropriate support framework that the teacher and the school system (or postsecondary institution) is able to provide to a specific motor/orthopedically-disabled student in order to achieve a quality and equitable education in science. The optimal appropriate educational environment for a specific motor/orthopedically-impaired student in science is not easily determined. There are many dimensions to this environment, which I will present below along with several factors of these dimensions.

In this paper I present five major sections; first, in order for the reader to know the breadth of disabilities that I am discussing, I present the major categories of disability that I consider to be motor/orthopedic-impairments (plus those resulting from chronic health problems). As a sub-section I give an overview of certain mitigative strategies that have been found to be effective in attempting to "neutralize" the impact of the specific disability on the learning content and process in science education.

The second section involves life function assessment. Not all students with a specific impairment will or can respond to the same strategies. Thus, we need to assess the functional attributes and limitations of each individual in an educational context so as to choose the most plausible and appropriate strategies to be used in the multi-dimensional science education environment.

The third section concerns formal and informal science teaching methods and experiences used in the science education of students with disabilities. Herein, I present the seven dimensions of science teaching methods used in science teaching. The strategies needed for the mitigation of specific disabilities in the lecture presentation are most likely not appropriate for most of the other six types of science teaching methods used, such as field trips. The change of teaching objectives and educational environments among the various science teaching methods requires that knowledge about the disabled student's life function impairment(s) be coupled with the teaching method and the teaching environment chosen for that aspect of the science curriculum. In this section is presented examples of specific strategies which can be used in the mitigation of specific types of motor/orthopedic disabilities.

The fourth section, past work on various aspects of science education for students with disabilities, is presented to give a general background of what has been reported previously. Many times, presentations are given with good theory, suggestions, and directions, but there is little to take home to use. This section presents the body of work in regard to motor/orthopedically-impaired students and the generally successful modifications/adaptations that have been used to assist students with disabilities to successfully achieve in science and math.

The last section, the bibliography, can lead to areas of specific concern as found in the literature to about 1990. The missing element in this literature base is that, due to a great difficulty in obtaining information in the traditional journals, mitigative computer applications and strategies about science education for students with disabilities are quickly out-of-date. They may be found published elsewhere or published in more computer-oriented newsletters or journals. I believe that this area will be one of the very useful mitigative strategies in science education for students with disabilities in the future in science, math, engineering, and technology.

Finally, it is one of the major purposes of this paper to provide a brief presentation of the teaching environment, adaptive strategies, modifications, etc., that have been examined for motor/orthopedically-impaired students. In several instances a particular article or report has been presented and referenced more than once. In these instances the article has relevance to the topic being presented in that section. The author would like your indulgence in these instances, since I hope that the topical design of this paper will justify this duplication.

The Major Types of Motor/Orthopedic Disabilities

The types of motor/orthopedic disabilities to be presented herein are selected because they account for most of the motor/orthopedically-impaired persons in the United States, according to Dudek et al., (no date). These categories have been grouped into the following seven categories.

1) Nervous system disorders
    - Traumatic spinal cord injury
    - Stroke
    - Cerebral Palsy
    - Epilepsy
2) Muscular-skeletal disorders
    - Rheumatoid Arthritis
3) Cardiovascular disorders
    - Coronary heart disease
4) Respiratory disorders
    - Emphysema
5) Digestive disorders
    - Cancer of the colon or rectum
6) Urogenital disorders
    - Kidney disease
7) Endocrine-metabolic disorders
    - Diabetes mellitus

Certain motor/orthopedic-impairments in the above categories, viz., stroke, coronary heart disease (including congenital heart disease), emphysema, cancer of the colon or rectum, and kidney disease, are not included in the following briefings because of their very low incidence in the target population.

The Major Neurological Disabilities

Neurological disabilities are those in which there is permanent damage to the central nervous system.

Traumatic spinal cord injuries result when the spinal cord is partially or completely severed. Such injuries are generally permanent. The location and extent of the damage determines the magnitude of the paralysis. If the damage to the spinal cord occurs in the back area, partial or total paralysis of the trunk and legs result. This condition is called paraplegia. If the damage occurs in the neck area, partial or total paralysis of both arms/hands and the trunk and legs results. This is termed quadriplegia. Characteristics of spinal cord injury can include the inability to walk, the loss of hand dexterity, bowel and bladder dysfunction, sensation impairment, etc.

Cerebral Palsy (CP) is a syndrome (a set of symptoms which occur together) that affects movement and posture and may be accompanied by language problems, seizures, mental retardation, and disorders of vision, hearing, other modes of perception, and speech. Because impairment may range from simply an awkward walk to severe dysfunctions, it is extremely important to use an assessment of life functions. Cerebral palsy generally results from an insufficient supply of oxygen to the brain before, during, and immediately after birth. There are also several other causes of CP. Cerebral palsy is commonly classified and described in the following three general forms:

a) Spastic - characterized by jerky, spasmodic movements.
b) Athetoid - characterized by rhythmic, writhing movements.
c) Ataxic - characterized by disorder in balance.

Spina Bifida is a congenital defect. Spina bifida occurs in embryonic development. The vertebral column fails to completely enclose the spinal cord. In some cases this results in a protruding sac that may contain cerebrospinal fluid or even parts of the vertebral column. Spina bifida is frequently accompanied by hydrocephalus or meningitis, which can result in mental retardation. The limitations of the student with spina bifida can range from weakness and reduced sensations in the feet to a total lack of sensation and movement below the waist. Therefore, some individuals will require braces and crutches and some will use a wheelchair most of the time. There are three general categories of spina bifida:

a) Spina occulta - This is the mildest form of spina bifida, and generally there is no neurological impairment or protrusion of the spinal cord.

b) Meningocele - This condition occurs when there is an opening on the vertebral column with a sac containing cerebrospinal fluid (but without exposing nerve tissues) protruding through the opening.

c) Myelomeningocele - This condition occurs when parts of the vertebral column (and hence nerve tissue), are contained within the sac that protrudes through the opening. This latter form is the most debilitating type of spina bifida.

Epilepsy is not a disease, but a malfunction in the electrical pathways in the neurons (nerve cells) of the brain. Epileptic seizures are a result of these neuro-electrical irregularities in the brain neurons. Anti-convulsant medication can either completely or partially control seizures in approximately 80 percent of persons with epilepsy. A major problem with students with epilepsy is seizures. Most other people have a constant opportunity to adapt to their disability, but the person with epilepsy not controlled by medication may function normally one minute and be in a seizure the next. There are four major types of seizures:

a) Grand Mal seizure is a major motor seizure that lasts from 30 seconds to six minutes. An "aura" such as a particular feeling or odor sometimes warns the individual with epilepsy of an impending seizure. During the seizure the person may thrash around, lose bladder and/or bowel control, vomit, and/or breathe heavily. After an individual has such a seizure, he/she may be lethargic and confused for several minutes or hours.

b) A Petit Mal seizure is a mild type of seizure which usually occurs more frequently than grand mal seizures. The petit mal seizure is characterized by momentary and frequently unnoticed loss of consciousness accompanied by rapid blinking, a vacant stare, the dropping of an object, etc. Teachers often mistake a petit mal seizure for day-dreaming.

c) A Jackson seizure is a seizure that begins with involuntary twitching in one part of the body but which may progress throughout the entire body into a grand mal type of seizure. This form of epilepsy appears more frequently in adults than in children. This type of seizure is also called "status epileptics."

d) A Psychomotor seizure is characterized by the person being in a trancelike condition, but yet displaying unusual behavior such as facial contortions, violent movements, or robot-like movements. These seizures may last from only a few minutes to several days. As with the Jackson form, this type of epilepsy is not common in children. Teachers frequently mistake these seizures for misbehavior.

Poliomyelitis (or "polio") is a viral disease, rarely encountered today in students, that attacks the tissue in the spinal cord. The individual is often paralyzed for life, thus requiring orthopedic appliances, surgery, and long-term medical care (Greer et. al., 1980). This disease is not progressive and treatment, although it often takes many years, may increase residual functions considerably. In that the polio virus affects only the neuromuscular system, it does not affect intelligence, speech, sensations, and bowel and bladder control.

Multiple Sclerosis is a disease of unknown cause characterized by slow, progressive degeneration of the central nervous system. It may cause visual disturbances, weakness/paralysis, difficulties with bladder control, or mild emotional responses.

Hereditary Ataxias are a group of conditions characterized by many non-coordinated muscular actions, particularly when voluntary movements are attempted. Such conditions all follow simple, predictable single-gene inheritance patterns. In addition, there are many other related conditions which do not appear to follow a simple inheritance pattern, but nevertheless are probably at least partially caused by genetic factors.

Major Orthopedic Disabilities

Orthopedic conditions are those involving defects in bones and/or muscles. The major types of orthopedic disabilities likely to be encountered in the target population are muscular dystrophy, rheumatoid arthritis, and amputation.

Muscular Dystrophy is the general designation for a group of chronic diseases whose most prominent characteristic is the progressive degeneration of the skeletal or voluntary musculature. They are, for the most part, hereditary conditions although spontaneous occurrence, as the result of genetic mutation, is not uncommon.

Three major types of muscular dystrophy affecting high-school age students are:

a) Pseudohypertrophic (Duchenne), which generally begins between the ages of two and six:

b) Facio-scapulo-humeral (Landouzy-Dejerine), in which the onset is usually in early adolescence; and

c) Limb girdle (including Juvenile Dystrophy of Erb), which may begin any time in the first three decades of life. Mental deterioration does not occur with muscular deterioration.

Rheumatoid arthritis is characterized by severe pain which is a result of inflammation and swelling in the joints and connective tissue. While the disease may begin as early as six months of age, it stops in about two-thirds of the children by 10 years of age; however, permanent and destructive bone alterations may have occurred by this time.

Amputation is the removal of any of the limbs. Amputation causes significant changes in lifestyles, but the educational mitigative strategies and life function limitations are quite similar to those of non-disabled individuals who have minimal or no use of their limbs due to other causes.

Chronic Health Problem

There are a variety of chronic diseases that are not "formally" considered to be motor/orthopedic-impairments, but certain of the outcomes do resemble the motor/orthopedic disabilities. These diseases are:

Hemophilia - an inherited coagulation disorder characterized by excessive bleeding.

Diabetes - a disorder of the body in the production of insulin, thus the inability to use carbohydrates, resulting in excessive sugar in the blood and urine.

Sickle Cell Anemia - a condition characterized by sickle-shaped red blood cells which reduce oxygen transport in the body.

Cystic Fibrosis - an inherited disease of the mucous glands throughout the body, characterized by pulmonary/respiratory disorders and chronic respiratory infections.

Asthma - a respiratory disease marked by labored breathing and coughing.

Leukemias - a group of cancers of the blood, characterized by a proliferation of the white blood cells.

Rheumatic fever - an infectious disease frequently resulting in damage to the heart.

Congenital heart disease - deficiencies in the heart and/or circulatory system present from the time of birth.

Tuberculosis - a communicable disease usually affecting the respiratory system.

Osteogenesis imperfecta - an inherited abnormality of connective tissue that may affect various organs causing fragile bones, short stature, or hearing loss.

Scoliosis and Kyphosis - diseases of the spinal column characterized by a curvature of the spine.

Table One: Function vs. Disability

	General Disability Area		
Life Function	Motor/ Orthopedic	Behavior	Chronic Disease
Health			
Mobility			
Communication			
Social/ Attitudinal			
Cognitive/ Intellectual			

Life Function Assessment

One of the first considerations in the effective education of motor/orthopedically-impaired students is an understanding of their impairment and the degree of educational limitation it can cause. With such information, a set of mitigative strategies can be derived that are specific and appropriate to that particular student. Without guidance or experience gaining an understanding of a student's impairment and educational potential can be difficult. As Calhoun and Hawisher (1979) note, "the combination and permutation of levels and types of motor impairment plus the number and levels of related disorders are limitless."

There is a traditional classification of motor/orthopedically-impaired individuals: orthopedic conditions, muscle system impairment and neuro-muscular disorders. Orthopedic conditions primarily affect the skeletal system, the joints, and the connective tissue (e.g., tendons and ligaments); muscle system impairment involves only muscle tissue; and neuro-muscular disorders concern impairments of motion and speech due to damage of some part of the central nervous system, i.e. brain and spinal cord. This classification, however, does not provide a thorough understanding of the nature of the motor/orthopedically-impaired student's disability as it relates to educational potential. A related problem is that people who rely on the traditional classification tend to think largely in terms of the degree of disability (the student limps, uses a cane, uses crutches, uses a wheelchair, etc.) rather than in terms of what particular individuals are capable or not capable of doing.

I, therefore, suggest the modification of Dudek's (no date) functional system of characterizations, the Life Function Impairment Assessment System, which is presented in Table 1. By defining motor/orthopedic-disabilities in terms of function, this system gives the teacher much better insight into the actual limitations caused by the disability, and since these are the attributes that affect educational activities, it is much easier for the teacher to select appropriate strategies for each disabled student.

For motor/orthopedically-impaired individuals there are three general disability areas: motor/Orthopedic, behavior, and chronic disease (such as emphysema or diabetes). There are, in addition, five categories of functional impairment, areas of concern that can be affected by a specific disability. The five categories of functional impairment are listed below:

a)Health - refers to the physical and physiological functioning of the individual.
b)Mobility - refers to operating and negotiating in the physical environment.
c)Communication - refers to sending and receiving messages with people and the environment. It includes hearing and vision.
d)Social/Attitudinal - refers to regarding oneself positively and interacting successfully with others.
e)Cognitive/Intellectual - refers to interpreting events, learning, and applying learning.

The two strengths of this system are that it recognizes the possibility: 1) that a motor/orthopedic-disability in one of three general disability areas can potentially create difficulties in more than one category of functional impairment and 2) that this system can be used with multiply impaired individuals so that they can be assessed for equitable educational delivery. For instance, a paraplegic individual can also have a health disability (such as brain disorder), other mobility problems (such as poor balance), communication problems (such as speech impairment), social and attitudinal problems (social isolation and lags in social/emotional/educational development), and cognitive and intellectual problems (difficulty in learning). Also, an individual can have impairments stemming from more than one disability - for instance, an orthopedic problem coupled with impaired speech or with diabetes. In such a case, any life function impairment caused by either disability would be recorded in the appropriate box for that general disability area. This table will then be used by instructors or other school personnel to consider the extent of the student's functional impairment(s).

Although we believe that some form of life function assessment should be completed for each motor/orthopedically-disabled student, this suggested life function impairment assessment system indicates the wide range of life function limitations that can be caused by an individual's motor/orthopedic-disability, or multiple disabilities. The life function impairment assessment system is particularly valuable to use with motor/orthopedically-impaired students, since motor/orthopedic-disabilities tend to have a broader range of life function impairments.

In order to give the teacher a realistic perspective on the variety of attributes of motor/orthopedically-impaired individuals, brief descriptions of the major motor/orthopedic- disabilities are provided below. In addition to neurological and orthopedic disabilities, some chronic health problems are also presented.

Science Teaching Methods and Experiences

To present the other dimensions or the factors to be considered for optimizing science education for motor/orthopedically-impaired students, use the general teaching methods of science teaching:

- Teacher presentation
- Active and passive laboratory work
- Reading
- Group interaction
- Audio-visual/tactile
- Research problem
- Active and passive field trips

Other more specific objectives or methods are sometimes present in formal science teaching, but I believe that the above list covers a majority of the situations in K-12 science education.

My experiences over the years have taught me two important lessons about mainstreaming: (1) the teacher is the "role model" for behavior toward the disabled student, i.e. the teacher's attitude and reactions, how she/he communicates and assists the disabled student will be the model for the other students, and 2) the disabled student must offer advice, constructive criticism, and information to the instructor and to his/her peers regarding his/her needs, the teacher must then integrate this advice into the teaching strategies for each student.

Since the early 1930's, reports document efforts in providing disabled students with relevant science education experiences through modified curricula and hands-on-activities. An enormous amount of work has been done in making science available to disabled primary and secondary students. However, virtually nothing has been published on the facilitation of disabled students in science in college/university programs from the baccalaureate to the graduate/professional levels. In the primary/secondary levels, considerable work has been done on formal curriculum content and assessment. Further, science education outside of the classroom has received a considerable amount of effort especially in museum education, nature trails, summer activities, and other outside-of-the-classroom activities (e.g. summer programs at sites throughout the country such as the Nature Center in Davenport Iowa, The Marine Science Center at Wallops Island Virginia, The Pocono Environmental Education Center). A few teacher training programs have been designed for the science education of disabled students (such as American University which operated in the 1970's, the University of Nebraska-Lincoln based on performance/competency and the Milwaukee Project in the 80's). Considerable work has also been reported on adaptive materials and equipment along with the strategies describing how to use them. And finally, considerable work has been completed on laboratory, lecture, test, and lecture adaptations.

Special Needs of Disabled Students in the Regular Science Classroom

A student with a motor/orthopedic-impairment may have deficiencies in educational background, limitations in experience, coupled with an inability to perform common life functions. As a result, a motor/orthopedically-impaired student often has special needs compared to his/her non-disabled peers. These needs are not generally related to intellect or mental ability, but they often affect educational needs. It is my belief that almost all motor/orthopedically-impaired students have special assistive needs to some extent, depending upon such factors as rehabilitating success, efficiency of medication, and the degree of disability, among others.

In order to accommodate and effectively teach the motor/orthopedically-impaired student, an instructor should have an understanding of the disability as well as its ramifications in the educational setting. The motor/orthopedically impaired student must have ample opportunities to communicate, via all modes of communication available to him/her. This opportunity is of utmost importance in the learning of science information, science concepts, science technology, and related processes. Optimal access to the information is also an important attribute in the mitigation of specific disabilities, e.g., speech impairment, or lack of upper limb use. Opportunities for experiencing science common to the non-disabled student may sometimes need to be programmed into a disabled student's maturation; however, the disabled student may not have been exposed to this type of learning in everyday living. It is rarely "built into" the curriculum found in either the mainstream classroom or in special schools. Opportunity for experiential learning however should be provided. In addition, there are incidental learning experiences which involve those common life events which most non-disabled children and young adults experience while growing up. Certain gaps in incidental learning may be apparent in the disabled student. Such students need to attain some easily available comparable experience in order to simulate those life events and learning experiences that his/her non-handicapped peers draw upon for adjunct educational information. The development of self-esteem and successes in learning are two areas that warrant special attention. These are critical in the maturation process of all students. But again, opportunities for these experiences need to be assured since they may be lacking, to some degree, in many motor/orthopedically-impaired students. Multi-level learning opportunities are needed in all learning situations but, again, may be lacking for the motor/orthopedically-impaired student. All students must be able to deal with complex theoretical issues and be able to relate advanced topics of knowledge to concepts already learned. Multi-level learning opportunities should, therefore, be built into the educational experiences for the motor/orthopedically-impaired student. Finally, part of the overall strategy for the neutralization of disability in the mainstream educational environment is providing successful role models and promoting recognition that a *motor/orthopedically-impaired student is just another student who happens to have a disability.*

General Comments on Mitigative Strategies for Motor/Orthopedically-Impaired Students

Motor/orthopedically-impaired students need access to all learning resources. If a classroom or faculty office is inaccessible, it will be necessary to find an alternative classroom or office.

If breaks between classes are short (10 minutes or less), the student who uses a wheelchair or walks with braces and/or crutches may regularly be late for his/her next class. Frequently, the student must wait for assistance in opening doors (unless electric doors are available), and maneuver along crowded pathways and corridors. It is appropriate to discuss the situation with the student having these problems and to seek solutions. A "buddy-system" where an able-bodied student opens doors, etc., has proven effective in some schools.

If class involves field work, ask the student to participate in the selection of modes of transportation and possibly the selection of sites. The school is required to provide accessible transportation for students who use wheelchairs.

Classes taught in laboratory settings will usually require some modification of the motor/orthopedic-impaired student's work station. Considerations include increased knee clearance under the student's desk or bench, lower working counter top height, reduced horizontal working area, and increased aisle widths, though perhaps for only one aisle (Blumenkopf, Swanson, and Larson, 1981). Working directly with the student on what needs to be done may be the best way to determine modifications to the laboratory work station. However, if a work station is modified in accordance with established accessibly ASNI standards, then it will be usable for most students in wheelchairs. There is also a Portable Science Station now available designed especially for wheelchair bound students. The station can be moved from laboratory to laboratory as needed.

The motor/orthopedically-impaired student should be allowed to benefit from the laboratory work to the fullest extent. If the assistance of an aide is required, the motor/orthopedically-impaired student can give complete instructions to the aide, including what chemicals to add, what type of test tube to use and where to dispose of the used chemicals. The motor/orthopedically-disabled student in a lab science can learn virtually everything except the psycho-motor manipulations of the equipment and materials.

Many motor/orthopedically-impaired students using wheelchairs are not always confined to their wheelchairs. They often transfer to automobiles and to furniture. Some who primarily use wheelchairs can walk with the aide of canes, braces, crutches, or walkers for short distances. Using a wheelchair some of the time does not mean an individual is faking a disability. It may be a strategy of conserving energy or for moving quickly.

Since the motor/orthopedically-impaired student may have social adjustment problems which "spill-over" into his/her classroom, laboratory, research, and field trip activities, it is imperative that the teacher, instructional assistants (aides), and other school personnel understand his/her situation and accept him/her as a student wanting to learn. The acceptance of the motor/orthopedically- impaired student by the teacher can have a great influence on his/her acceptance and understanding by his/her peers. At times, the teacher may have to go beyond his/her usual approach to teaching. For example, during a class discussion the teacher may need to specifically ask for the student's opinion. This will allow the student an opportunity to be perceived by the other students as a thinking individual.

Most students who use a wheelchair will ask for assistance if they need it. Teachers shouldn't assume automatically that assistance is required. Offering assistance (but not insisting) and accepting a gracious "No, thank you," will serve teachers and aids well.

Motor/orthopedically-impaired students must have opportunities to communicate and, in many cases, the opportunity must be deliberately provided, since there is a tendency for isolation from peers. Further, the disability should not be used as an excuse for non-participation in all regularly assigned oral presentations.

When talking to a student in a wheelchair, sit down, kneel, or squat, if the conversation continues for more than a few minutes, in order to maintain the same activities that require speaking. Even if he/she has adjusted to a speech impairment, new situations may aggravate old anxieties. It is important that self-expression be encouraged, but pressure to speak is not apt to be helpful. It is important to allow time for a speech-impaired student to express himself so that confidence can be gained. It is also important for the instructor to accept and respond to all appropriate attempts at communication. When speaking to a speech-impaired person, continue to talk naturally. Instructors should strongly resist the temptation to complete words or phrases for a speech-impaired person.

For persons who cannot speak and who are otherwise physically disabled so that they cannot sign, write, or type, various communication aids are available. These aids may range from sophisticated electronic "speaking" machines activated by punching a keyboard with a head pointer or mouth wand, to a spelling board consisting of the alphabet and a few common words and phrases when the speech-impaired person points to the letter and words on the spelling board, an assistant or the teacher may then speak them. Some devices provide a "ticker tape" print out, or display the message on a calculator-like screen across which the letters move. With less portable devices, the message is displayed on television screen.

Depending on the severity of the impairment, various adaptive methods may be required for the speech-impaired student. Many of the adaptive methods suggested above will also be appropriate for the speech-impaired students. Some speech-impaired students will require no adaptive methods at all, but most will need the patience of the group, encouragement, and an opportunity to develop self-confidence in an unfamiliar group.

Mitigative Strategies: Specific Motor/Orthopedic Disabilities

There are some general mitigative strategies that are unique to certain of the motor/orthopedical disabilities. We present these strategies here since they do not fit easily into the above specific strategies.

Short Stature - Students of short stature will have in-classroom access problems similar to those of a student in a wheelchair. Additional problems involve seeing demonstrations, chalkboards, etc. Fatigue may also be encountered; hence, some of the students may use a walker, cane, or crutches.

Epilepsy - The appropriately medicated student with epilepsy will have little problem in the classroom. In most cases, seizures will be controlled by the medication. Students with epilepsy will generally have learned to manage their seizure activity through adequate rest, proper diet, and regular medication. Most students with epilepsy will be able to participate in sports and lead active, normal lives.

Foster et al., (1977) offer the following suggestions to teachers of students with epilepsy:

a) *Attend an information/sensitization program on epilepsy.*
b) *Know the type of seizures the student might have.*
c) *Know how to deal with the student's type of seizure.*
d) *Know the safety factors that should be considered.*
e) *Know the type of medication taken and its possible side-effects.*

Spina Bifida - Spina bifida can be a reason for an ostomy. The student with spina bifida may also have short stature and may use a wheelchair, braces, or crutches. Classroom modifications that may be required will depend on the student's life function limitations.

Muscular Dystrophy - Strategies for students with muscular dystrophy again depend upon the severity of the condition, state that if the condition is mild, the student will have adequate independent living skills and will require no special instruction and modifications. However, if the condition is severe, the student will have acquired little physical independence. These students will require strategies similar to those needed for students with the lack of, or abnormal use of, their arms and legs.

Rheumatoid Arthritis - The student with rheumatoid arthritis has different needs than most other motor/orthopedically-impaired students. For instance, during periods of increasing pain, the teacher will need to be patient and allow more time for educational activities to be completed. Calhoun and Hawisher (1979) state that rheumatoid arthritis may interfere with school attendance and after school activities. Physical endurance will probably also be affected. The disease may result in permanent deformities that may restrict mobility, thus making walking for any length of time extremely difficult. Further, during peaks of incidence, the student with arthritis may experience stiff, painful joints as well as fatigue, thereby resulting in a "cranky" and sometimes hostile student.

Mitigative Strategies: Chronic Health Problems

There are a variety of chronic diseases which may result in considerable student absenteeism. The teacher may need to spend extra time with the student to help make up missed classroom work or arrange for some home-bound activities. These diseases may also require some, though not extensive, mitigative strategies. The most common of these chronic diseases and their educational implications are presented below:

Hemophilia - While students with hemophilia should avoid contact sports and sports involving excessive strains on joints, they should not be excluded from all physical activity. In fact, moderate exercise is necessary to protect the joints from severe bleeding (Foster et. al, 1977).

Diabetes - In lower school grades the diabetic student may require mid-morning snacks and frequent trips to the restroom. As the student becomes older, he/she will have developed a more regimented schedule, and the teacher will only need be aware that the student is a diabetic in case of an insulin reaction (Love, 1978).

Sickle Cell Anemia - The student should be given a schedule that does not call for vigorous exercise. The student's parents or the medical personnel of the school should be notified in the event of discomfort or pain. Additional problems that may occur as a result of sickle cell anemia include:

a) Delayed growth and puberty
b) Urological problems
c) Heart failure
d) Stroke
e) Severe limitations if the bones and joints are affected (Calhoun and Hawisher, 1979)

Cystic Fibrosis - This condition is not a communicable disease, but a congenital, inherited one. But because cystic fibrosis is a respiratory problem and feared by those not knowledgeable about its noncontagious nature, peer acceptance can be a serious problem. Also, since cystic fibrosis is a respiratory problem, the instructor should be aware that the student will fatigue more easily than other students (Love, 1978).

Asthma - During an asthma attack, the student will have difficulty breathing due to the closing of the small bronchials of the lungs. The asthmatic student should be provided with the appropriate medicine (as determined before-hand) and given a chance to rest during and immediately following an attack.

Rheumatic Fever - The student may have to miss school for long periods of time during convalescence. While the student's physical activity may have to be altered, reinfection is a problem of which the instructor should be aware.

Congenital Heart disease - Symptoms that the teacher should be aware of in interacting with the students who have heart disease include: shortness of breath, chest pain, tendency to faint, rapid heart beat, and fatigue. The student will probably need to be limited in activities which require strenuous physical exertion, and may also require shorter school days and periods of rest (Calhoun and Hawisher, 1979).

Leukemia - The educational implications of this type of cancer depends upon the seriousness of the disease. If acute, the student's life expectation will be shorter than his non-affected peers, and he/she may eventually require a home-bound tutor as the disease progresses.

Tuberculosis - Tuberculosis is an infectious disease. Students with tuberculosis must therefore attend hospital schools in the early stages of the disease followed by some form of home instruction. After the disease has been arrested, the student can return to the regular classroom. Upon return to the regular classroom, students with tuberculosis of the bones or joints will need to avoid strenuous physical activities.

Scoliosis and Kyphosis - Students with scoliosis or kyphosis may require a schedule of restricted mobility. They may wear a Milwaukee brace day and night, except while bathing and exercising, for about two years (or until the spine is positioned correctly). The brace is restrictive,and the student will not be able to sit in a conventional chair while wearing it (Calhoun and Hawisher, 1979).

Osteogenesis Imperfecta - Students with "brittle bone disease" will need to avoid strenuous physical activities and may, in their early years, be susceptible to a high incidence of bone breakage and fractures (Calhoun and Hawisher, 1979). This condition usually persists into adulthood.

Other Information on Mitigative Teaching Strategies

Students use wheelchairs as a result of a variety of disabilities including spinal cord injury (quadriplegia and paraplegia), cerebral palsy, polio, multiple sclerosis, severe arthritis, amputation, and muscular dystrophy. Wheelchairs come in a variety of styles and sizes, and many types of optional attachments are available. Wheelchairs are either manually or electrically powered. Students who are unable to propel the chair themselves might use an aide or an electrically powered wheelchair. However, being assisted by an aide who pushes the chair creates a dependance on another person that most students prefer to avoid. Some of the standard accessories that a student may add to their wheelchair are special seat cushions (to prevent pressure sores, which result from long periods of sitting), tote bags that attach to the chair back or arms, and trays that fit over the arms that are lower in front, so that the chair will fit under a regular-height desk or table.

To a student with a wheelchair, the wheelchair is part of the person's body space. No one should hang or lean on the chair since that would be similar to hanging or leaning on the person. Doing so is fine if you are good friends, but inappropriate otherwise.

A student sitting in a wheelchair is only about as tall as most young children, and since a pat on the head is often used to express affection toward children, many people are inclined to reach out and pat the wheelchair student on the head. Such a gesture is patronizing and demeaning. Pat him/her on the back or shoulder instead.

Motor/orthopedically-impaired students must be given opportunities for incidental learning, as pointed out earlier. Learning and motivation of the motor/orthopedic-impaired student are improved by the successful use of role models in science careers. Further, some degree of success at various tasks and educational experiences is extremely important for the motor/orthopedically-impaired student. The science teacher should be aware of these needs in planning the student's science experiences.

History of Science Education for Students with Disabilities: Curriculum Content

Science Enrichment for Learners with Physical Handicaps (SELPH) is a project based on Science Activities for the Visually Impaired (SAVI) materials (Tunnicliffe, 1987). In using SAVI, teachers recognized the potential, with some modifications, for its use with students having other disabilities (Anonymous, 1980c). SELPH, designed for children in grades 4 through 7, employs a multi-sensory approach to teach science to vision-impaired, orthopedically-disabled, learning-disabled, hearing-impaired, and multi-disabled students. In addition to the five aforementioned modules of SAVI, there are four others included in SELPH: measurements, magnetism and electricity, kitchen interactions, and environmental energy (James, 1987). Each module contains an insert for the teacher with information about modifications in equipment and procedures appropriate to particular disabilities (Anonymous, 1980c). The applications of SELPH include: 1) the teaching of science concepts, 2) the development of science process skills, 3) the improvement of manipulative skills, 4) the enhancement of language development, and 5) the motivation of learning and its integration into the classroom. SAVI and SELPH were developed at the Lawrence Hall of Science, University of California, Berkeley (Anonymous, 1976-79).

Ball (1978) described the Elementary Science Study (ESS) as a "hands-on" program in interdisciplinary science curriculum for special education, grades one through twelve. The 28 activities of ESS include such topics as Mirror Cards, Pattern Blocks, Clay Boats, Mapping, and Earthworms. Overviews, objectives, methods, and time requirements are provided with each activity.

Coble (1977) described a curriculum in science and mathematics for disabled students in mainstreamed classrooms. The curriculum consists of two sections, each with 36 weeks of activities. Each lesson has a daily objective, a section on teacher preparation, and descriptive pictures. Some of the science activities are: describing the colors, size, and shapes of objects; observing changes in matter; friction; and gravity. Some of the math activities involve learning to count, fractions, and the metric system.

Parallel Science Materials (PSM) is a modified and adapted multi-sensory curriculum in the life and earth sciences written at an "easy" reading level for disabled students mainstreamed into regular classrooms (Barkey, 1979). In PSM there are fourteen life and earth science units, each containing objectives, activities, teacher guidelines, vocabulary, experimental procedures, discussion, and questions. Kaschner (1978) described another multi-sensory earth science program that included soil type identification, stream table erosion, and relief map activities.

Part 2 of "Science for Handicapped Children" for ages 11 through 16 consists of science activities in the following areas: 1) chemicals around the home, 2) electricity, 3) ice and water, 4) forms, 5) candles, light, and hot air, 6) strength of materials, and 7) a collection of several short activities on various science topics (Jones, 1983). All of the materials needed for the above experiments are readily available and easy to assemble. Another elementary science program for disabled students in Milwaukee, adapted from the Handicapped Project at the Manitoba Science Center, includes subjects ranging from "Air and Water" for grade one to "Heredity" for grade six (Swanigan et al., 1982b). Other early general science curricula were reported by Botts (1934), (1932a), Gibson (1932), Hurst (1933), and Myers (1935, 1943).

Manuals from the "Initial Learning in Mainstreaming Project" (ILMP) covered several areas of mathematics including: 1) least common denominator, 2) multiple multipliers (to 3 digits), 3) off base 10, working with years, months, weeks, and days, 4) off base 10, working with hours, minutes, and seconds, and 5) long division to remainder. The program was developed to teach mathematical concepts to mainstreamed disabled students. Each manual includes tests, worksheets, and pages which can be made into transparencies for projection (Tipton, et al., 1976a; 1976b; 1976c; 1976d; 1977). The ILMP led to the development of another series of three mathematical concept manuals for mainstreamed disabled elementary students. Subjects covered in the manuals are: 1) subtraction (regrouping), 2) the carrying process, and 3) rounding numbers. These manuals also consist of tests, worksheets, and pages which also can be made into transparencies (Kingston, 1976a; 1976b; 1976c).

Other disability-adapted curricula offer such diverse classes as health careers (Beller, 1978), educational experiences at a zoo (Berkovits et al., 1980), ornithology (Daniel, 1954), sex education (Enis et al., 1972, Knappett et al., 1976), fishing (Frith, 1980), dendrology (Heisler, 1944), horticulture (Lee, 1983), gardening (Piltz, 1968), and nature study (Vaughn, 1929-1930).

Evaluations of Adapted Materials or Programs

Several of the references contained evaluations of programs, adaptive materials, modified teaching methods, etc. for use in teaching science to disabled students. Chibrowski (1988) wrote of the development of a text analysis task that can determine if a textbook contains enough effective teaching strategies for disabled students. Several programs and projects were also evaluated. Searle et al. (1973), Hadary and Cohen (1978a), and Peterson and Sullivan (1982) all wrote articles concerning the evaluations of several instructional programs for disabled students. Berger (1978) reported on the evaluation of a project designed to encourage physically disabled students and adults to enter some facet of science as a career.

Science Education Outside the Classroom

Science education outside the classroom available to disabled persons is herein grouped into three general categories: 1) museum activities, 2) nature trails, and 3) summer programs.

Museum Activities: Chapter five of the Educational Work in Museums of the United States is entitled "Museum Work for Handicapped Children," and presents lesson plans for blind children in the American Museum of Natural History in New York City as well as other activities by museums in other parts of the country.

Not until 1979 were activities of disabling conditions other than visual-impairments included in the area of museum education. The inadequacy of physical accessibility of the museums for orthopedically/motor-impaired individuals probably caused this delay. Schatz (1979) stressed that museums are natural resource centers that can easily provide in service workshops for adapted science activities for disabled people. A conference on "Access to Cultural Opportunities: Museums and the Handicapped," (Anonymous, 1979a) included the desire of disabled persons to be able to visit the museums of the nation as a regular part of their life experience. This publication also mentioned the importance of developing museum staff sensitivity.

Once museum access and staff sensitivity are in place, the preparation and encouragement of disabled persons to visit museums can be addressed. The conference group also found that "shared information and encouragement will be an important factor in making museums fully responsive to handicapped constituents." Kenney (1981) discussed increasing the accessibility of exhibits and described several ways of encouraging disabled persons to visit museums and ways to reach this audience. The Metropolitan Museum of Art has developed a manual, "Museums and the Disabled," (Anonymous, 1979b) which describes an accessible gallery tour. The museum used information from disabled people to make changes to accommodate them. This publication also presents information on programs for reaching disabled persons who may not be able to arrange museum visits.

Nature Trails: Utilizing a wide diversity of plants and animals, nature trails are also a means through which disabled people can learn about nature. The article by Garvey (1968) discusses access problems and presents some solutions to the problems. In the literature, most of the adaptive nature trails reported have been modified for vision-impaired individuals.

Summer Programs and Camps: Several publications exist that pertain to summer camps and programs for disabled students. Stern, et al. (1981) published a book entitled, "Out-of-School Programs in Science" based on information assembled during the AAAS project "Integrating Handicapped Students in Special Science Enrichment Programs." The book contains a sample of important out-of-school programs in science listed by state. Frost (1984) wrote an article entitled "Choosing a Summer Camp" that provides a framework for helping parents evaluate a camp to make sure it will meet the needs of their disabled child. Recommendations are offered to help the parent choose a camp that offers a well-rounded variety of activities.

A controversial topic on summer camps was integration or segregation of disabled persons and non-disabled persons (mainstream vs. targeted programs). Robb (1973) stressed the need for more studies regarding the absolute value of integrating or segregating disabled students in summer programs. Robb described Camp Allen for Handicapped Children in which many positive results were observed which resulted from the interaction of children with various types of disabilities and those with no disabilities. Keller and Schroyer (1981) found very positive interactions/results of not having vision-impaired, hearing-impaired, nor motor/orthopedically-impaired students together in one program. Also, Bain (1975) reported on a camp for disabled/non-disabled students in which positive interpersonal interactions and program outcomes were observed. The South-End Day Camp is an eight-week summer day camping program with 700 disabled and non-disabled students in integrated groups. He stated that "the effect of this program is one of educating all involved."

Lustig (1976) discussed the analyses of two nature centers in Maryland. Data were collected to determine critical parameters affecting use of the facilities by disabled clientele, so that recommendations could be made to rectify problem areas. One of the recommended actions was the acceptance of modifications in nature center programs and facilities to attract elderly and disabled people. Cloutier (1982) described how a disabled person can hike a rocky trail in a wheelchair at the Pocono Environmental Education Center. In addition, two publications (Anonymous, 1970; Robb et al., 1984) provide detailed instructions on outdoor science activities for disabled students to enable them to become more conscious of their environment. Two other programs for young physically-disabled children have taken advantage of the seashore environment. The first of these overnight camps was designed to acquaint New York City school children with crabs, rails, and other wildlife along a Manhattan beach (Kessin, 1982). The second camp, in Delaware, exposed its disabled participants to beach, bay, and marsh environments (Watling, et al., 1974).

Hoyt, et al. (1978) presented advice to teachers of physically disabled students about field trip difficulties. He also gave examples of adaptations and modified lesson plans. Polloway, et al. (1985) presented information on instructional strategies for a variety of teaching methods, including field trips.

In a series of articles which were published in the late 1970's and early 1980's, Keller described field programs in Marine Science held at Wallops Island, Virginia (1982a; 1979). This NSF-supported program was designed to more formally introduce outstanding pre-college disabled students to the marine sciences through instructional classes, field work, shipboard activities, off-campus experiences, and mini-research projects. The adaptations for field exercises developed for vision—hearing—and motor/orthopedically-impaired students were summarized in a resource book entitled *Mainstream Teaching of Physically Disabled Students in Science* (Keller, et al., 1983). A similar summer program currently in operation at the same site is now limited to students with hearing impairments (Keller, et al., 1991).

An interesting series of activity guides for elementary teachers was produced by the Handicapped Children's Nature Study Center in Davenport, Iowa. The guides fully utilize the five senses and are constructed for use by both disabled and non-disabled children (Anonymous, 1970). A ten-day Outward Bound wilderness training course, the first of its kind for motor/orthopedically-impaired individuals was described by Bisbing (1976). The group included six disabled students, five non-disabled students, and some non-disabled instructors. In another program, adaptive fishing for physically and visually-impaired children and adults was reported by Firth (1980). The topics and experiences ranged from types of habitats to lures to fishing techniques.

The Georgia State Department of Education (Anonymous, 1984) produced a six chapter guide designed to help Georgia science teachers incorporate new strategies into the science curriculum of the local schools. Included in this guide are adaptive field strategies and experiences for disabled students. Also, a special education teacher's guide for environmental studies was published in 1980 (Anonymous, 1980b) by the Ontario Ministry of the Environment. Brief indications of the difficulties to be encountered with certain types of disabled students are given before each activity. However, adaptive measures or strategies for accommodating disabled students in such activities were not presented.

Laboratory Adaptations

Although there is considerable overlap of coverage within most relevant articles between the adaptive teaching methods, materials, and equipment for science and engineering education, a certain sub-set of articles was found with a focus on adaptive laboratory exercises, methods, and equipment interfacing with disabled students.

Coville (1932b) presented criteria for selecting appropriate laboratory materials for use in teaching science laboratories to disabled students. An example is presented as a simple project involving root, stem, and leaf systems. An article on agricultural laboratories adapted for motor/orthopedically disabled students was published by Ashley (1968). Likewise, a system of constructing radio and electronic circuits without solder was presented. This program is consistent with the modern physics syllabus of England (Pickles, 1973). Guidelines for laboratory-based math and science for disabled students were presented by Post, et al. (1976). Later, Larson, et al. (1978) published an article on college-level disabled students in science laboratories. Both general and specific solutions provided for problems in science laboratories for students who: lack coordination, experience weakness in hands and/or arms, have communication problems, have impaired spatial/visual perception, and/or the inability to follow sequential instructions. Further, three adapted junior high school experiments concerning 30 scientific principles were presented by Jones and Barnett (1980).

Blumenkopf, et al. (1980) described laboratory modifications for orthopedically disabled students in college chemistry laboratory classes. Also, an article on the design and modification of college chemistry laboratories for motor impaired students was given by Brindle, et al. (1981). Furthermore, several adapted laboratory exercises illustrate aspects of chemical reactions, as described by Loeb (1981). Moore (1981) presented a series of designs for college chemistry laboratories to help facilitate impaired students' mobility in performing laboratory exercises. Also, Moore and Blair (1981) described a rolling laboratory platform for mobility-impaired students. The wheelchair is fastened to the platform and allows the student to use stand-up laboratory benches. Miller, et al. (1981) reported on a variable height wheelchair which can be used in laboratories with different height lab benches.

Foley (1981) summarized the problems associated with teaching biology to motor/orthopedically disabled students. He presented adapted techniques for both lectures and laboratories, without changing course content. Mathematics laboratories for disabled students are given in the handbook series published by the National Education Association and edited by Brockman (1981).

Swanson and Steere (1981) reviewed the safety records of motor/orthopedically-impaired students in chemistry laboratories and concluded that "the majority of physically handicapped individuals face no greater risk and pose no greater hazard in a laboratory setting than do their able-bodied counterparts." Gerlovich (1986) also addresses the safety of disabled students in science laboratories along with some of the litigation factors involved in addressing these concerns.

Reese (1981) edited a manual which was published by the American Chemical Society on adapted teaching methods, equipment, and materials for teaching chemistry to disabled students. It was designed primarily for the college chemistry instructor focusing on familiarizing instructors with the practical aspects of teaching activities. Presenting "hand on" laboratory experiments was the focus of the report by Swanigan, et al. (1982b). Exercises in the handbook begin with grade one for "air and water" and progress to "heredity" in grade six. Anderson (1982) described a simple, inexpensive, and easily implemented approach for introducing motor/orthopedically-impaired students to the use of chemical instrumentation.

Jones (1983) published a book with science activities for disabled students ages 11 through 16. The first part of the book presents information for teachers, parents, and curriculum planners involved in curricula for disabled students. The latter part of the book consists of a number of science activities and experiments. Adaptations were also presented for various educational environments, e.g., in school, at home, and at the hospital. In addition, two papers reported on the accommodation of physics laboratories for mobility-impaired students (Frinks, 1983; Frinks, et al., 1985). These papers identified potential problems and solutions for the science education of disabled students.

Davis and McCowen (1986) recounted the experience of providing and strategies used in a chemistry laboratory for a student who had cerebral palsy. LaPemina (1986) reported on an adaptive set of science laboratories in a five credit physical science course at the junior and senior high school levels. The adaptive methods were designed for neurologically-impaired students. Specific information was given on how to proceed in producing these adaptive learning environments.

Adaptations

Texts: Several articles discussed adapting texts - some modified in content, others in form - for students with various types of disabilities. One article emphasized the need to improve the use of science and social studies books by disabled students (Chiborowski, 1988). A second article described an experiment with disabled and non-disabled students that compared programmed-text adapted math classes to traditional lecture methods (Bornstein, 1964). Little difference was found between these two methods for elementary algebra and plane geometry, but the students in the programmed-text classes performed better in the intermediate algebra classes.

Tests: A resource book devoted solely to testing techniques for disabled students for teachers was published by Brown, et al. (1980) which made suggestions and presented strategies to assist in the development and administering of tests for various types of physically-disabled students.

There were also a number of articles pertaining to specific types of tests for disabled students. Rescigno (1988) described criterion-referenced computer tests, which allow students to proceed at their own pace. They are being used in mainstreamed classrooms to determine if content objectives have been mastered. A pilot study that was reported by Allen (1974) revealed a need for adaptive revisions of the Intermediate Science Curriculum Study (ISCS) test. Additional materials were produced to help disabled individuals take the Maryland Functional Math Test (Anonymous, 1989), including a booklet containing a section listing adapted math tests for disabled students (Braswell et al., 1988).

Lectures: A number of articles have been written concerning the modification of lectures for disabled students. Pappas (1950) examined several types of modifications to the content of class lectures for disabled students. Sheinker and Coble (1981) and Spagna (1991) proposed alterations that could be made to the style of the lecture, whereas Awad and Wise (1984) made suggestions related to lecture assignments. Parts of papers by Jones (1979), Foley (1981), Reese (1981), and Keller, et al. (1983) discussed altered lecturing techniques and motor/orthopedically disability-unique strategies. In his paper, Travis (1990) pointed out some general considerations for classroom lectures for disabled students. Banks (1979) presented the technique of outlining and distribution to students of lecture objectives. His article also included unique strategies for students with different types of disabilities and elements of consideration for optimal science education of motor/orthopedically-impaired students.

Computer Usage: The advent of the use of microcomputers in education has made it important for teachers to become familiar with this technology and acquire the knowledge and techniques to use them effectively in the classroom (Gray, et al., 1982-1983). In 1979 Goldenberg stated that even though the computer technology exists, it is not being utilized to its fullest capabilities in regard to disabled persons. He maintained that "after a few minutes of computer training, a severely handicapped person can match in style and detail the typical performance of a bright, able-bodied person."

Due to the rapid and continual changes in computer technology and adaptation for disabled persons, I will not report on the more formal aspects of this area. The most recent up-date of this literature is the 1990 IBM resource guide that is concerned with computer adaptation and usage for disabled persons in all areas of endeavor (Anonymous, 1990). This is clearly an area where great benefit would result from a more precise literature search and review.

General Adaptive Methods, Materials, and Equipment: With the advent of programs designed to mainstream disabled students in science classrooms, laboratories, and field experiences, there has been concern with respect on how to adapt the institutional instructional methods, materials, and equipment that have been traditionally used to accommodate disabled students.

Throughout the literature there were numerous articles concerning physical disabilities in general. Papers by Tombaugh and Davis, Sharpton, Szymanski-Sunal and Sunal (1981), Anonymous, (1980a) and Anonymous (1981c) were among a few of the publications written about science for disabled students. Ricker (1979b) made suggestions for developing materials and making the appropriate adaptations for integrating physically disabled students into the science classroom. Other articles by Yuker, et al. (1967a; 1967b), Tombaugh (1981), and Tunnicliffe (1987) described modified or special equipment designed for disabled students. Further articles indicated concern over providing teachers with classroom strategies, general considerations, and various teaching suggestions (Anonymous, 1981b; Anonymous, 1988; Keller, 1983; Stefanich, 1985; Travis, 1990; Tunnicliffe, 1987; Vacek, 1984; Wagner, 1981). Hofman, et al. (1978) noted a lack of information available about the performance of disabled students in a mainstreamed science-educational environment.

"Mainstreaming" math and science was defined and discussed by Metsker and King (1977) and information was given on the physical limitation of students with orthopedic, vision, and hearing impairments. Teachers were encouraged to learn sign language and help children learn self-acceptance and independence. Activities were presented for strengthening math skills and the student's familiarity with the environment.

Cochin and Herman (1979) described a program at the New Jersey Institute of Technology where disabled participants were involved in the development of skills, adapted methods, and adapted devices which enabled them to overcome barriers arising from their disabilities. Many examples of devices and materials were presented. Davies and Dech (1980) reported on the research results and literature that is available to the science teacher in the mainstream program. One of their focal points was the learning and conversion aspects of the metric system.

Disabled students, ages 11 through 13, from a "special" school (with only disabled students) were taken to a "regular" school (which had no disabled students) where the disabled students had access to science apparatus in a laboratory (Raynor, 1983). The disabled students were given extra time, if needed, to complete the science modules. When provided with these opportunities, the disabled students showed progress in overcoming the lack of knowledge and retained a strong interest in science.

Piper (1979) strongly recommended the use of activities when teaching disabled students. A teachers' guide and an article by Ball (1977) provided ESS units that can be used for disabled students in grades 1 through 12. The emphasis of these units is for "hands-on" activities. Another article by Tunnicliffe (1987) related how a "hands-on" multi-sensory science curriculum for disabled elementary children was developed from the adaptation and merging of SAVI and SELPH activities. Details of both projects were given in three papers (Anonymous, 1976-79; Anonymous, 1980c; Tunnicliffe, 1987).

Brown (1979) reviewed the literature on teaching science to visually—auditory—and orthopedically-disabled students. The article gave science teachers of disabled students an overview of state-of-the-art, adaptive methodologies for teaching science to disabled students. Later, a paper by Noel (1966) showed the effectiveness of placing more emphasis on functional academic skills when teaching disabled students. Benson (1980) produced a handbook which describes problems, provides adaptive approaches, and gives specific modifications to be made for individualized instruction of disabled students. Bennett (1982) reviewed problems and precautions in teaching science to disabled students. Methods were presented to circumvent several of the concerns raised. In a book about teaching elementary science, edited by Abruscato

(1988), there is a section on methods of teaching science to disabled children and a bibliography of resources.

A paper by Burns (1974) gave details and diagrams of apparatus for coordination, shape, color recognition, number work, matching, and other math skills for elementary special education classes. Later, Bybee (1979) presented guidelines to assist science teachers in effectively teaching disabled students. A program for presenting science instruction to hospitalized elementary children was presented by Dewsbury and Jones (1984). Resource materials were produced to accommodate children in wheelchairs and those with additional disabilities.

Thornton (1979) discussed the advantages of teaching geometry to students with disabilities. Further, Brockman (1981) edited a teachers' resource book for teaching mathematics to disabled students in kindergarten to grade 12. The twelve papers covered a wide variety of topics including teaching mathematics to visually-impaired students, teaching physically-disabled students in regular math classes, and teaching the mechanics of telling time to disabled students. Fennell (1984) discusses the requirements under PL 94-142 in developing Individualized Educational Plans (IEP's) for each disabled student. He presented teaching strategies, diagnostic techniques, and learning environments, in teaching mathematics to disabled students. Similarly, Fleischner (1985) gave an overview of instructional practices in teaching arithmetic to disabled students.

Fusco (1977) provided teachers of orthopedically-disabled students with a framework and resource base to assist in planning programs for such areas as science and mathematics. Goodstein (1974) discussed the importance of using pictorial aids with disabled children to develop word problem skills in addition and subtraction. Grondin (1988) gave guidelines useful for teachers in promoting disabled student learning. He also presented a variety of adapted teaching methods. A source book by Hofman and Ricker (1979) has ten presentations on various aspects of science education for disabled students ranging from mainstreaming strategies to science education specifically for the various types of disabled persons.

An article by Hoyt, et al. (1978) gave a wide variety of adapted methods for teaching science to disabled students. Barriers, attitudes, field-trip difficulties, and adapted lesson plans were presented, along with other topics. Further strategies used in eighth-grade science classes were given by Johnson, et al. (1985). Two books by A. V. Jones (1986; 1983) present a large number of examples, strategies, adapted materials, adapted equipment, etc. for teaching disabled students science. A.V. Jones (1988) and Webster and J. Jones (1990) discussed a report by a British advisory group concerning attainment of targets, programs of study, and the assessment of science methodology for disabled students in a human biology course.

In several publications, Keller presents unique adaptive methods which can be applied to various teaching situations (e.g., lecture, laboratory, research, seminar) in the science teaching environment (1981a; 1981b; 1982b; 1983). The Milwaukee Public Schools produced a science teachers' handbook for disabled students in science (Anon., 1982b), that offers information on adaptive methods and ideas for teaching disabled students in the mainstream classroom. A source book published by Switzer, et al. (1980) was designed to provide educators with information on mainstreaming K-

6 disabled students in science. The source book has a section on identifying and evaluating materials, a section on student materials, and a third on teacher materials. Other handbooks with lesson plans, science objectives, teaching techniques, and/or student activities for disabled students in science education were described by Tipton and Kingston (1976a; 1976b; 1976c; 1976d; 1977), Stephens, et al. (1977), Swanigan, et al. (1982a) and three anonymous authors (1977a; 1982a; 1984).

Lambie and Hutchens (1986) adapted materials, instruction, assignments, and learning environments for disabled students in ten of the more difficult areas of elementary mathematics. A summary of a twelve lesson course was given concerning the history of the solar system, tides, principal constellations, etc. Aids and adaptations for science classes with severely disabled students were also presented. Guidelines also are offered on precautions to take and other adaptive methodologies to use (Leach, 1982). Maheady, et al. (1987) presented findings about 9th and 10th grade peer-mediated instructions involving mildly disabled, mainstreamed students. When these instructions were followed, both group and individual math scores showed significant improvement.

A few articles have been written about individuals with cerebral palsy and certain aspects of science teaching. When teaching children with cerebral palsy, two articles reported that the needs of each child must be interpreted and teaching methods must be adapted to meet these needs (Anonymous, 1966). A paper by Davis and McGowen (1986) described how a college chemistry student with cerebral palsy obtained help from a laboratory assistant who would assemble the apparatus and manipulate the small equipment for various experiments. Two other publications included descriptions of a program in which engineering students design devices for people with cerebral palsy (Newell, 1990) and the other publications reported on a study that was conducted to test the effectiveness of several different methods for individuals with cerebral palsy (Nicholson, 1969).

Teacher Training

The need for the development of programs to sensitize and train current science teachers and future science teachers to the unique needs of disabled individuals was stressed in the literature (Lang, et al., 1978; 1983). Lang suggested that programs should include an awareness of attitudinal, communicative, environmental and other barriers, methods, and materials which have been successfully employed with disabled students.

The programs should also include approaches for testing and evaluation, psycho-social consequences of mainstreaming, and career planning aspects. Basic skills should be stressed as a foundation on which students can develop their ability to work out more complex problems. According to Lang, educators of future teachers of disabled students need to develop courses whose objective is to sensitize science teachers to the special needs of physically-disabled students as well as to reach the conclusion that science is an integral component of the school curriculum (Lang, et al., 1983).

One of the recommendations of the National Science Teachers Conference on Science Education for Physically Handicapped Students was for the education of prospective classroom personnel to teach science to disabled students (Ricker, 1978). Also recommended were inservice programs to provide school personnel access to current information on teaching science to disabled students. Reported in the literature resulting from the above conference were recommendations for teacher education, one of which was that pre-service teachers be sensitized to the fact that all disabled students should have opportunities to pursue science-related careers, equal to those of the non-disabled students (Anonymous, 1978; Ricker, 1979c). Ricker (1977) also described a pre-service science education course especially designed for special education teachers.

A performance/competency-based teacher education program was described at the University of Nebraska-Lincoln. The Nebraska University Secondary Teacher Education Project (NUSTEP) was "an attempt to build an integrated and well articulated professional education program based on a set of competencies to which the college is committed." Special methods, learning theory and principles, and pre-student teaching practicum experiences are the three components of the program. Competency areas covered are: instructional planning, direction of learning experiences; assessing and evaluating; the teacher as a "humanizing agent," the professional educator, and subject area leader (McCurdy, 1978).

A teacher's guide for revision of "Science" and "Spaceship Earth-Life Science," is an adaptation of an existing commercially available school science program. Part of a teacher workshop deals with how to implement the above adaptations for the use of the program with disabled students (Sunal, et al., 1981).

Two of the programs involved the establishment of "centers" which allowed "hands-on" training of both inservice and pre-service teachers. "The Milwaukee Project" was a mainstream demonstration and inservice center designed to provide teachers at all grade levels with the background training needed for involving disabled students in regular science classes, following the regular curriculum, and using no special or unique equipment. Both inservice and pre-service teachers learned through observation and direct involvement in modifying science laboratory activities and materials to insure the success of their disabled students (Anonymous, 1982b).

The Center for Educational Research and Innovation (CERI) offered both in-service and pre-service training for teachers of disabled adolescents (Hameyer, 1980). Topics at the center were focused on mathematics and environmental education.

Later, the adequate pre-service preparation of elementary teachers was also pointed out as a persistent problem in elementary education (Anderson, 1979). In describing science education needs in regard to disabled students, Redden (1984) stated that elementary science teachers do not generally have special training to facilitate science learning for disabled students. Two of the major needs stated were: 1) teacher training and certification in adaptive/modified teaching strategies for disabled students, and 2) special education teachers should take science as part of their pre-service training.

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Response to Ed Keller's Presentation: "Motor/Orthopedically-Impaired"

Science Education for Mobility Impaired Students

by

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This paper deals with three major issues: an appropriate education for students with disabilities in elementary school and high school; an appropriate science and mathematics education for students with disabilities, whether they go to an integrated or special school; and appropriate techniques for assisting students with disabilities in college. I will emphasize students with mobility impairments, but it is difficult for me not to think in terms of all students with disabilities. As a result of The Education for All Handicapped Children Act, all children with disabilities are required to have an individualized educational plan (IEP) developed for them annually. The IEP should be developed by an appropriate team that may include a school administrator, teachers, counselors, parents or guardians, medical people and, even the student.

Mobility-impaired students with at least normal intelligence can often function in an integrated setting quite well. During my elementary and high school education in the 1940's when schools were not accessible, it was apparent why students in wheelchairs were unable to go to public schools. Today, because there is a tendency to place a greater number of students, sometimes inappropriately, in special education classes than in the past, it is possible that even more students are segregated than when I went to school.

In 1988, the International Center for the Disabled (ICD) in cooperation with the National Council on Disability (NCD) published "Report Card on Special Education in Public Schools," which revealed the necessity to improve the education of students with disabilities. This nationwide survey of educators, parents, and students with disabilities, prepared by Louis Harris and Associates, {1} suggested that education for students with disabilities would become more effective if the following changes were instituted: increased funding, of course; increased individualized attention to disabled students; increased cooperation between special education teachers and public school teachers; disability awareness for educators; improved vocational programs and preparation for higher education; increased parental involvement; organized parental support; and information centers for parents outside the school.

I contracted polio at the age of almost three and received my elementary education in hospitals and in special segregated schools. Until recently, children with serious mobility impairments, such as wheelchair users or those who walked with crutches and braces, as I did, received home instruction because schools and buses were not accessible. However, when I came home from the hospital at the age of ten, my mother urged the doctor to let me go to school rather than receive home instruction. In the 1940's, an elementary school student in New York City with a motor impairment and/or chronic illness would be placed in a segregated classroom located in the basement of a public school. Generally, grades would be combined; for example, first grade through fourth in one room and fifth through eighth in another. The education offered, too frequently, was not especially stimulating. Since I was not being challenged in the school I attended, I spent most of my time reading.

It was not until high school that I was integrated into regular classes with nondisabled students. However, if my mother had not insisted that I go to school, I think it doubtful that I would ever have become a mathematics professor. Neither home instruction nor special segregated classes generally include science, languages, nor mathematics beyond arithmetic. Friends of mine, who received segregated high school educations, had to make up all these subjects before they could go on to college. One of them, Anne Emerman, the Director of the Mayor's Office for People with Disabilities in NYC, was required to overcome her inadequate education as well as to cope with her disability. Few disabled people have the capacity, willingness, and good fortune to persevere in this way.

Major accommodations that mobility-impaired students require include accessible transportation to and from school, accessible school buildings and campuses, assistance by means of adaptive materials or equipment for functioning in classrooms and laboratories, and personal assistance for functioning in school. Inclusion of students with disabilities in elementary schools and high schools means more than just placing them in physically accessible environments. Inclusion, for each student with a disability, means providing appropriate services when and where required as part of a total school program. If accessible transportation is not provided; if schools are not accessible; if adaptive materials, equipment, or personal assistance is not available; or if there is no resource room for a child, a parent can help his or her child by demanding these facilities and services as part of the IEP. Furthermore, if necessary, legal action is a useful alternative.

Some people believe that students with other disabilities may benefit more by a separate education. A blind woman I know said that the current view of blind adults is that blind students should first receive mobility training; then, she said they should learn braille, the typewriter, and the braille keyboard before they are integrated into regular classrooms. It has also been suggested that many deaf students and learning disabled students benefit by a segregated education, at least in their early years.

For some students, even in their college years, a segregated education is preferable to an integrated one. For example, there are deaf students who choose to go to Gallaudet University, a liberal arts college for students who are deaf or to the National Technological Institute for the Deaf at Rochester Institute of Technology.

Children with disabilities need to be given the same options as nondisabled children. However, counselors have traditionally steered disabled children away from technical fields. In an effort to deal with this problem, the first Science and Mathematics Enrichment for the Disabled program (SMED) was held, in the summer of 1986, at New Jersey Institute of Technology (NJIT). The five week summer program provided sixth to eighth grade students with physical disabilities including mobility and visual impairments, profound deafness, chronic illnesses, and learning disabilities with exposure to technical career options and an introduction to skills needed for success in technological fields. Classes included hands-on instruction in science and mathematics as well as computer science and personal and career exploration. Several adult disabled role models—generally engineers, scientists or students at NJIT—shared their struggles, experiences, accomplishments, and insights with the students to encourage them to pursue technical fields. On campus, they visited the robotics laboratory; the modern library; and the MacroLab, a specially designed laboratory to make it possible for disabled students to pursue a scientific program at the college level. They also went on three all-day field trips. These trips included visits to hands-on science museums such as the Franklin Institute in Philadelphia, PA; the New York Hall of Science in Queens, NYC; the Trailside Nature Center at the Watchung Reservation in NJ; and a sail on the Clearwater, an educational and conservation sloop.

(Other hands-on science museums include the Liberty Science Museum that recently opened in Jersey City, NJ and the Museum of Science in Boston, MA. New Dimensions for Traditional Dioramas, a book by Betty Davidson (no date), describes a project at the Museum of Science in Boston in which a gallery of traditional window dioramas was augmented with multisensory interactive components. "By incorporating diverse learning styles and sensory modes ... visitors teach each other. Before the changes, only 19% of the groups visiting the exhibit could name any of the adaptations they observed in the exhibit. Afterwards, 100% of the groups interviewed answered this question with a much greater range of appropriate answers."

Students selected for the SMED program primarily came from special schools in the Newark area, segregated by disability, where little or no science or technical courses were offered. The program was developed because the poor quality of education often received by disabled students was most apparent in technical fields. The SMED program improved each year it was funded, and a National Science Foundation evaluator described it as very important and innovative.

Those of us involved with SMED realized that a summer enrichment program is important, but it is not enough. If a segregated education is considered necessary or preferable for any disabled children, then it is beneficial for those students to have instructors who can teach them science and mathematics at least ten hours a week in the classroom.

I would like to suggest this idea to Judy Heumann, whom President Clinton just appointed Secretary of the Office of Special Education and Rehabilitative Services (OSERS). Heumann is an activist who sued the New York City Board of Education in the late 1960's when her application to obtain a teaching license was rejected because of her disability. Although the suit was settled out of court, the publicity it received served as the impetus for founding Disabled In Action (DIA) to fight for equal access and other civil and human rights struggles. (DIA is the group that won a federal lawsuit in 1984 which required that all NYC buses be lift-equipped. The Americans with Disabilities Act (ADA) (1992) now requires all local buses in the United States to be accessible to people in wheelchairs.) Recently, Heumann co-directed the World

Institute on Disability where she brought the concept of independent living to countries around the world.

Technology has enormously improved opportunity for mobility-impaired students, making independent living a reality. Motorized wheelchairs, lift-equipped buses, as well as computers that can do almost anything, make integration of mobility-impaired students into regular classrooms preferable most of the time. Rehabilitation engineering is a relatively new field where an accommodation is specifically fitted to a person with a disability. Students, graduating with bachelor's or master's degrees or even certificates in this field, are required to do a practicum that often necessitates that a device be adapted for a particular disabled person. These rehabilitation engineers can help mobility-impaired students and those with other disabilities function with increased independence in school and in society.

Almost all college students with mobility-impairments that I have encountered have attended integrated schools. In other words, the lack of integrated education for students with disabilities appears to dramatically decrease the probability that students will go to college or will live up to their potential. The socialization skills learned in an integrated setting may be as important as the improved quality of education these students receive.

Many college students with mobility-impairments are survivors of accidents. Accident survivors have generally developed a sense of identity before they became disabled and they frequently expect their lives to be similar to what they envisioned them to be before the onset of there disability. On the other hand, students who were disabled since birth, or in early childhood, often have had segregated and relatively poor education, as well as inadequate socialization resulting in low self esteem. Students with disabilities entering college with an appropriate elementary and high school education, good socialization skills as well as an awareness of their rights and power, have a good chance of living successful and rewarding lives.

The most effective technique for assisting college students with disabilities to attain their goals is not to do everything for them, but instead to empower them to be their own advocate and problem solver. Not too long after I began teaching, I had a student who stuttered. In my class, I ask students to put problems on the board and explain them to the class. When this student started to explain his problem, he stuttered quite a bit. As a result, I told him that I would explain the problem to the class. However, before the class ended, I realized that what I did may not have been appropriate. I thought if someone did that to me, I would have been very angry. So when the class ended, I asked him what he preferred. He said he would rather explain problems to the class himself. This student not only received an A in the course, but he also asked me to be his thesis adviser. His thesis was on 12 tone music and he did not need me at all. By the way, as the term progressed his stutter diminished greatly.

To foster college students with disabilities taking charge of their lives, it would be useful for them to organize committees, like support groups, in every college open to all interested members of the college community, such as students, teachers, counselors, administrators, and staff people. A support group, meeting at least monthly, could serve as a place where ideas are exchanged and problems are confronted to ensure communication and protection of rights for people with disabilities. Later, students with disabilities may want to form groups of their own, a development to be encouraged.

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Response to Ed Keller's Presentation: "Motor/Orthopedically-Impaired Students in Science"

by

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Dr. Keller begins his presentation by defining various kinds of disabilities which he categorizes as motor/orthopedic disabilities. As he states, many students having these disabilities will require extra attention from the classroom teacher. Physical accommodations such as access to the classroom or lab, a buddy-system to help manipulate materials, and modified equipment are extremely important in making it possible for students to work independently with their peer group.

When thinking about a student with a motor or orthopedic disability, the classroom teacher must be careful not to assume that the student with a motor/orthopedic disability is incapable of functioning well in intellectual areas or has deficiencies in specific educational and other life experiences. While this may be true for some people, for many others, it is not. It depends on the circumstances surrounding the person at home and during the pre-school and elementary school years and the support systems that were available to assist the person and the family in making choices for an appropriate education. It also depends on, as Dr. Keller states, the attitude of the teachers and their willingness to get accurate information from each individual student, about her or his specific needs.

As a child with cerebral palsy, I grew up in a home environment filled with friends, chores, expectations and family disagreements, like many other homes around me. I was encouraged to function like any other child. Like my friends who did not have disabilities, I remember having many hopes and dreams for what my life would become. I was very curious about the world around me.

During my school years, however, some of those dreams started to fade. I felt that more attention was paid to my disability than to my academic strengths. For grades first through third, I attended a day school for students with physical disabilities where I went through rigid therapy routines, but somehow managed to become a good reader and did well in most of my lessons. I received some encouragement for performing well, and it was with mixed emotions that I was mainstreamed into a regular fourth grade in public school where my teachers did not convey much enthusiasm about me or my ability to learn. As long as I made passing grades, everyone was happy. The thing most puzzling to me was that I was never asked my opinions about my own needs and interests. Nor could I ever get enough information or encouragement to nurture and build on my curiosity, which is a prerequisite to becoming a scientist. No one really thought about physical accommodations or creative ways to enhance my ability to perform academically. I was excused from activities and field trips that might have been difficult for me to manage, and people were understanding about my slow handwriting. Access to computers was not an option in those days, although I did eventually use a typewriter for homework. If I hadn't been so talkative or insistent about trying to participate in everything, my ability to learn might never have been noticed at all!

As an adult working for an organization devoted to education in science and math, I feel envious when I hear Dr. Keller speak of hands-on science projects for students with disabilities, and the many educators who have paid attention to the importance of developing adaptations in the classroom and lab. In college, botany and geology were areas of science in which I was interested. But, I had difficulty with some of the work, especially in lab assignments, many of which required fine motor coordination movements. No one offered techniques or strategies that might have facilitated my learning. Again, I just did the best I could on my own. I remember the frustration of not being able to draw and diagram leaves or flowers, or manipulate sample gems and rocks so that I could understand their formations. The most helpful advice I remember receiving was from a physician who suggested I take a pack of carbon paper to lectures and ask fellow students to carbon copy their notes for me. A lab assistant would have been helpful as would have been some technology such as special attachments on microscopes to steady my head when I studied tiny specimens. Dr. Keller is exactly right about the importance of the teacher's attitude toward students with disabilities having an important effect on the learning process. How different my education might have been if my teachers and guidance counselors had been more helpful in encouraging me to figure out what I needed to develop the areas where I showed some strength and interest.

Many educators at every level often underestimate the potential of people with disabilities to compete and excel alongside their non-disabled peers. Counselors for students with disabilities at the precollege and undergraduate levels also discourage students from pursuing a technical career because it is considered too demanding. Even before a young student with a disability begins considering directions in higher education, he or she may be counseled out of mathematics courses and therefore will be poorly prepared to follow a technical curriculum.

Good support systems are possible and are essential in encouraging young students to study science and math. Dr. Keller cites many examples of modifications and assistive technology which are now widely available for the student with a mobility or orthopedic disability.

Access to role models or mentors is important for students with disabilities. People with disabilities who have become scientists or engineers can be the most helpful of all in helping students understand what coping skills and education requirements are needed to succeed in a specific field. Most students with disabilities have little or no opportunity to interact with scientists or engineering role models with disabilities. It would have made a big difference if I had met some people with disabilities like mine who had gone through the education system and were successfully employed and could have encouraged me to follow some of my dreams.

I finished college with a Liberal Arts degree and took an additional year of courses in special education. The message was that since I had a disability, I should teach others with disabilities. When I discovered I didn't enjoy teaching, I felt lost. Somehow I found jobs and opportunities for community involvement that helped me build experiences and skills in areas that I thought I wanted to pursue.

As Dr. Keller reports, the education picture for students with disabilities looks very different than it did when I was growing up. To make certain students have every opportunity to excel in math and science, teachers must have positive and encouraging attitudes and be willing to involve the student in identifying useful strategies and adaptations for him or herself. If only I had known that it is possible for any student with potential and a desire to learn to enter a science or engineering field, my life could have been very different!

Response to Ed Keller's Presentation: "Motor/Orthopedically-Impaired Students"

Moving Motor/Orthopedically-Impaired Students Toward Independence in the Science Classroom

by

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The quality of everyone's life is improved by the ability to participate. How much, and in how many ways, are the motor/orthopedically-impaired students active at your site. One way to overcome attitudinal barriers is full participation. Students are individuals and need to be perceived as able to contribute positively to the group. This can be structured by the educational staff.

Accessibility also means independent accessibility. What about doors, drinking fountains, bathrooms, mirrors? Can the motor/orthopedically-impaired students function independently? Do students need to ask for water because the drinking fountain isn't appropriate for a wheelchair? Do aides intervene too quickly to open doors that a student could open? These are examples of taught dependence and make dependence acceptable, denying individuals the opportunity to make choices and decisions for themselves. It is not acceptable, neither personally, or socially, to be expected to be seen as needing help because the environment needs modification. Cost cannot be a barrier for independence.

The numbers of students who are disabled are increasing. Medical advances are saving more lives. Some of these lives also will be motor/orthopedically impaired. Career access begins with attitudes of the disabled person along with the attitudes of the general population who will share their lives. Will you do your own grocery shopping? How will you be accepted when you ask for something you cannot reach? Where will you live and work? How will you be accepted by those around you? Do you feel included by your co-workers? Did they learn acceptance in school? When and where does true mainstreaming occur?

In an increasingly complex technological society it is imperative that everyone be scientifically literate. We must prepare all students for life-long learning as we face the increasing pace of change in all of our lives. Including all students in the science classroom should be fairly painless. If the nature of the class is "doing," investigations, explorations, activities in general will help each student construct their own knowledge based on their own experiences. The nation is moving to authentic assessment, acknowledging that there are more ways to learn and express understanding than the traditional word recognition and recall. Teachers can check for conceptual understanding and provide additional experiences to bring student thinking more in line with scientific principles.

The teacher monitoring a working cooperative learning classroom has time to structure participation for all students including the student who is motor/orthopedically impaired. As the teacher reviews the life functions assessment, an idea of the ability of the student emerges. Planning with the student and family can be helpful.

The student with upper torso strength can plan traffic patterns with the teacher to sinks, garbage cans, materials center, etc. Their participation can look like that of any other student. Students with poor upper torso strength and/or palsy may have difficulty handling some activities and investigations but certainly not all of them.

Some motor/orthopedically-impaired students will be directing attendant care in their future. When appropriate, it should be possible for an able-bodied student to choose elective time to complete a laboratory assignment under the direction of the disabled student. (I am thinking of students who choose "office" or "library" or choose to work with profoundly-disabled students.)

In the cooperative learning classroom the teacher can plan role assignments with the student's ability in mind. Group accountability and personal accountability are built into the classroom management system. As in all good teaching, the material to be mastered must be presented in a variety of modes to match the many ways people learn. The cooperative learning classroom provides many opportunities for success for everyone.

National trends in teaching are moving toward student-centered learning. Teachers are learning new roles as they work together to meet the needs of every student. Students are more directly involved in their own education. Authentic assessment using portfolios and projects will be part of next year's California Assessment Program. Active participation includes full mainstreaming. Cooperative learning groups provide support for each learner. If we are to be successful at all in building bridges between able-bodied and motor/orthopedically-impaired students, the active science classroom is an excellent place to start.

Science Education for Students with Disabilities: The Visually-Impaired Student in Chemistry

by

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Science Education For Students With Disabilities: The Visually-Impaired Student In Chemistry

by

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This paper provides some perspective about the current situation of the visually-impaired student in science education—particularly chemical education—and offers suggestions for making improvements. In the course of the paper, I intend to address most of the eight specific goals outlined in the conference announcement.

Does it make sense to expend the resources to train students with disabilities for any occupation or profession? After all, are there really any jobs waiting for these individuals even if they do obtain appropriate credentials? There are certainly those who believe, for example, that it is oxymoronic to think about a blind chemist. Just consider all of the hand-eye coordination involved in manipulating chemicals at the bench, and all of the various instruments, not to mention the sheer volume of reading that any scientist must do. This attitude represents "gatekeeping" and is not only based on misconceptions about blindness, but also on a very narrow view of what a chemical professional really does. Gatekeepers are found almost everywhere and are the single most significant barrier faced by students with disabilities at all levels of education (Redden, 1978; NSF, 1981; P.L. 99-383, 1989; NSF, 1990). Gatekeepers can have a host of different titles: parents, teachers, counselors, deans of colleges, managers.

Fortunately, there are those who are risk-takers. These people enjoy an adventure, experience the thrill of a pioneering spirit, and light the path for an aspiring career seeker. Occasionally, a blind student slips through all the obstacles and pursues a productive professional life. It may take a spark to start a forest fire, but that isn't the only necessary condition. And it takes more than one soldier to constitute an army. This gathering will hopefully stir up the sparks into a roaring fire for the benefit of society by enlisting and recruiting lots of informed people to the cause.

There are jobs to be had by qualified and aspiring candidates, and that's why the interested blind individual pursues training. Yet, there is also resistance to the hiring of these people as evidenced by the 70 percent unemployment rate among the blind (U.S. Dept. of Labor and National Federation of the Blind). Ignorance and resistance can and must be conquered through persistence. Sometimes this persistence must be manifest in legislation, and sometimes through one-on-one, close-up and personal contacts.

I have been very fortunate in my experiences as a student because I have not had to deal with the gatekeeper mentality. Like most undergraduates, I needed eight hours of science courses to meet core requirements. I liked chemistry best in high school, and even had a guidance counselor tell me that it was too bad I could not continue to study that science. So I went to visit the chemistry department at the University of Iowa and asked if I could enroll. The professor I spoke with could have said "no," and I would probably have gone on my way. But he remarked that no one in my particular situation had ever taken chemistry in his recollection, but he didn't know why it should be a problem. That was all the support I needed.

Near the end of the first semester, I was encouraged by Professor Cater to continue the chemistry sequence the second semester even though he wasn't teaching the lecture and it meant enrolling in a two-hour credit lab course. He assured me that his colleagues had already been alerted to my special circumstance and that they were eager to have me as a part of their classes. In fact, without any suggestion from me, the two laboratory professors had arranged for a group of graduate students to provide me with assistance. I really enjoyed my contact and involvement with the graduate students and the professors that spring. While visiting with Professor Frank, one of my lab professors, I mentioned my enthusiasm for chemistry and my disillusionment with economics, the subject in which I had intended to major. He suggested I consider chemistry as a profession, and he was not joking. Clyde Frank became my undergraduate advisor and mentor. He convinced me that if I chose chemistry as a profession, I should go all the way to a Ph.D. to improve my chances for employment. I accepted his wisdom then, and I would now so counsel any blind student with the same aspirations.

Satisfying a core requirement is one thing; majoring in the subject is entirely different. The chemistry faculty could have been stirred up to collectively say, "No." I entered into Organic Chemistry unchallenged, however. I suspect the doubters figured that I would encounter so much difficulty in visualizing structures that I would get discouraged and quit on my own. Competing against more than four hundred pre-med students, I scored second highest in the class my first semester, and set the curve during the second. The doubters would have had more success if they had stood up and made a lot of noise before I finished Organic. Actually, my nemesis was math anxiety, and that accounts for why I also have a degree in mathematics. It still doesn't make sense to me and I certainly do not feel comfortable with the stuff.

The strategies for coping with laboratory work changed as I progressed through the program. After my initial experience with graduate students in freshman laboratory, I had lab partners for a while, then was able to employ assistants during my senior year. My mentor and I talked a lot about adapting equipment, but we were never successful at accomplishing much in this area. Due to a lack of money and/or available technology, we recognized that adaptations would only be useful when performing repetitious tasks. During the initial learning process, not much seemed to be repetitious. I opted to wait until graduate school before pursuing much adaptation, but it didn't happen there either. Since I was blessed with undergraduate help, it was just easier to let them do the hands-on stuff, and cheaper too! Other tasks of survival required my time, energy and money. Now that I have a Ph.D. and am employed at an undergraduate institution that stresses undergraduate research, I still have the students doing the work!

I describe my background to provide a basis for my perspective. Mine was not the typical experience of a student meeting resistance at every turn. However, my experiences have certain commonalities with other blind students. I know this to be true because I network with science professionals who are blind. Since I am listed in the Resource Directory of Disabled Scientists and Engineers of the American Association for the Advancement of Science (1987), I receive calls and letters from educators and students and I visit with colleagues at chemistry meetings across North America. How have conditions changed, and how have things stayed the same? In my opinion, the issues remain unchanged while the wherewithal to deal with the issues has certainly improved. What are the issues, concerns, problems and needs that confront blind students and professionals? I list the following points to provide a substantive place from which to begin:

Attitudes

Assessment of classwork and laboratory performance

How to get things done in lab

Laboratory safety

Access to theoretical and experimental data graphics, manipulating data with calculators, computers and software

Knowledge about and acquisition of technology, and specific adaptations of lab equipment and methods

Opportunities to establish a record of professional achievement

Networking with other blind professionals

Attitudinal barriers put up by instructors, counselors, parents, and even the prospective student pose the first obstacle in pursuing science education for students with disabilities. Since attitudes form the basis of action, much work has been done to publish information and guidelines to help overcome misconceptions and misgivings. I am most familiar with the work done by the American Chemical Society (ACS) and the American Association for the Advancement of Science (AAAS). ACS has produced the manual, "Teaching Chemistry to Physically Handicapped Students," ostensibly for use by college educators, but it is very useful to pre-college teachers and students at any level (NSF, 1981). This manual has recently undergone a major revision and is now titled "Teaching Chemistry to Students with Disabilities." This publication has been labeled with an ISBN number, allowing it to be accessed by persons searching for literature in this field.

The AAAS has recently released four booklets in a series called "Barrier Free in Brief" (no date). Each booklet focuses on a specific audience and sensitizes students, instructors and meeting organizers to accessibility issues. Attitudinal barriers generally arise because of a lack of information and not so much from malice and ill-will. Current and future students need to be armed with all the information we can give them. Where do they get this in their educational development? That is a question we should address.

Once a student gains admittance to a lecture and/or laboratory, the assessment issue may surface. It is not news to us that taking tests in alternative formats takes longer for bona fide reasons (NSF, no date; AAAS, no date). These reasons need to be understood by the evaluator so that appropriate grades can be determined. The extra time needed causes concern about equivalence between tests and among test takers. Faculty and institutions in the past have sought to lower the grade of a student or decrease the number of credit hours earned. Not only is the equivalence of tests in question, but also student performance in the laboratory.

Grade lowering and credit decreases have been sought for students using a personal assistant to do the hands and eye work in the lab. So far, advocacy on the part of the Chemists with Disabilities (CWD) has been successful in mediating favorable outcomes for the students who have asked for support. We need to provide a rationale and/or research, statistics to demonstrate that a longer examination time augurs no ill effects. Meaningful research is needed to validate the results of alternative-format tests. This validation needs to gain acceptance by the major testing companies, the certification committees of professional societies, and various governmental agencies.

Gatekeepers often invoke laboratory safety as a concern to prevent or deter students from enrolling in laboratory courses. Since safety affects everyone, the lab should be made safe for everyone (Swanson, 1991). Paranoid instructors may worry about the erratic behavior of the disabled student causing a safety hazard to others. Ignorance strikes again. Safety studies conducted by DuPont indicate that its employees with disabilities perform as least as well and in some instances better than the temporarily able-bodied (Wolfe, 1973-74; Garner, 1978). For the Dupont employees who work in the lab, these results shoot down the erratic behavior argument.

If the student successfully enrolls in a science course, serious problems may begin. Accessing information and getting things done in lab confront the student. The student now wishes that there had been a role model who had done this already and could demonstrate what to do. What resources are available to the student and the instructor? What can they read in the literature? At this point, the fainthearted quit because of the lack of a support system, i.e., a network or a role model. Of course, those who continue have either found help and/or figured things out for themselves. Students and instructors who turn to the library and professional organizations for help may find it, through contact with the AAAS and the ACS. The "survivors" have been found and are being found. The Resource Directory of the AAAS allows professionals already in the various fields to network with each other for mutual support, and these people provide information to aspiring students (6).

Blind students must deal with the problem of accessing information in every class. Science and math courses are especially challenging. Normally, a student would employ a reader, send materials off to be read onto tape by volunteers at Recordings for the Blind (RFB), or scan material and then either read it with a voice synthesizer or convert it to Braille. In science and math books, charts, figures, graphs and tables abound. Now the student must employ readers who can make tactile graphics or accurately describe the graphic information (Edman, 1992). Another alternative is to use an Optacon (Telesensory, no date) to decipher the information. RFB volunteers accordingly must possess similar skills. The scanner becomes not quite as useful because the software doesn't convert graphics into meaningful output and tables of information are really difficult to interpret using a voice synthesizer. Even if a scanner recognizes the material as a table and displays it properly, Braille software hasn't evolved far enough yet to reproduce it faithfully for interpretation. Notwithstanding, diligent students can succeed in reading the materials for the courses.

Fortunately, more and more information is available through electronic means, either on CD-ROM or from databases established by universities or commercial outlets. At least one state (Texas) has passed legislation requiring school books sold in that state to be available in the ASCII format so that the material can be printed in Braille or read by a voice synthesizer. As positive as this legislation may seem, the two-dimensional information required in chemical and mathematical formulas, as well as molecular structures cannot be communicated within the ASCII format. Additional software needs to be developed to cope with these problems.

Within the past several months, a leading Braille translation programmer, Charles Hallenbeck (of Kansys, Inc., Lawrence, Kansas), incorporated the ability to import several different kinds of image files into his software for raised-dot reproduction. I have spoken with him about several other facets of the graphics problem. Interpreting experimental data from a raised-dot format would be preferable to me, so I am looking for ways to get various kinds of spectra put into Braille graphics. Chuck, who is blind himself, tells me that I can take a hard copy of the particular spectrum, scan it into the Wordperfect Graphics (WPG) format and then take it to the Braille printer. Alternatively, an ASCII file of dots and spaces can be constructed into appropriate forms, saved, and incorporated into other files or just printed as is. Of course, I want the raw data from the instrument to be sent directly to the Braille printer in some way or another, i.e., make the printer act like a strip chart recorder. Chuck is working on that, too!

Other individuals are working on related facets of the problems with the ASCII format. One such individual is John Gardner, a blind physics professor at Oregon State University. He has received an NSF grant to develop a method of using a phase-change ink technology printer to reproduce mathematical notation in a combined Braille and raised dot/line format. Since I am a consultant on this project, I have seen the initial results of his DOTS+ program, and they are very encouraging.

As technology and software continue to improve, the goal of being as independent and productive as possible becomes a reality. We want machines to seamlessly interface with each other and to eliminate as much as possible our dependence on readers, transcribers and lab assistants.

Information access and data acquisition are not the only problems regarding data. Doing calculations and manipulating data are also a part of what goes on in science education and research. Students need access to affordable (less than $200) scientific calculators that talk. This may be considered a matter of convenience because there are two very good, low-cost computer-based calculator programs available (National Federation of the Blind, no date; Corbier, 1992). In a pinch, one could use a talking four-function calculator and a log table to do most introductory science-course calculations. With the advent of microcomputers and spreadsheet programs, the students in today's lab courses are being asked increasingly to perform more sophisticated calculations involving not only the collection of the data, but also the production of charts and graphs. The problem here is to find out what spreadsheet is accessible to what screen review program. An active network can supply such information in a field that seems to change by the hour.

People perceive chemistry not so much as a cerebral, intellectual pursuit, but as a "hands-on" occupation. This root misconception causes most of the resistance and hesitation to encouraging students with any kind of disabilities entering chemistry and related fields. Certainly, laboratory work supplies the grist for the thought processes, but the actual manipulations do not have to be performed by the thinker. Many modern instruments collect data automatically which then must be interpreted. "Normal" chemists do this all the time and their competence does not fall under scrutiny. Nonetheless, the actual "doing" of the experiment generates a feeling of excitement and accomplishment and represents a personal investment and contribution. These contribute to a sense of self-worth and self-image. So, even though the director-assistant approach yields necessary data and exposure to lab practices, the do-it-yourself approach is still the most satisfying for most people. Electronics and computer-controlled instrumentation offer solutions to the problem of quantitatively handling mass-volume measurements, albeit expensively. As the "able" world strives for more convenience and precision, the "disabled" population usually gains ground, too.

The faculty member interested in offering as much "hands-on" experience as possible to the blind student would, of course, turn to the available literature. Some of the references are out of print, or in rather obscure sources while some techniques and technologies are outmoded (Corille, 1932; Benham, 1947; Bryan, 1952; Benham, 1952; Bryan, 1956; Evans, 1958; Gunderson, 1958; Cranmer, 1968; Carven, 1968; NOAA, no date; Ricker, no date). Current instructional aids from the ACS and AAAS have been described above. The National Science Teachers Association (NSTA) used to print such a resource, but I couldn't obtain it from the national headquarters because it is out of print (Hofman & Ricker, 1979). The Science Association for Persons with Disabilities (SAPD) may still be able to distribute it.

The "how-to" literature is sparse for any science. Dorothy Tombaugh (1972, 1973, 1978, 1981) probably has done as much as anyone to publish such information. Her experience spans both biology and chemistry. Ira Cochin (1981) and Barry Horowitz (no date) have both published reports to NSF, but both reports had very limited circulation. Cochin's report centered on specific instrumental adaptations, while the

Horowitz report focused on identifying basic techniques that could be useful in more than one laboratory experiment. This report also included information about the interfacing of a laboratory balance and other instruments with an Apple computer. The devices and software may be outdated, but the basic premise is not.

If a teacher is energetic, enthusiastic, creative and imaginative, but has no time for developing anything out of the ordinary, the problem can be addressed. With large classes and several preparations, the focus must be on standard materials, evaluation, supervision and maintenance. One solution to this impasse is to develop curricula that automatically include everyone such as those developed by Larry Malone and Linda DeLuccci at the Multisensory Learning Center, Lawrence Hall of Science, Berkley, California (1971). Another option would be to take the work done by Barry Horowitz et al. and actually apply it to various levels of curriculum, demonstrating exactly how different experiments can be done using the articulated techniques in the NSF report. After a few very successful examples have been put forth, the creative juices of teachers will likely prevail. It has been my desire to provide such material for a long time. Certain experiments have been published in the literature already and certain instruments have been modified successfully (see Bibliography). These and more could be collected in a "how-to" type compendium.

It takes a lot of time, energy, and money to keep abreast of the latest technology and maintain an exhaustive database on the latest instrumental modifications and strategies. Who would be the likely caretakers of such information? How would it be disseminated, and how would it be found? The NSF Task Force on Persons with Disabilities poses these questions and recommends that a national clearinghouse approach be taken, funded by the Foundation. Historically, certain individuals like Ben Thompson and organizations like the AAAS, ACS, SAPD, and The Foundation for Science and the Handicapped (FSH), as well as several institutions of higher education, e.g., Wright State University, Moorhead State University, and Brock University have been involved in such roles. Ways must be found to utilize the current networking systems to mobilize disabled youth.

The Science Institute for the Disabled, run by David Lunney at East Carolina University, has offered a unique opportunity for students with disabilities to gain research experience from a grant funded by the NSF. Role models were brought to campus and networking was established. However, these students represent the "survivor" set. Efforts must be made to recruit students to science at an even earlier age.

Parents send their children to any number of different summer camp programs. What if summer camps existed to expose students with disabilities to science and useful technology (Ferrera & Murray, 1984)? Youngsters wouldn't be separated from their families for very lengthy times, and they could participate in lots of successful science experiences. Networking begins at this time and a sense of ownership and comfort with science emerges. Educators of teachers of science could train themselves and others and a portion of the experience could be dedicated to developing new curricula. This type of program could be conducted at various levels depending on funding and participant needs.

According to the Task Force Report on Persons with Disabilities (1990), NSF seems to be open to grants pursuing the above ideas. In addition to getting students started in science education, several recommendations were made supporting graduate training and job opportunities. Certainly students with disabilities have more expenses than ordinary day-to-day living expenses to contend with. I have been in contact with several individuals who did not continue their career path because state funding of their education was terminated after receiving a Bachelor's degree. We need to recommend to Vocational Rehabilitation and NSF to continue to provide financial support for aspiring and academically able students with disabilities.

Getting a job is the last item mentioned on my short list. I was fortunate in obtaining a part-time position at my graduate school alma mater: Kansas State University. I was also fortunate that as a graduate student I was permitted to teach in the laboratory as well. I am certain that these credentials helped to secure my current employment at Northeast Missouri State University. However, many students need an opportunity to demonstrate employability. One of the Task Force recommendations was to expand the Visiting Professorship program to include persons with disabilities and extend work opportunities at NSF supported national laboratories and centers (1990).

The goal of complete acceptance and independence seems at times very distant and unattainable. Education and civil rights legislation contribute a great deal toward achieving this goal along with the public education efforts of many disability groups across the nation. We can help make this more of a reality by proposing solutions and then seeking their implementation.

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Response to David Wohlers' Presentation: "The Visually-Impaired Student in Chemistry"

by

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It is a privilege to review and comment on Dr. David Wohlers' excellent paper, "The Visually-Impaired Student in Chemistry." Dr. Wohlers is to be commended for his extensive study, scholarship and ideas.

I feel that I am well qualified to interact in this area since I am a biologist, a science educator and a special education professor. I hold teaching credentials in life science, visual impairment and physically handicapped. I have served as an itinerant teacher of visually-impaired students in preschool to grade 12 and also was a visually handicapped specialist for disabled support services at a community college. I teach braille, Optacon and the Kurzweil Reading Machine as well as other compensatory skills. As an itinerant teacher, I was able to help, not only students in self-contained classrooms and mainstreamed students, but also preservice teachers, and regular students in the area of science. I have taught many disabled students with varying hearing, vision, orthopedic and learning impairments. Those creative juices to which Dr. Wohlers referred helped me make many tactile models and adaptations for totally blind Tonya who completed both my college biology and physical science courses. Presently, I am professor of science education at Fresno Pacific College in Fresno, California where I teach biology, direct an M.A. in science education program and supervise math and science student teachers. I teach a graduate course entitled, "Science for Students with Special Needs." I also am a life science consultant for the Activities that Integrate Math and Science (AIMS) Education Foundation which creates and publishes an excellent kindergarten through nineth grade math and science curriculum. One of my tasks is to modify or adapt the AIMS lessons for students with special needs. Presently, I am involved with two other special education professors in a research/teaching study of AIMS science lessons to 14 orthopedically/multi-handicapped students. One of these students is a student with a low vision who has only peripheral vision.

Dr. Wohlers' paper addresses at least eight vital issues. His comment on the public misconceptions about blindness could be expanded by all of us. This is the fundamental problem that leads to attitudinal barriers of the so-called gatekeepers. Over time, this problem can be somewhat alleviated by having states require a mainstreaming class in their educational certification programs. Another impact on attitude includes exposure to excellent role models, such as those who are represented here in this audience.

As I teach science to disabled students and adapt AIMS lessons, I find it fun and challenging to create adaptations to enhance learning. Many times these handmade, inexpensive models not only help the special-needs student but also regular students. Learning theory research stresses the importance of active hands-on learning. Please don't give up on using those creative juices that Dr. Wohlers has mentioned in continuing to make vital adaptations. It may take energy and time but the rewards never end.

Please remember in working with visually-impaired individuals that about 80 percent of these individuals have some residual vision that should be utilized. We must include both low vision and totally blind in our studies of science for the disabled.

New technology is continually expanding the horizons for visually-impaired students. We are excited to learn of some of these new programs. Technological advances are very helpful and wonderful but mind-boggling. Dr. Wohlers referred to the cost of such equipment and the funding cuts. Most VH individuals cannot afford the latest technological advances. Optacon and the Kurzweil Reading Machine have been life changing to my students but for many are out of their budget reach. We must continue to share ideas and help write grants for individuals and institutions to obtain equipment.

Dr. Wohlers' emphasis on networking and working together is a vital must. The Science Association for Persons with Disabilities (SAPD) organization is a top priority.

National frameworks, the National Science Education Standards, and the Science for All Americans (Project 2061), as well as the California State Science Framework all stress science for all students and require hands-on, active learning. Disabled students should be encouraged to participate where possible so as to continue learning independence. Science education for all students must start in the preschool and kindergarten programs and continue through high school and college. It should be a curriculum with a story line of big conceptual ideas that articulates a thematic and integrated life, earth and physical science comprehensive curriculum. Constructivistic, hands-on science is a must. Integrate and correlate the math and science curriculum to include language arts, social studies, physical education, drama and art.

Dr. Wohlers has emphasized proper assessment of science classes. Many states including California and Vermont are stressing alternative assessment for all students. One component of this is portfolio assessment. Assessments on demand or tests of just the teacher's one right answer are soon to be history. Disabled students need extra time. In California, if individuals can prove medically or by examination the presence of a disability, the California Basic Education Skills Test (CBEST) given to all potential teachers before being credentialed in California, can legitimately be given to disabled teachers with extra time to complete the reading, writing or mathematics portions of the exam with no penalty.

Dr. Wohlers has addressed important issues, shared his own interesting life story and challenged us to a task for the future. Let us all network and grow together for the benefit of each of us and all future students.

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Response to David Wohlers' Presentation: "The Visually-Impaired Student in Chemistry"

Access to Scientific Data by Persons with Visual Disabilities

by

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Science progresses by the classic model of hypothesis, test, refined hypothesis. Therefore, the work of a science student or scientist can be viewed primarily as an intellectual undertaking and may not be expected to be hampered by visual-impairment. But, although the hypotheses are constructs of the mind, the testing involves interaction with the physical world. Hypotheses are confirmed or refuted based on experimental data. Therefore, a central problem for visually-impaired science students at all levels and career scientists is how to inspect and manipulate data. Scientific data come in a bewildering variety of forms, some of which are amenable to representation in ways accessible to persons with visual impairments, and some of which are not. Even for those which can be made accessible, the cost in time and funds for adaptation may exceed the benefit. This is particularly true for types of data which are used infrequently.

The problem of the large cost of each access solution and the shortage of resources make it imperative to concentrate efforts where they will do the most good. In the chemical and biological sciences, computer acquisition of data has become increasingly common in recent years. This factor, coupled with the availability of adapted computer equipment at reasonable cost, suggests a strategy for making large amounts of experimental data available to people with visual impairments. From the point at which computerized data can be made available as computer text, to whatever later point in analysis they must be expressed as graphics, access can be had for the cost of an adapted computer.

As a working example, the main features of the author's laboratory setup and access solution will be described. The laboratory group in question performs a great deal of DNA sequencing in the course of studying the molecular basis for neurogenetic diseases. The most essential type of data is the sequences of particular DNA molecules comprising the genes involved in these diseases. These data are expressed in biochemical shorthand as one-dimensional strings of the letters A, C, G, and T. They are generated by computer analysis of automated laser scans of electrophoresis gels. These sequence data are then analyzed by computer programs designed to identify the biological function, detect the presence of genes, and make predictions about the products such genes would produce if activated. The author uses a microcomputer with an 80386 processor running MS/DOS. Access to the computer is provided by an Accent Speech Synthesizer (1) and special software to enable the operator to have various portions of the material on-screen spoken. The speech access programs in use are JAWS (2), ISOS (3), and ASAP (4). Choice of one of these programs depends on the application program being run on the PC. Furthermore, a Navigator refreshable braille display device (5) attached to the PC allows the operator to view, interactively, desired portions of the material on-screen as braille characters. If access to an unadapted computer using text data is required, the PC can run terminal emulation software, and connect to the unadapted machine over the laboratory network. In addition, the PC runs the Hot Dots (6) braille translation program, and hardcopy braille can be printed on a Versapoint (5) embosser.

The access technology described allows the author to look at the sequence data, and to run tests based on statistical and sequence-dependent characteristics of them. Moreover, computer programs to compare, combine, and manipulate the data can be run at this point. If special types of analysis are needed, custom computer programs can be used to perform them. In all cases, the DNA sequence analysis programs and tests are the same ones used by nondisabled scientists to perform these operations. Thus, hypotheses can be made and tested on the laboratory-derived data by any worker in the laboratory group.

The advantage of this system is that it allows one to view and manipulate the data in a window that extends from the point at which a computer analyzes the laser scan and produces a text representation of the sequence to the point at which inferences drawn from the sequence data are represented as graphs and diagrams in the scientific literature. The system has several shortcomings. The primary data, computer-generated color representations of 2-dimensional electrophoresis gels, cannot be inspected. This is a serious problem because the automated computer procedure to analyze these gel data is imperfect, and scientists must on occasion inspect the primary data and overrule the computer analysis. Furthermore, some of the software runs on Macintosh and Unix workstations, and there is at present no access technology for the representation of graphic data on these machines.

The strategy exemplified above is simple, and depends on the use of computer equipment in the laboratory for standard data acquisition. It could, however, be readily adapted to other situations in which the data of interest have structure, or involve repetitive steps. After examining the way that data move through analysis in the laboratory before adaptation, concentration points are found in the flow. Major efforts at adaptation are then directed at these points for reasons of economy. The natural flow of work and data in the specific laboratory situation thus suggest where to spend scarce access resources. Where possible, commercial off-the-shelf devices and software are used to accomplish the adaptation. Such a "systems analysis" approach

3. ISOS (Interactive Speech Operating System) is available from Interface Systems International, Box 20415, Portland, OR 97220, (503) 665-0965.

4. ASAP (Automatic Screen Access Program) is available from Microtalk, 337 S. Peterson, Louisville, KY 40206, (502) 896-1288.

5. The Navigator refreshable braille display and VersaPoint braille embosser are available from Telesensory, 455 N. Bernardo Avenue, Mountain View, CA 94043, (800) 227-8418.

6. The Hot Dots braille translation software and Megadots braille translator/editor are available from Raised Dot Computing, 408 S. Baldwin Street, Madison, WI 53703, (608) 257-9595.

Learning Disabilities

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Introduction: ***General Educational Settings for the LearningDisabled Student***

There is no doubt that learning disabled (LD) people are very capable of learning and yes, even mastering content in all of the academic fields. It could be that the learning disabled person simply processes information differently or that non-learning disabled people process information differently. Perhaps some people are able to learn information in more than one way until we train them to learn in the "traditional manner" of information "dumping," rote learning, lecturing and writing examinations. This "traditional" method does not allow the student with a learning disability to thrive. Yet they do, as all students do, learn in forms and modalities that work best for them individually (Fairbanks, 1992). It has become apparent that the appropriate educational environment and technique for the learning disabled student, whether that individual may have a visual, auditory or other limitation, also happens to be a very good approach for other students. Yet, because LD learners are non-traditional learners, they need alternative learning methods, sensitive teachers, sufficient resources and the same general categories of educational support that all types of students need. The greatest obstacle to providing this kind of environment is our current educational system which requires that we form and mold students to fit the established system of learning rather than forming and molding the system and its components to meet the needs of all learners — traditional or non-traditional (Whitworth, 1991).

Seen again is the philosophy that LD students should not be removed from their schools or classrooms simply because they have disabilities. Moreover, retaining LD students in regular classroom facilities calls for instructing them and the non-disabled together. Whitworth (1991) states:

> "What we have known as special education then becomes not a place but a support and resource for classroom teachers to help them meet the needs of all students." (p.111)

In Fairbanks' "...Glenn's Story" (1992), we tune in to an LD student who researches and writes about his experiences and frustrations within the special education system. He and Fairbanks both question the research that supports a remedial system that does not respect the personal integrity of the tremendous variety of human experience. Fairbanks calls our attention to one of her theories: "It was not a question of mislabeling or misdiagnosing students, but an argument for a rational approach to students who learned differently than their peers." (p.489).

When Glenn began the research, he would relive his earlier anger and frustration of his pre-college education:

> "These people make me so mad. They say, here, that the learning disabled students don't have library skills. Well, how could they? When I was in school, I was writing in sand trays while the other kids were learning to use the library. If learning disabled kids don't have library skills, it's because no one ever taught them. It has nothing to do with their brains. (G. Hill, personal communication, December 3, 1988) (p.480).

What we need to address is the human right to an appropriate and adequate education. There is no philosophical reason not to adhere to the idea that all children deserve special and individual attention instead of forcing the educational system to pit the needs of one type of student, e.g. the learning disabled, against another, the gifted. In fact, Meade (1991) describes J.C., a child in the highly-gifted range, who, in addition to his "gift," has the learning problem of an attention deficit. J.C. is able to give the correct answer to a mathematical problem but cannot put it on paper. This is merely a conceptual problem that if approached in detail and slowly, J.C. can comprehend the presentation of his answer without losing the answer itself.

When we examine the characteristics of special students, we find that they include:

- an ability to retain information
- a highly developed curiosity
- an interest in figuring things out
- a desire to do things differently
- an ability to arrange concepts and ideas together in unique ways. (Halkitis, 1991) (p. 14).

Are we describing a learning disabled, gifted, non-disabled or a combination of labels in any given student? If the educational system continues to regard students who learn differently or more slowly as "deficient" and obstructs them from the learning environment that is made available to "normal" students, then, as Glenn's story illustrates, there is an overwhelming need to reevaluate our educational practices for learning disabled students (Fairbanks, 1992). Fairbanks' position continues:

> "Neither he nor I would deny that Glenn experienced difficulties learning to read. We do, however, argue that once his difficulty was recognized, he was sent into a holding pattern that limited his opportunity to confront complex tasks. Writing in a sand tray may have helped him learn the alphabet, but it would not help him read a science textbook or analyze concepts or arguments. What cripples the effectiveness of most learning disabilities programs is their obsession with skill-mastery. In mainstream classrooms that enable literacy (Green 1985) advocates the breaking down of bits and pieces of knowledge to enhance learning. Instead, students' attempts to grapple with complex concepts and a complex world, combined with the analysis and revision of those attempts are what matters and what fosters learning. (p. 491-492)

Improving Science Education Before Approaching Science Education for the Learning Disabled Student

Learning disabled students are exposed very infrequently to learning experiences which require them to think critically about subjects such as science. They do not receive the opportunity to explore science in depth, if at all. Simpson (1992) indicates that science education should exist as an open-ended inquiry because it appears to encourage behavior which is flexible and helpful for students in the learning process. Some students, however, may need to be gradually phased into the more abstract, creative and less-structured formats from the concrete or more structured settings of earlier educational experiences. The goal, while connecting science to technology and society, is scientific literacy for all students.

> Although definitions of scientific literacy vary, one thing that all science educators agree upon is that citizens in the future should be able to solve problems, think in the abstract and be sound, independent thinkers. (p. 335-336)

In order to accomplish this goal, science based on broad conceptual schemes and explored through inquiry-based pedagogy is a valid approach. It is, however, imperative that science education receives the same priority as other requirements for students, at all levels of education, as reading, writing and mathematics do. Two reformations of science education, The American Association for the Advancement of Science's (AAAS) Project 2061 and the National Science Teachers Association's (NSTA) Scope. Sequence and Coordination, are aimed at improving science education for all students (Fort, 1990). No matter what the approach, it is definite that science education needs to exist because little or none is not only detrimental to the students but ultimately to all of society. We cannot continue to have a dearth of science experiences for any or all of our students as it is vital to their education and development of critical-thinking skills.

Studying real science is the key to improving science education. Yager (1988) likens most current science education to spending 13 years of learning the rules of a sport, but never playing a single scrimmage, set or game during that time period. Students in science classes rarely get to "play" the game which is to explore real science. Instead, they spend their pre-college days in school learning theories, laws, parameters and content "on the bench," but never in the game. We need to have all students, regardless of their abilities, experience science, through real questions, real curiosity, real explanations and real testing of their own ideas (Hofman, 1990). There are numerous settings where teachers approach science with their students in this interactive way. Jim Minstrell, in Mercer Island, Washington, is using teaching methods based on the latest research on how students think and learn. Minstrell (1991) does not lecture, but rather helps students talk about and test their individual understandings or misunderstandings of concepts. He discovered that students in physics learned more through this method and actually became excited about the "real" science they were doing while exploring the principles of physics.

Rowe and Howland (1990) offer us ideas to help students of all abilities deal with counterintuitive ideas, as they work in the sciences:

- Believe the research that says that just telling students about ideas will not be enough for them to turn in old conceptions for new ones.

- Identify students' misconceptions and design activities to confront these notions directly.

- Draw students into the common sense of science which differs from every-day common sense.

- Assist students in their experiences and discussions as Winstrell indicates to help them deal with science ideas.

- Let students in on the situation. They will feel better (and have improved self-confidence) if they understand how natural it is to be more reflective about learning.

- Acknowledge that they may have some difficulty comprehending new science experiences as they experiment with transformations.

- Encourage conversation and argument over competing explanations so that students can accept the notion that their task is to evaluate theories just as scientists must often do.

As we realize that we must present science to every student in a manner which allows for her/his learning style and capability, we soon see that the foundations for science teaching as examined here are readily usable with the learning disabled. We also know that a curricular framework should be shaped through conceptual schemes but not determine the particulars of what should be taught. The National Center for Improving Science Education has a proposed framework which consists of organizing scientific concepts, attitudes and skills. The concepts are intended to give purpose and direction to the design of K-6 life and physical science and technology experiences which are vital for all students to build on for life-long learning. The conceptual schemes suggested as basic to understanding science and technology are: organization, cause and effect, scale, model, change, structure and function, variation, diversity and, the one I find to be the most basic and valuable to curriculum design, systems. From the early 1980's to the present, I have used the conceptual scheme of systems to be the basis of five science programs developed for early childhood, elementary and middle school students. These programs covered the areas of physical and space science and included the activities for students of all abilities and disabilities.

Providing Science Education Opportunities for the Learning Disabled

There is agreement among experts in gifted education that the presentation of boring, repetitive and unchallenging work is the key to destroying the motivation of bright children. Results of traditional presentations can be shown to have produced some of the best troublemakers and academic underachievers around. Pirozzo (1987) points out:

> It should be stressed that not only are the bright children frustrated by this approach but also the less able students who are asked to revise material that does not make any sense to them ... How can a school provide for the needs of these children. (p.23).

Providing for student needs, not en masse, but as individuals, is difficult. Approaching the task with every proven strategy, method and program available in our professional "bag," however, allows us to begin to meet the needs of not only the learning disabled but of the non-disabled student. We must depart from the traditional teacher-driven approach, based on the philosophy that students have similar needs and abilities as well as similar aspirations, that teachers have all the answers and that the efficiency of presenting the same science to all students justifies its use. Instead we need to view the teacher as a facilitator, make use of cooperative learning groups and empower students in their own learning and vice versa.

In the early childhood years, young students need to use their senses extensively. Before attempting to answer questions, young scientists should have the chance to "mess about" as Hawkins suggested in the mid 1960s. LD students, by virtue of their different learning styles, benefit greatly from hands-on/brains-on science experiences. Time is the crucial factor in "active sciencing."

Science is a verb. To science in depth is to follow the "less is more" principle. Students need time to prepare, explore and analyze science activities. Since we are no longer concerned about the traditional efficiency of information dumping on students, we do have to find a curriculum design which includes large blocks of time for all students and even larger blocks of time for the learning disabled to science. We should present specific concepts to LD students rather than hundreds of details which both LD and other students find difficult to deal with. We find as LD students grasp science concepts, they are able to use, transfer, build and apply those critical concepts listed above (Network, Inc. and Biological Sciences Center Study, 1991).

Science That Works for LD Students

The following is a smattering of strategies and programs which can open the doors to science education for the learning disabled. Being learning disabled does not imply impairment in learning ability, only a different ability to receive information and experience science. The imposed constraints for LD students necessitates a modification in, rather than the elimination of, sciencing experiences.

The National Governors' Association Task Force Report (1990) advocates that all children can learn and should be given the opportunity to do so. The task force recommended the following:

> Give students more options regarding when, where and how they learn. Alternatives must be expanded for reaching youth, who, though in school, are not

achieving and for retrieving those who have already dropped out (even though they may be physically still in school.) A wide variety of strategies must be used to enhance the students' self-esteem through counseling and other support services, to accommodate diverse learning styles (which is what being learning disabled is) and to provide open-entry/open-exit learning, Year-round educational opportunities and other ways of organizing the school year are needed. School and work must be linked more directly, with expanded options for apprenticeships, cooperative education and community service opportunities (p. 20).

We know how to present science to all students including the learning disabled. Curriculum we design, incorporate or adapt to foster scientific literacy ought to stand "on the shoulders of giants" and build on the many fine programs of the 1960's which created rich learning environments while following guidelines provided by AAAS, NSTA BSCS, National Academy of Sciences, etc (Fort, 1990). In the early 1980's, the "giants" to lean on for leading the way for catering to LD individual differences included: Exceptional Children Science Education Program (ECSEP), Science for the Learning Disabled and Developing Coping and Cognitive Skills though Science with kits and computer materials for learning disabled students (Hofman, 1990).

Pirozzo (1987) described a high school science program based on 1) a self-directed individualized Biological Science Program, 2) vertical time-tabling and utilization. Program objectives include:

*to provide flexibility in learning/teaching methods so that each student can choose the order in which the curriculum is covered and choose the preferred method of learning, and

to free the student from the constant repetition of subject matter that is often part of the regular classroom.

The Impact of P.L. 94-142 (Weiner, 1985) is "... not unusual for an IEP to have a 'goal' of 'mathematics' or a goal to 'improve motor performance.' That's it; no short term objectives (p. 64). IEP's must be specific and include objectives in science. Perhaps we should consider IEPs for all students. In states where performance objectives are the wave of the future, IEP's make sense as a method to map the student's educational progress best suited to meet her/his needs. IEP's would form the "Trip Tics" with an easily changeable itinerary to reflect the student's progress.

Slavin's (1987) discussion on the success of low-achieving, disadvantaged students runs parallel to strategies that should be employed with LD students in science.

He further states that effective programs differ markedly from traditional models, particularly those that use "pull-out" models. Frequently, LD students are "pulled out" during science or other content subjects because these models provide accountability systems which show who is receiving assistance. The more successful programs include comprehensive classroom strategies, continuous progress models and supplementary programs such as preventive tutoring and computer-assisted instruction. Program components which contribute to student success include individual pacing, small group learning and some skill-level learning and mixed grouping.

Providing for LD students in science is not simple because it is interconnected to all of the problems found in the current education system. For example, each summer, students do lose significant portions of the previous year's academic gains (Mikulecky, 1990). Better students grow much more slowly, average students barely stay even and the below-average students lose a great deal. Summer programs designed to stem the loss of academic gains is an obvious solution; however, the theories of presenting science to LD students are more directly related to Summer Training and Education Programs (STEP) (Mikulecky, 1990) principles which include the following:

- Keep teacher talk to 50 percent or less of class time.
- Have students actively read, write and compute at least two hours of each four-hour class day.
- Match assignments to abilities. This means different reading and other assignments for different students during part of each day.
- *Demonstrate to students, in a step-by-step manner, the comprehension process for drawing conclusions, making inferences and finding answers
- Model how-to-do assignments at students' desks.
- Use higher level skills (summarizing, predicting, drawing conclusions and solving problems).
- Spend 20 to 25 percent of each week with computer practice. (p. 518)

It is important to remember that "learning disabled students will often spend inordinate time on assignments even depriving themselves of sleep (Bogart, Eidelman and Kujawa, 1988). My purposefully not defining the phenomenon of learning disabilities until now is to stress likenesses, not differences, between students. Otherwise, we limit the idea of what is good for learning disabled and other disabled students in science education. Strategies that succeed for LD students are the same as those that succeed for gifted, at-risk and all types of students. Remembering, listening, thinking, speaking, reading, writing and even spelling differently, in effect, learning uniquely, will get a student labeled and placed in a learning disability category. As Bogart, Eidelman and Kujawa (1988) mention,

> learning disability has evolved as the general term for a variety of specific disabilities, including minimal brain dysfunction, dyslexia, sequential memory disorder and other problems. Since these factors (change) information processing, they affect the person's ability to assimilate information through the senses and interpret and interrelate the knowledge (p. 49).

The following list of suggestions are examples of the accommodations and modifications suggested for working in science with LD students. The list is not unlike excellent teaching techniques used with all students.

- Give clear written and oral instructions
- Use guidelines to supplement discussions and activities.

- Use handouts to reinforce content.
- Provide opportunities for students to get clarification on their work.
- Offer assistance in structuring long-term projects into monitored subtasks.
- Give assignments one at a time.
- Encourage the use of tape recorders.
- Permit enough time for responses.
- Provide alternatives for written work.
- Allow ample time for reading assignments.
- Reduce the amount of required reading.
- Provide vocabulary lists of specialized words.
- De-emphasize grading on spelling.
- Use many multisensory approaches.
- Face students when talking.
- Be flexible — look for alternative approaches.
- Be patient and accessible.

And above all —

- Ask the students for help in devising individual accommodations.

As a teacher, it is imperative that you do your "homework" about the abilities and disabilities of the students in your charge. Hoyt (1979) tells us, however, that it is appropriate and "... very healthy for disabled people to talk about what they can and why they cannot do other things and how they compensate for what they cannot do." In Glenn's Story (Fairbanks, 1992), Glenn tells us that as early as third grade he probably could have told his teachers about his learning problems, but no one asked (p. 475). Fairbanks worked in tandem with Glenn as they researched the area of learning disabilities. She places emphasis on the importance of the teacher-student dialog. Students can be helped to understand their problems, and teachers can better understand how students learn, if the students are asked about what they need. As Fairbanks indicates,

> Teachers should make explicit the purpose of interventions eliciting the student's cooperation. If students have the opportunity to develop goals and expectations, they will be more likely to feel invested in their own educations. Most importantly, teachers should not discourage students from seeking higher learning, whether it be college or vocational school. Learning disabled students are, by definition, of average or above average intelligence. This would suggest that students with learning disabilities will do as well or better than any other students, if they receive the kind of instruction they need (p. 490).

Teacher, Technology and Technique in Science for the LD

All students need a basic understanding of science concepts to face the challenges of the 21st century. Teachers have the opportunity to monitor students in the sciences. It is easy, however, to mentor students with expected or mainstream abilities and not as easy to do with LD students. When Glenn (Fairbanks, 1992) was mainstreamed, he found that the LD label caused teachers to discriminate against him. Many of his teachers, however, were supportive and able to offer assistance. My personal experience with a child who had special needs in public schools during the 1970s and 1980s indicated that a maximum of only 50 percent of her teachers were supportive and had the techniques to assist her in her education.

Providing time for regular teachers, special education teachers and support staff to meet on a regular basis to plan for and solve the specific problems of LD students will improve the percentage of teachers capable of addressing individual student needs (Whitworth, 1991). A model for supporting teachers with mainstreamed elementary students was developed in St. Paul, MN, at East Consolidated Elementary School (ECON), in the early 1970s. Teachers and staff used the time for staff meetings, common planning, cross grading in the basics and setting up exploratory classes in science. Staff included a full-time nurse, a half-time psychologist and social worker, specialists on every teaching team, paraprofessionals and volunteers. These are just a few of the components which were designed before P.L. 94-142 was even implemented.

Another component necessary to address the lack of confidence, skills and even inappropriate prejudice on the part of teachers is effective teacher preparation courses for faculty in the methods and techniques to use with LD students. Preservice and in-service courses are needed which specifically help teachers with methods in teaching science to the LD student. "Once a teacher is 'tuned in' to adapting lessons to the handicapped, many novel methods become evident," says Hoyt (1979). In both science education and general education approaches, the teacher should not lecture nor spoon feed information but rather act as the manager, guide and facilitator to help students conceptualize and develop skills. This is the best approach for teachers to work with the disabled as well as the non-disabled (Halkitis 1990).

In addition, advances in technology have escalated over the past two decades to the point where the benefits affected all segments of society. It has also enabled us to develop materials and equipment which allow disabled people to be in the mainstream of life. Computers are at the center of this progress with a multitude of software programs to assist both the teacher and the learner. This technology is also making it practical for people with disabilities to pursue careers of their choice including those in science and science-related fields. The linkage between microcomputers and laser video disks provides powerful applications for the disabled. It should be noted that communication is made easier for LD students as software offers simple spell check and grammar checks. It is quite possible that the future may see more technology and even outer space exploration activities becoming the great equalizers between the disabled and the non-disabled.

Finally, in the use of cooperative learning techniques, R.T. Johnson and D.W. Johnson's research puts forth the benefits for all students — particularly for science activities (Reported in Gabel, 1989). Advantages of using cooperative learning make its use with LD students desirable.

We all must remember:

- Cooperative learning experiences promote more learning and more retention than competitive or individualistic learning experiences.
- The more difficult the material the wider the gap in achievement. Again,

achievement results favor cooperative learning over competitive or individualistic learning experiences.

◦ Cooperative learning experiences tend to create higher levels of self-esteem and individualistic learning experiences.

◦ Students demonstrate acceptance of differences, which comes with successful cooperative experiences (p. 24).

Because we are barely scratching the surface of the techniques and the use of technology, we may be assured that the job of providing LD students with accessible science instruction is a challenge but very possible.

The Effect of Labeling, Prejudice, P. L. 94-142 and the Americans with Disabilities Act of 1992 (ADA 92), on Career Development

Education is vital for creating and keeping life and career options open. No one has the right to deprive any student of a full education or specific subject matter. Redden and Malcolm told us almost 15 years ago (Hofman and Ricker, 1979) based on P.L. 94-142 that "...students have a right to function in an optimum (educational) environment that is the least restrictive to their personal development." Unfortunately, even with mainstreaming, students are labeled, creating lower expectations of success for them. "The child was labeled as disabled, thus emphasizing (her or his) dissimilarity when in fact the similarities to other children were always greater than educators realized" (p. 32). This same point was also addressed in the National Governors' Educational Task Force Report (1990):

> Challenge educators to eliminate ability groupings and tracking. Schools must challenge all students to meet high standards. Yet ability grouping in the elementary grades and tracking in the secondary grades prevent this, especially for students placed in lower groups. There, low expectations become self-fulfilling prophecies and limit students' access to challenging material or instruction. Once placed in lower tracks, few students move up.
>
> By high school, the consequences of tracking are particularly devastating for students in the general track, who find themselves unprepared for either work or postsecondary education. For all students, artificial barriers between academic and vocational curriculum and between theoretical and applied learning must be removed. (p. 17).

Ironically, the very system that is supposed to help LD students and other labeled students actually deprives them of access to materials and instruction they need to prepare for additional education and/or careers. This is particularly true in science education. There is even a phenomenon of "inadvertent tracking" in schools which do not even have tracking. By taking students out at certain times of the day or by putting them in special classes for remedial work, these students are often not able to take science or other courses necessary for further training, Wasting talent in this manner is tied to labeling and sorting students by their lack of early promise to excel, by their home life or by learning idiosyncracies that create academic or social obstacles. Many of these students have the desire and ability to pursue science, engineering or related technical careers but find themselves shunted from the mathematics and science courses which could make it possible (Office of Technology Assessment, 1988). With about 36 million learning disabled people in their working years, only about 2 to 3 percent are actually working in the science and engineering fields. Not only are low expectations of disabled pre-college and postsecondary students contributing to this low percentage, but prejudice, too, plays a major role. P.L. 94-142 gave access to LD students, but unfortunately the changes it calls for are occurring with the speed of "glacial dignity" and the law itself did not eliminate the prejudice which research shows is directly related to low expectations for learning disabled students. The ADA (1992) should facilitate the next phase for increasing the numbers of learning disabled people in science career areas. This can and will only happen if educators take to heart the components of ADA and work accordingly with LD students and others. The ADA is premised on:

> The obligation of employers (educators) to consider people with disabilities as individuals and to avoid prejudging what an applicant (student) can or cannot do on the basis of that individual's appearance or any other easily identifiable characteristic, or on a preconceived and often erroneous judgement about an individual's capabilities based on "labeling: of that person as having a particular kind of disability (p.7).

The labeling situation becomes intensified when you look at the increase in the number of students who have been identified as learning disabled. Weiner (1985) indicated in a report of the Office of Special Education and Rehabilitative Services that the number of children labeled as learning disabled in 1977 was almost 800,000 and rose to 1.8 million in the 1983-84 school year while the total student population was decreasing. This increase is beginning to have an effect on college enrollments. In 1988 reports estimated that the number of college students labeled as learning disabled increased 300 percent in just over a decade (Bogart, Eidelman and Kujawa, 1988). Why the increase in LD students? The National Association of State Directors of Special Education reported the following reason for the growth in LD numbers:

- Greater public awareness of learning disabilities.
- Wider availability of assessment techniques.
- Liberal eligibility criteria.
- Budget reductions in other remedial programs.
- Perception that the LD label is less stigmatizing than the mentally retarded classification.
- Court orders to reevaluate minority placements in the mentally retarded category. (p. 87).

This is not only frightening but difficult for all children in school and even harder on those children who are always having their differences from other students highlighted instead of focusing on their similarities. Glenn personally attests to this situation (Fairbanks, 1992):

> During my first year of high school, counselors and teachers started telling students to think about what they were going to do after high school. This is when I realized that I was going no where fast. I wanted to go to college, but didn't think I could get in if I was in LD classes. So I worked hard and by my senior year, I was out of all LD classes, but the label stayed with me. I guess that's here to stay.
>
> My counselor and LD teacher advised me not to go to college; in fact they went so far as to tell my parents not to let me go. They wanted me to go to a junior college or a vocational school. I knew my strengths and weaknesses and I also knew I could make it through college if I got the chance. But the chance was hard to get. (p. 436).

The Past, Present and Future Direction of Science Education for the Learning Disabled

More than a decade ago, the National Science Foundation, among other organizations, put a great emphasis on science education for students with disabilities. Preparing the proposal and planning the first national conference on science education and the handicapped was particularly important to me personally. Our second daughter, who was born with a mylomenengis seal, continued to experience numerous surgeries for correction to that "condition." I had to battle not only the medical establishment but the educational one as well. A child who was disabled but gifted did not fit into the schooling system as it existed in 1979. With this personal incentive and my professional background in science education, I accepted the task of change for the first NSF conference. The responses to this endeavor were excellent and the products produced by Dr. Kenneth Ricker and myself (1979) were representative of the results of the working conference. Not unlike the environmental sections at the same conference, we have had to wait for over a decade and a half with little or no movement in providing science education opportunities for the physically disabled. In this summary section, I would like to refer to the present and the future needs of disabled students.

The state of the art has advanced, but it is debatable if the move was in a positive or progressive direction. There is no doubt that P.L. 94-192 was a great impetus to the movement, but we need to reassess our current position and move forward for the sake of disabled students who deserve a chance and a choice of experiencing and studying science in order to pursue careers in the field or in related fields. The recommendations from the 1979 conference included the following examples that are still pertinent today:

- Careers in science should be included among areas of career exploration and skill development for handicapped students; i.e. science should be an integral part of career awareness, exploration and vocational preparation programs.

• Counseling and guidance training programs should be encouraged to include components pertaining to employment opportunities for the handicapped in various areas of science in their preservice and inservice curricula.

• Education of the handicapped should permeate teacher and counselor preparation programs. Special emphasis should be placed on increasing sensitivity to and awareness of the unique needs of physically handicapped students as well as the needs of students with other special learning needs in science classes, while stressing the similarities they have in common with non-handicapped students.

• Science teachers should encourage physically handicapped students to pursue independence in learning and augment that independence with strategies such as peer teaching.

• Non-handicapped students and physically handicapped students should work together when possible using scientific problem-solving skills to invent techniques and devices to assist one another in learning science.

• Special consideration should be given to the identification and development of instructional materials and programs that will help eliminate barriers to the study of science for physically handicapped students.

• Classroom teachers must have on-going access to current and relevant information so that they can plan and implement appropriate science programs for physically handicapped students.

There was a call for networks, clearinghouses, changes in evaluation and assessment techniques, support from educational organizations and agencies, inclusion in teacher education programs, elimination or better understanding of labels. But have we made progress in the area of science education for the physically disabled including the learning disabled (as their disabilities very often reflect the same characteristics as the auditorially, visually and orthopedically-impaired, including average or above intelligence) over the last two decades? What marks any progress? How would we know if we have succeeded? If we are falling short of our goals and expectations, what do we need to do to meet Ricker's predication for the future (Hofman and Ricker, 1979)?

Hopefully by the end of this century there will be no need for a publication of this kind. By then, we hope quality and appropriate science education will be available to all learners, regardless of their special learning needs. The challenge is even greater as we are only seven years away from the 21st century instead of 21 years when these concerned parents, educators, scientists and the disabled met to provide strategies for opening doors in science and related fields for all students. We must come away from this 1993 conference not only with recommendations, but with a list of goals that can be immediately enacted. This is our challenge for meeting the needs of the learning and other disabled students. We must provide science for them to pursue in their own career choices and for the vital information they need to use in their lives.

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Response to Helenmaire Hofman's Presentation: "Learning Disabilities"

by

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This is a great time to be living! There are breakthroughs being made with students who have disabilities especially in the areas of facilitated communication, auditory training, and a move in the country for full inclusion (not mainstreaming) in education. More and more students with disabilities are being educated in regular classrooms.

Helenmarie spoke of several issues to be considered with students who have learning disabilities. One advantage would be for them to be exposed to cooperative learning experiences in regular classrooms. Textbook companies such as Charles Merrill, Prentice-Hall, and Scott Foresman & Company in recent editions are including large sections in teacher sections on cooperative learning. Curriculum development projects such as SAVI/SELPH suggest small groups, while full option science systems (FOSS) name theirs collaborative groups and include job descriptions for the identified student roles of reader/reporter, recorder, getter, and starter. *Science for Life and Living,* the new BSCS elementary curriculum, incorporates cooperative learning strategies directly into all lessons. Student roles are communicator, manager, tracker, checker, and coach. Teachers not only facilitate the science content learning, but teach cooperative team social skills of a) moving quickly and quietly into teams, b) speaking softly, c) remaining with teams during task, d) taking turns, and e) practicing team roles. Many teacher preparation programs on the college and university level are including cooperative learning strategies in their theory and methods classes. More needs to be done in this area. Textbook developers need to include names and job descriptions of student roles, and social skills that students should be learning in their teams. Also, teacher tips on including diverse individuals in cooperative learning groups should be included.

Many textbook developers, including D.C. Heath, Addison-Wesley, and Charles Merrill, hired special needs consultants in the 1980's to suggest tips for teachers on ways to include disabled students. Scott Foresman & Co. in their 1991 Discover Science has gone a step further in not only having a large section in the teacher edition for mainstreamed, emotionally handicapped, orthopedically handicapped, visually impaired, hearing impaired, mentally retarded, and learning disabled students, but includes a "Special Education" section in every teaching plan. Other textbook companies need to include more tips for teaching these students and include others such as multiply challenged, autistic, and gifted. The words, "handicapped" and "retarded" need to be replaced with the new term, "challenged," i.e., mentally challenged.

Broad conceptual themes, in keeping with the new science standards, should be the focus for science content for all students. *Activities Integrating Math and Science (AIMS), Great Explorations in Math & Science (GEMS), SAVI/SELPH, FOSS,* and Merrill's *Biology: The Dynamics of Life* all include broad themes. In the *GEMS* approach, teachers may choose those themes that best meet their students' needs.

Interdisciplinary content, scientific literacy, "hands-on," "real" science, "critical thinking skills," career options, all need to be kept in science content for special students. Textbook and curriculum developers may want to follow the AIMS way of offering teacher workshops in how to use their programs during summer and winter vacations. The workshops at national conventions, such as NSTA, are great for preparing teachers and need to be continued. Public and private schools need to offer more and better teacher inservice programming in science for special needs students.

Textbook developers such as Houghton Mifflin, and Macmillan that produce reading, science, social studies, mathematics, and English methods books on the college and university level are beginning to add sections on the teaching of students with disabilities. More needs to be done and expanded in this area. I'd like to suggest more than just an introductory course on the exceptional student for those college students who want to become teachers. This second course would stress the teaching of the learning disabled and those with ADHD (attention deficit hyperactive disorder). We are having more and more "at-risk" students in our public and private schools today.

In closing, many of the above textbook developers and curriculum projects have already built upon the research, expertise, and even activities themselves, that came out of ESS, SCIS, AAAS, and BSCS of the 1960's. The process skills continue to be increasingly emphasized in the design and framework of science content for the 90's, as is evident in the emerging science standards. Let's continue building upon this great work and by the year 2000, let all students have success in science.

Response to Helen Marie Hofman's Presentation: "Learning Disabilities"

A Question of Fit: Epistemological Perspectives on Science Education for the Learning Disabled

by

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Modern educational wisdom speaks of fitting the school to the student in a way which accomodates the learning needs of all students within the system. Yet, when many of the hidden structures of the school are exposed (through the deconstruction of tacit assumptions), we see instructional practices which reflect an attempt to make the student fit the school. This traditional approach to education, which Hofman (1993, p. 2) describes as a system which "requires that we form and mold students to fit the established system of learning," has been guided by a Cartesian-Newtonian way of seeing the world. The Cartesian-Newtonian way of seeing the world replaces the uncertainties of teaching with verified knowledge about the act of teaching.

Educational reductionism, which is often called positivism or objectivism, is an approach to teaching and learning that reflects a Cartesian-Newtonian view of a world that is never changing and "out there," as manifested in the search for ultimate truth. This approach, which is closely interwoven in many of our schools, science classrooms and science teacher education programs, is recognized in definitions of learning as mastery of isolated bits of knowledge, the marginalization of conceptual knowledge, the defining of students according to ability levels, the failure to understand individual ways of knowing, and in research which neglects to reveal "the experience and meaning of disability in our culture" (Ferguson, Ferguson & Taylor, 1992, p. 7).

Science classrooms, when shaped by Cartesian-Newtonian perspectives, are places where students are ranked according to their ability to memorize and regurgitate facts. They are places where concern for the testing of mastery of prearranged objectives is paramount. In these classrooms we see teachers "who are unaware of their students' thinking processes...teachers guided by a politically neutral 'world view' through which they are taught not to examine instructional goals and strategies within a broader social and political context" (Gallard & Tippins, 1992). We see students who view the world as a fixed set of connections, isolated from a sense of connection to their environment. And we see research, framing many of the prevailing instructional practices, which neglects the voice and multiple perspectives of people with disabilities. As Ferguson, Ferguson & Taylor (1992, p. 7) have pointed out, "people with disabilities and their families have historically belonged to those groups of devalued people without much voice in what was done to and for them by more powerful groups within society."

Admid a background of national reform emphasizing goals of scientific literacy for all students, Hofman (1993) decries a reductionistic vision of science education which minimizes the personal experiences children bring with them to school; a system which perpetuates a deficit view of learning disabled students which far too often diminishes the opportunity for equitable science experiences. In this context of reform, Hofman calls for alternative viewpoints and explanatory frameworks for analyzing science teaching and learning. Constructivism is one such set of beliefs that enables us to develop a vision of science teaching as a meaningful learning activity.

Constructivism may be viewed as a way of knowing. When constructivism is used as a basis for thinking about research and practice, dramatic changes in the science curriculum can occur. Constructivism is a set of beliefs about knowledge which begin with an assumption that a reality exists but can not be known as a set of truths because of the fallibility of human experience (von Glasersfeld, 1989). From a constructivist perspective, learning is an active process where learners construct knowledge in a way that fits personal experience. While knowledge is a personal construction, it is socially mediated as learners interact with living and non-living components of the cultural milieu. Consider, for example, the process of using language, which occurs within the mind of an individual, but is socially mediated as the individual constructs speakers and listeners and assigns roles to those with whom he/she interacts. Tobin and Tippins (in press) have described the social and individual components of knowledge in terms of a dialectical relationship: " Just as it is sometimes useful to think of an electron as a particle and at other times a wave, so it is useful to think of knowledge as an individual construct and at other times as a social construction" (Tobin & Tippins, in press). The recognition that knowledge has both individual and social components which can not be meaningfully separated holds important implications for the science education of learning disabled, as well as all students. This social constructivist perspective enables us to construct science learning environments where multiple ways of knowing are sought and valued.

To facilitate a better understanding of constructivism, Kincheloe, Steinberg and Tippins (1992, p. 74) have drawn on the following metaphor:

> "A lumberjack, a real estate developer, an artist, a hunter and a hiker are walking through the forest. Each of them sees and responds to their environment in different ways. To the lumberjack, the forest is a source of wood; to the real estate developer, it is land to be cleared so a housing development can be constructed; the artist sees something to paint; to the hunter, the forest is a cover for game; the hiker sees a natural setting to explore."

Each walker has prior experiences and backgrounds through which perceptions of the world are shaped. In the same way, teachers and students, too, enter the science classroom with unique sets of beliefs and rich backgrounds of prior experience and current knowledge. Constructivism, as a set of beliefs about knowing and knowledge, recognizes that what already is in the learner's mind is important in analyzing the learning potential of any given situation.

Poplin (1988) contrasts the sequentially ordered materials, curriculum of study broken into skills and facts, knowedge of possible malfunctions of cognitive and/or psychological processing and myriad of strategies designed to encourage reluctant learners found at the center of traditional teaching practices with constructivist principles important to the teaching learning process. The following tenets are among the principles she describes as important to the processes of constructing and reconstructing meanings:

- All people are learners, always actively searching for and constructing new meanings, always learning.
- The best predictor of what and how someone will learn is what they already know.
- Learning often proceeds from whole to part to whole.
- Errors are critical to learning.
- Learners learn best from experiences about which they are passionately interested and involved.
- Learners learn best from people they trust.
- Experiences connected to the learner's present knowledge and interest are learned best.

It is important to examine the teacher's role in a constructivist perspective. Metaphors are important tools for reflection which guide the way teachers approach the classroom. Because they represent beliefs, they are useful in identifying teaching roles available to teachers, and the beliefs associated with these roles. Hofman (1993) discusses the need for teachers to conceptualize their roles in terms of alternative metaphors that depart from many of the teacher-centered metaphors in which the teacher is viewed as a disseminator of knowledge. Teacher as facilitator and guide are two metaphors that Hofman suggests are appropriate in working with both disabled and non-disabled students.

What are significant roles for teachers from a constructivist perspective? A teacher needs to provide opportunities for students to learn by developing an environment that enhances learning. In order to provide an environment which facilitates meaningful learning, the teacher needs to be a mediator, a provocateur and an evaluator of student learning (Tobin & Tippins, in press). As a mediator, the teacher acts to constrain experiences in a way that "provides students with a scaffold to build knowledge in directions that would not be possible without the influence of a teacher." As a provocateur, the teacher provides experiences for students which create conceptual conflict and which help students stretch beyond their current understandings of a concept. The evaluative role of the teacher is essential, as teachers must understand what students know and how they best represent this knowledge, in order to provide opportunities for meaningful re-learning to take place.

The role of the student will also change in a constructivist perspective. Because students arrive in the classroom with sets of beliefs which through experience have been culturally validated, their role should be one of constructing emancipatory systems of meaning. Grundy (1987) provides a framework for thinking about the science curriculum in terms of three knowledge constitutive interests—technical, practical and emancipatory. Technical approaches to improving science for the learning disabled student have been prevalent in the vast majority of classrooms. The dominant epistemology underlying technical approaches has been that of objectivism. Technical interests and approaches are characterized by a bureaucratic view of teaching, a static notion of knowledge and a passive view of learning. By contrast, emancipatory interests are associated with empowerment which allows individuals or groups of students to engage in autonomous actions which arise from reflection. Hofman (1993) is describing a science curriculum conceptualized in terms of emancipatory interests when she discusses science that works for learning disabled students. In an emancipatory science curriculum, learning disabled students are provided with greater autonomy in decisions about what to learn, how to learn and assessment of learning. They are able to design and carry out science projects built around their own personal interests, and they have opportunites to make sense of science individually and through interaction with other students in a safe learning environment (Tippins, Tobin & Hook, 1993).

As we contemplate we must consider criteria for reform. Hofman (1993) states that an important key to improving science education rests in opportunities for students to study "real" science, that which facilitates real questions, real curiosity, real explanations and real testing of ideas. Yet how this goal might be accomplished is rendered elusive in the attempt to define what is meant by "real" science. Consider, for example, an eighth grade student's description of "real" science in a recent interview:

Deborah: What do you understand science to be?

Rick: Real science to me is like dealing with chemistry or using a microscope to study diseases. It may be a study of people, animals, chemicals or energy, but real science is defined by what certain people decide is important. But I live out in the woods and I see wildlife and reading animal signs as science. What we do in school is real world science. The real world science is what we take in school. Like going to the Everglades. People say that's not science.

What is real science and what role does it have in the reform of science education? For Rick, "real" science is seen as that which has been legitimized by society. His definition raises critical socio-cultural issues for educators to consider as they seek to change the way science is taught.

Another component of reform that Hofman (1993, p. 16) describes as necessary to "address the lack of confidence, skills and even inappropriate prejudice on the part of teachers is effective pre-service courses for faculty in the methods and techniques to use with the LD student." This is an example of a technical approach to science teacher education, characterized by an expert metaphor which implies the transfer of knowledge and skills from those who have it, to those who need to learn. Far too often, technical approaches have failed to understand how teachers were making sense of their practice or how they perceived change as appropriate and essential for improving classroom learning (Tippins, Nichols & Tobin, 1993).

Constructivism provides a different lens for constructing a vision of what the science teaching and learning process could be like with respect to students with learning disabilties and their teachers. What might this vision of schools and classrooms look like? In conclusion, Kincheloe, Steinberg and Tippins (1992, p. 218) have developed the following criteria for reform which they hope science educators will include in future discussions of change:

- School leaders and teachers need to understand what schools are for and why reform is needed.
- Knowledge is produced in the classroom through the interaction of student experience with information derived from the disciplines.
- We must make use of knowledges and understandings of the world which have previously been devalued and excluded.
- It is necessary to contextualize facts.
- The community and the school must cooperate in all educational endeavors.
- Learning networks must be built between schools and communities, making use of recent developments and innovations in communications technology.
- Both teachers and students must become researchers together.
- Schools must become places which support teachers as learners.
- We must recognize the inability of orthodox methods of studying education to explain the world of schooling in the late twentieth century.
- We must redefine genius, intelligence and disability.
- Schools must develop appropriate modes of assessment.
- All of us, teachers, students, parents, citizens, must recognize how power shapes the everyday life of schools.

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Footnotes

{1} A copy of the study can be obtained for $15 from ICD which is located at 340 East 24th Street, New York, NY 10010, Att: Education and Training Department; or by calling 212/679-0100.

Science for Deaf Students: Looking Into the Next Millennium

by

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Science for Deaf Students*: Looking Into the Next Millennium

by

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I am very happy to have this opportunity to be here with you today. I was a young physics teacher back in 1978 when I was invited to participate in a working conference much like this one. It was sponsored by the National Science Foundation (NSF) and the experience of meeting and working with persons who envisioned opening wider the doors of science for persons with disabilities was a turning point in my professional experience. It launched me on a career with direction and purpose. As far as I am aware, in the 175 years since the first schools were established for deaf students in the United States, we have conducted only one major survey to identify the needs and qualifications of science teachers (Lang & Propp, 1982). We have only one study of the attitudes of deaf students towards science (Lang & Meath-Lang, 1985), one major summary of research on science curricula and teaching (Lang, 1987), and there has been only one effort to identify and publish the priorities in science education in a major journal in the field of educating deaf students (Lang, Egelston-Dodd, & Sachs, 1983). Looking back, it was that NSF Working Conference in 1978 that led me to take the leadership role in these and other projects, and I hope this conference will have a similar motivating effect for some of my younger colleagues here today. I would like to draw upon these research experiences as I offer five broad recommendations. I hope that the respondents to my paper and others in the audience will work together to discuss details and find ways to turn these recommendations into reality. This is an exciting time when new standards are being developed for science education in our country, technological advances are changing the quality of life for people who are deaf, and federal legislation is providing opportunities for us to identify ways in which students who are deaf learn best.

*Note: By "deaf students" in this paper, I include deaf and hard-of-hearing students in residential and mainstream environments.

Teacher Training

Recommendation 1: A comprehensive and coordinated national program should be established to address the science and science education preparation of K-12 teachers in school programs serving students who are deaf.

Within this program we should examine a number of critical issues. I list four issues pertaining to teacher preparation below:

1. For many instructors who are trained in the principles and practices of teaching children who are deaf, there is a strong need for further education in the sciences. Science teaching in school programs for deaf children is sadly in need of improvement. In one study of 480 science teachers in 326 school programs, more than three out of every ten of the respondents had absolutely no college-level training in science and more than half had fewer than 12 credits (Lang & Propp, 1982). Two-thirds of these teachers were in mainstream programs. In another study of 4,887 teachers in programs serving deaf students, only 3.4 percent of the 2015 teachers responsible for teaching science had undergraduate majors in the physical sciences. Moreover, only 3.7 percent of the males and 0.6 percent of the females were certified to teach science (Corbett & Jensema, 1981). With many teachers struggling to teach without having adequate content knowledge, it is not surprising that deaf students are poorly-prepared in science as they enter postsecondary programs.

   Fewer than one out of every ten science teachers of deaf students is a member of the National Science Teachers Association. Teacher preparation programs in the field of education of deaf students must emphasize the value of membership of science teachers in organizations for science educators. They are missing out on the professional development opportunities to remain current in their areas of science as well as the wealth of information provided in the NSTA publications, the availability of free or inexpensive materials, and, especially, the opportunities to learn from other teachers at the local, regional, and national conventions.
2. Teachers who are well prepared in science content often lack training in the principles and practices of teaching students who are deaf. Importantly, there is no strong link established between science teacher-preparation programs and professionals with expertise in the education of students with disabilities. Consequently, teachers being prepared in most programs are not being well informed of the resources, strategies, and materials available to assist them. A process should be developed to build stronger bridges between teachers in the field of education of deaf students and experts in science education. We have experimented with a graduate program at the National Technical Institute for the Deaf at the Rochester Institute of Technology where participants with content expertise on the undergraduate level are graduated with dual certification: in a secondary content area like science, for example, and in the K-12 education of deaf students. There is now a requirement to earn certification from the Council in Education of the Deaf (CED), for separate content certification in secondary education of deaf students. We need to look into the costs and benefits of such a requirement, state by state, as we reshape teacher preparation over the next decade.
3. A third problem we face in teacher preparation is that many school programs are

having difficulty attracting qualified science teachers who are themselves deaf. While it is exciting that industry is opening its doors to more and more deaf men and women with scientific training, there is a serious barrier faced by many aspiring deaf teachers who wish to be certified. National and state teacher certification exams should be studied to see if there are factors which explain why deaf examinees are selected out at inordinately high rates. Teacher training programs should be encouraged to follow up with recommendations for change in both testing procedures and/or in their own preparatory curriculum. In addition, we need to establish tuition incentive programs that provide stipends which may attract more deaf men and women into science teaching.

4. Minority teachers, both deaf and hearing, are also underrepresented in the science classrooms in school programs serving deaf students. Efforts should be made to attract qualified African-American, Hispanic, Native-American and other minority science teachers to instruct students who are deaf.

New Directions for Teacher Preparation. Regardless of the primary focus of a preservice or inservice teacher preparation program, whether it be on deafness or on science, there are certain topical areas that should become integral components of preparation programs for teachers of deaf students. The eight areas I briefly describe should be packaged in a prototype curriculum for both undergraduate and graduate programs as well as for workshops and other preservice and inservice training experiences. Importantly, these topical areas should not only complement traditional preparation in instructional methods and materials, but they should become the major emphases. In this way, teachers will be prepared to become change agents in developing more effective science curricula in their K-12 school programs.

1. ***Cognitive Development Through Science*** - The development of thinking skills, especially problem-solving skills, is a major concern among educators of both deaf and hearing students. We need to show how science courses can provide an excellent context for the cognitive development of deaf students and convince science teachers to infuse these strategies. We have a strong rationale through research and theoretical reports on the value of constructivism in general, and Piaget's theory, in particular, in the education of deaf students. This rationale needs to be incorporated into teacher education programs. Experimenting and observing through multisensory instructional strategies must be emphasized.
2. ***Language Development Through Science*** - A second crucial focus in science teacher preparation should be on the infusion of language development into science lessons. We must become more convincing with school administrators that science courses provide an excellent context for language development, both for English and American Sign Language. The frequent argument that English language development should be a high priority in the education of deaf students cannot be contested, but in many schools this belief has practically precluded time for learning science content. In preparing science teachers to infuse English and American Sign Language skill development into the science learning experiences, we need to discuss criteria to be considered when selecting textbooks, laboratory workbooks, and computer software. We must be more systematic in adapting

materials used in mainstream science classes so that they are custom designed on the appropriate reading levels for deaf students. And we should be increasingly sensitive to the fact that, like many hearing minority students, there are deaf students for whom English is a second language. As a consequence, we should apply appropriate bilingual and bicultural principles to the development of our content curricula.

3. ***Career Development Through Science*** - Third, the principles and practices of infusing career education into school curricula have been well-defined in a major program led by Judy Egelston-Dodd titled the "National Project on Career Education" (1980). The NPCE ideas need to be packaged for science teachers with the basic principles and suggestions applied to classroom use, and with resource guides related to science. We must emphasize the importance of deaf role models, in particular. As stated in the *Report of the National Science Foundation Task Force on Persons with Disabilities*, a major issue is "The virtual invisibility of role models in science, science education, and engineering for children with disabilities" (NSF, 1990). In this sense, deaf scientists have been largely "invisible" in the history of science as well. Yet, deaf scientists have made many important contributions in nearly every field of science, and information about them should be integrated into science lessons for our deaf students. This effort may have a positive impact on our students' self esteem.

   On the one hand, it is understandable that because deafness is mostly an invisible disability, stories about deaf men and women in the history of science are not well known. It is nevertheless surprising that we have not capitalized on the visible success stories about deaf scientists in order to motivate deaf students to learn science. Few science teachers today, for example, can identify one of the six craters on our moon named in honor of deaf scientists and mathematicians. Nor is it widely known that more than 5000 stars, comets, novae, and other celestial objects have been discovered by astronomers who were deaf. To extend this a little further, few teachers are aware that the launch date of the famous Sputnik satellite was originally planned to honor a deaf Russian rocket pioneer. The launch date of our own Voyager spacecraft was chosen to honor a deaf American inventor (Lang, In published press).

   Another important issue in career development is the serious lack of representation of deaf women and minorities in the sciences. In six years of historical research, I have been able to identify a small number of deaf female scientists, physicians, and engineers, and only one black deaf scientist. I believe the need for increased representation of deaf women and minorities can be addressed effectively over the next decade through career education infusion in science classes. Teacher preparation programs should address this concern by providing greater emphasis on the importance of women and minority role models. Since most school programs have few deaf adults on the faculty and staff, particularly in their science programs, it is all the more important to invite deaf role model scientists to the classroom. Doing this allows the young deaf student to see the diversity of viewpoints held by deaf adults and to learn about the strategies which successful deaf people have used to overcome communication and "attitude barriers," better known as prejudice and discrimination. Failure to tap the potential influence of successful deaf adults may lead to occupational stereotyping which precludes science as a career choice.

4. ***Collaborative Science Education*** - A fourth critical need which should be built into teacher training to prepare teachers as change agents is an emphasis on the importance of collaboration in developing and offering science education. I strongly agree with the importance of building bridges between science and other content areas, as summarized by Tim Beardsley (1992) this past October in Scientific American as he described the new National Research Council efforts to establish new standards for science education in the United States. The notion of exploring multiple representations of a concept is of particular value to students who are deaf because it helps them to see the wide range of possible applications of what they are learning in science. We must also find ways to articulate across grade levels so that students have a more continuous and coordinated learning experience in science. And we need to develop better procedures for showing teachers how to collaborate with local museums, planetariums, universities, and scientists in industry to enhance the science program for deaf students. These partnership resources in the community will especially enrich science education for programs in schools having minimal budgets.
5. ***The Importance of Attitudes*** - Distaste for science among students in U.S. schools today is a national dilemma. While we do not have extensive research on the attitudes of deaf students toward science, one study of more than 300 deaf adolescents in nine school programs (Lang & Meath-Lang, 1985) indicated that nearly 80 percent of deaf students surveyed enjoy science classes. These students especially value hands-on experiences. The results of this study also provide support for the idea of infusing English language development and career development into science. The motivation of deaf students to learn science appears to vary across topics, instructional methods, and teacher strategies (Lang & Meath-Lang, 1985; Merton, 1991). We need to conduct additional research to identify those science topics which are particularly enjoyable to deaf students and which lend themselves to the infusion of language and cognitive skill development.
The attitudes of "significant others," especially teachers, parents, and counselors, about deaf students and their aptitude for learning science, must also be addressed in teacher preparation programs. My historical research involved reading the journals, diaries, autobiographies, and personal correspondence of many deaf scientists as far back as 250 years ago. The message is clear to me that the attitudes of others were the primary barrier to the success of these distinguished men and women. Attitude still remains a primary barrier today. We should bring this issue to the attention of pre-service teachers and create effective strategies to counter these attitudes.
6. ***The Importance of Time-on-Task*** - Research which has included both classroom observations across the country and the examination of the views of deaf students about effective teaching has revealed a serious problem in regard to time-on-task (See, for example, Daniele & Aldersley, 1988). In many classrooms, the overhead projector sits in the corner while the teacher spends a great deal of learning time

writing lists of words and facts on the board for the students to copy. Deaf students do not like "seat work" in general when they could be learning by discussion or through active participation in activities. We must show teachers how to use instructional time more efficiently with deaf students.

7. ***Evaluation of Learning*** - I also recommend that the principles and practices of unbiased testing and evaluation of the learning and achievement of deaf students in science be further emphasized in teacher preparation programs. Often, the verbal loading of evaluation instruments or the instructions for taking the tests cloud the validity of the assessment results (Lang, 1983).
8. ***The Use of Support Services*** - Science teachers also need to learn how to take advantage of available support services which will enhance science learning for deaf students in their classes. The deaf student should help decide the extent to which these services are needed. Support services include tutoring, notetaking, interpreting, and career counseling.

Science Materials

Recommendation 2: A national program should be established to provide a network for science teachers of deaf students and this program should coordinate efforts to develop, disseminate, and evaluate science instructional manuals.

In the 1983 article titled "Science Education for Hearing-Impaired Students in the Eighties: Priorities and Projections," eight needs were described with the hope that the field would respond in a systematic manner. A decade later, little has changed. Exemplary materials specifically designed or adapted for use with deaf students remain a great need. Yet little progress has been made toward meeting this need. Related to the development and dissemination of instructional materials, I recommend:

1. The identification of exemplary materials designed and/or adapted by individual teachers and/or schools, and a mechanism for helping other teachers to gain awareness of them and to evaluate them.
2. The modification of suitable materials as follows:
   a.They should be written on an appropriate English language level with progressively-challenging English language structures incorporated.
   b. They should include career education infusion, following the principles and guidelines outlined in the National Project on Career Education (Egelston-Dodd, 1980).
   c.They should incorporate communication skill development, including American Sign Language in general, and technical science signs, in particular, as available from the Technical Signs Project (Oglia, Caccamise, Mitchell, Lang & DeGroote, 1990). As the most popular topic in a series of many subjects, the science signs manual developed at NTID quickly sold out the first printing and has been reprinted.
   d.They should be versatile, inexpensive, and packaged in a way as to be able to fit into a variety of programs.
   e.They should incorporate multisensory and hands-on experiences which enhance cognitive development and heighten motivation.
   f.They should provide guides for teachers who wish to prepare more extensively for

both the use of the instructional materials and the science content being presented.
g.They should be comprehensive in both scope and sequence and follow the general guidelines being established by the National Research Council (1993).

The proposed national network of teachers of deaf students focusing on materials development and evaluation should include the distribution of a newsletter to help keep teachers abreast of issues, strategies, and resources in science education in general. The newsletter should also summarize relevant research findings and upcoming events which may have positive impact on teaching science to deaf students .

Implementing the Two Programs: The Role of Scientific Societies

Recommendation 3: National science organizations should take a leadership role in planning and coordinating the enhancement of science teacher preparation and instructional materials development and dissemination for use in programs serving students who are deaf.

The good news is that few people will disagree with the needs I have identified. The bad news is that these needs will likely remain unchanged over the next decade. That is, these needs will be unchanged *unless we take some bold steps.* Why has there been little response since the 1983 report? Teachers and their supervisors in most schools are too busy to take leadership roles in effecting positive change on the level we need. Professional organizations for educators of deaf students are struggling for survival and direction. It is highly unlikely that they will be able to lead in implementing these recommendations during the next decade.

I am not here today simply to describe these needs. Recommendation #3 is the bold step to which I refer. I strongly believe that scientific societies and organizations should take the leadership role in collaborating with universities and other organizations to coordinate the national network. Some of you may not be aware of the pioneering work of scientific societies in the education of deaf students. You may recognize the name Dr. John Wallis, for example, as the distinguished Lucasian professor of mathematics who wrote the preface to Newton's Principia, but did you know that Wallis was one of the first two teachers of deaf pupils in 17th-century England? Robert Boyle, the famous author of The Skeptical Chemist and the Royal Society's secretary, worked with Wallis in examining issues in language instruction of deaf pupils. And many other eminent scientists of the Royal Society made similar contributions to the education of deaf students. In France, as a member of the Academy of Sciences in Paris, the great philosopher and scientist, Jean-Jacques Rosseau, who helped ignite the French Revolution, joined with other distinguished individuals such as Comte de Buffon, Charles de la Condamine, and Denis Diderot to study the educational needs of deaf pupils in 18th-century France.

For those who may wonder how such efforts to improve the education of deaf people can pay off, let me briefly mention a few findings from my historical research. Three hundred years ago, a profoundly-deaf physicist stood before the French Academy of Sciences and gave one of many demonstrations of his experimental work on heat and temperature. Guillaume Amontons is now recognized as the first person to conceive the notion of absolute temperature, and he provided Fahrenheit with the impetus to further examine the fixed points on thermometric scales. In 1786, the

Royal Society of England presented an astronomer who was born profoundly deaf with the Copley Medal for the most significant scientific contribution of the year. John Goodricke had laid the foundations for the study of binary stars with his measurements of Algol in the constellation Perseus. He was not yet 22 years old. In America, the very first elected member of the National Academy of Sciences, Leo Lesquereux, was a profoundly deaf man who is now recognized as a founder of North American Paleobotany, the study of fossil plants. A deaf woman, Annie Jump Cannon, was considered for election as the first woman member of the National Academy of Sciences in the 1920's. The general attitude toward women in science, however, was another barrier she faced. She did not make it. Nor did any hearing woman for some time. One of the first presidents of the American Association for the Advancement of Science in the 19th century, Frederick Barnard, was a deaf scientist who published many reports on both his scientific work as well as on teaching deaf students. Another deaf man, through an AAAS presentation in the 1880's, described his work in assisting Charles Darwin to develop his theory of evolution. He was Thomas Meehan, known as the "Father of American Horticulture," and he published hundreds of reports on his botanical studies. With these few stories in mind, and many more about scientists with other disabilities, scientific societies should take note that there is a long history of such contributions of people with disabilities to all fields of science. Any effort to provide better education and further accessibility for people with disabilities in science in the future will likely benefit science and humankind as well.

I would like to make three final points in regard to professional organizations. First, we must make every effort to continue the great gains made by the AAAS, NSTA, and other organizations in relation to barrier-free annual conventions. Second, I encourage you to join the Science Association for Persons with Disabilities and the Foundation for Science and Disabilities and become active members in these pioneering science education activist groups which have enhanced the opportunities for science students and scientists with disabilities for more than 15 years. And, third, with the support of the National Science Foundation, it is my hope that the American Association for the Advancement of Science and the National Science Teachers Association, in particular, might be able to expand their staff and collaborate with us in our home schools and universities to build the networks I have described.

Collaboration Among Professionals in Special Education
Recommendation 4: Professionals in science education for students with disabilities should collaborate in sharing resources and expertise.

I have previously mentioned the need for collaboration between schools and local industry. My fourth recommendation addresses a much broader collaboration on a national scale. We all recognize that human resources are scarce in science education for students with disabilities. I would like to suggest three kinds of collaboration which will enhance our efforts over the next decade. First, most universities will not be able to offer specialized courses in science education for deaf students, for blind students, and similar courses for students with other disabilities. The bibliography of the Science Association for Disabled Persons provides evidence that many material resources are now available. We need to work together and develop a prototype training course to be piloted and evaluated across the country, a course that is periodically updated with current research results and innovative strategies.

Second, collaboration is recommended for meeting the needs of students with more than one disability. An example of this is the curriculum developed and distributed by the American Printing House for the Blind for teaching mathematics concepts to students who are both deaf and blind (Franks, Albrecht, & Lang, 1985).

And third, collaboration will be helpful in developing and disseminating innovative instructional strategies found to be successful across disabilities.

Toward a New Paradigm in Science Education

Recommendation 5: Professionals in the field of teaching science to students with disabilities should work as closely with the National Research Council and other leaders now establishing new standards and directions for science education in the United States.

We educators in the field of teaching students with disabilities need to become an integral part of the planning, developing, and evaluating teams involved in the national science education efforts. The benefits are mutual. Science teachers in general share many of the same concerns we are describing today. In teaching the millions of English-as-a-Second-Language (ESL) students now in our schools, they might benefit from the materials we have developed for deaf students, for example. Or, in infusing career development or cognitive development through hands-on experiences in science, they might benefit from the materials we have developed for students with disabilities. Let us not watch this exciting movement toward enhanced science education pass us by without offering to help guide it. The National Research Council (1993) has informed us that our participation is important to their work.

Conclusion

To summarize my presentation, I believe that working conferences and national surveys serve a useful purpose in identifying and prioritizing needs. But our hopes of enhanced science education for children with disabilities will not be realized without the increased support of federal agencies such as the National Science Foundation. We have been very fortunate to have the projects and offices in the American Association for the Advancement of Science which have successfully followed up many of the recommendations of the NSF Working Conference in 1978. Such follow-up and continuity are crucial to progress.

In the field of the education of students who are deaf, we have conducted surveys and made many recommendations over the years. But, unfortunately, we have often failed to follow-up with coordinated programs.

With all of this in mind, I firmly believe that a viable solution to the problems we face is a national team of experts established and sponsored by the National Science Foundation to address the curriculum and teaching/learning issues and to coordinate efforts to enhance curriculum and teaching/learning according to the recommendations of this working conference. With such a structured approach on the federal level which taps the expertise currently available, our dreams for quality education may very well become reality, and the next millennium will truly be one of opportunity in science for people with disabilities.

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Critique of Harry Lang's Paper "Science for Deaf Students: Looking into the Next Millennium"

by
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We often hear American business leaders say, "Improve your schools!" Shouting, "Improvement!" without a plan is rhetoric. Harry Lang has provided a working plan to improve science education for deaf students that goes beyond rhetoric. Lang has effectively set out to build a national agenda for the science education for deaf students. He has delineated directions for the future into the next millennium, identified the critical issues that are presently confronting us, and set forth a framework from which many initiatives may grow.

Several issues which need immediate attention were identified as enhanced teacher preparation, teacher networking to share materials and evaluation resources, and collaboration among science educators of all disabilities to share courseware, which I consider appropriate, since it has been my observation that deaf students frequently exhibit other disabilities. With the National Committee on Science Education Standards and Assessment (NCSESA) about to embrace the philosophy of "Science for All," (Rutherford & Ahlgram, 1989), it is crucial that special educators in science be poised to assist with expertise ready to join in the reform movement.1 It is also appropriate to embrace National Science Teachers Association's Scope, Sequence and Coordination Project (Aldridge, 1992) which advocates, "Every Student, Every Science, Every Year." Lang's contribution here is to move us as special educators in the same direction, knowing that the risks we take will be supported by policies of the national systems. By Fall of 1994, when the new standards are ready for dissemination, our input will be ready, thanks to Lang's framework for the future. The biggest challenge will be confronting the impact of standardized assessment measures on deaf students. We may rely on the input of groups like Science Association for the Persons with Disabilities and the Foundation for Science and the Handicapped to protect the integrity and validity of testing for deaf people. It might be possible for a national science education evaluation program to be designed with norms for deaf students. The network of science educators who work with deaf students must be tapped for input on developments leading to national assessment standards. As Lang points out, it will be the scientific societies and professional organizations which will make the proposed networks happen, and which will collaborate with universities on reform of teacher preparation programs (p. 15). This is a valid and hugely important role for them with a long-range pay off for industry and the U.S. economy.

Harry Lang's background as a physics professor and science educator are enhanced by his knowledge of the many contributions of deaf people in the history of science. By spot-lighting the scientist-heroes whose deafness was invisible, Harry shows us their genius and ability, not their disability, and leaves us to wonder how they did prevail in their scientific efforts without educational support. These accomplishments are awesome and as a career educator of deaf students, I can only hope he publishes his science history book soon so that future deaf scientists will realize that there are role models for their aspirations.

How many educators of secondary students who are disabled have seen too many who use their disability as an excuse not to do their best work? The availability of role models for deaf students studying science would change that "can't" attitude and raise their aspirations. Knowing that a Nobel prize winner was "deaf like me" would help students see the respect they have earned in the world of science for their outstanding accomplishment and help them realize that deafness is not a disability that limits achievement and honor. Deaf pride, like Black pride and feminist pride, can only be built on the body count of outstanding predecessors. If these deaf people stay invisible in our history of science, the future scientists of tomorrow will lose the opportunity for being inspired to excellence. They are an inspiration for us all, and I am personally thrilled to see Lang's action agenda ready for implementation.

Notes

1National science education standards: An enhanced sampler. (1993). Washington, DC: National Research Council, 2101 Constitution Avenue, N.W. HA486, Washington, DC 20418. 202-334-1399 (voice).

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Response to Harry Lang's Presentation: "Science for Deaf Students: Looking Into the Next Millennium"

by

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The recommendations promulgated by Harry Lang for a national program to address the science and science education training of K-12 teachers of the hearing impaired is both comprehensive and focused. I support his proposals with enthusiasm. However, I would like to see them broadened to include, as well, those teachers who are in the mainstream, since many of them may also have the opportunity to teach hearing-impaired students in the conventional classroom; especially those in grades K through six.

Dr. Lang proffers seven areas for consideration in a prototypical course of study for pre-service teacher preparation. I believe that emphasis should be placed on the cognitive development and language development components of his proposal. In my view, if we are successful with these two components, then we are most likely to increase both the scientific literacy of teachers and their comfort level in teaching the subject. Concomitantly, the other five components are also likely to be achieved as well.

My hope is that this course on cognitive and language development will focus both on the process of science as well as the content of science. If the training is to achieve success it must emphasize that science is a verb and not a noun. Although my previous statement almost sounds like a cliche, it has significant relevance for hearing-impaired students, in that by "doing" science, there is movement away from the language-permeated techniques of demonstrations and lectures, which tend to ignore the benefits of a multi-sensory approach.

Cognitive development is more likely to be facilitated through a multi-sensory approach with the aural, tactile and visual systems interacting. Therefore, the program to prepare teachers to work with hearing-impaired students must be laboratory and experimentally based. It must focus on the strengths of hearing-impaired students, and not on their weaknesses.

Dr. Lang's proposal for establishing a network for the development, dissemination, and evaluation of science instructional materials for the hearing impaired is another significant component that needs to be addressed. He is correct in pointing out that this idea has been around for a decade without any significant affirmation from the educational community. Perhaps the time has come for governmental intervention in the form of specifications that would require all school systems to link up with the proposed national network. Perhaps the U.S. Department of Education, with input from the National Science Foundation (NSF), American Association for the Advancement of Science (AAAS), National Science Teachers Association (NSTA), and teachers of the hearing impaired could provide the impetus for establishing the network. As Dr. Lang has pointed out, we have passed one decade since the idea was generated. It is incumbent upon us to prevent this lost decade from becoming a score.

The remaining points of Dr. Lang's proposal are also focused on the issues at hand and serve to strengthen his arguments for national action.

It is pleasing to note that many of us who are here today, met for first time at the Working Conference on the Disabled in Science which was sponsored by the AAAS in 1978. Put together by Martha Redden and Virginia Stern, the 1978 meeting was to lay the foundation for significant progress in improving the science education of the disabled. The fact that much progress did occur, often in spite of seemingly insurmountable odds, should encourage us to be hopeful that the future for the disabled in science and science education will be realized by continued action. Just as science is a verb that requires "doing," we must be vigilant as well in doing what we have to do, to assure that we are persistent in providing direction and guidance for the schools of our nation and the disabled students that they serve.

Summary Of Strengths, Limitations And Recommendations Of The Working Groups At The Conference On Science For Persons With Disabilities Held In Kansas City, Missouri March 30 -31, 1993

Motor/Orthopedically Impaired

Strengths

1. Independent physical accessibility is improving in the publicsector, private sector, and in schools.

2. Role models have become more active and more visible in allaspects of society.

3. There is improved availability of new technology and applied science technology (robotics).

4. Schools are moving toward full inclusion of students with motor/orthopedic impairments in all aspects of the educationalprogram.

5. Constructivist paradigms and the integration of disciplines,particularly through whole language initiatives and multisensory instruction, are providing students with increased opportunitiesto be successful in science.

Limitations and Recommendations

1. Limitation. There are still many "negative gatekeepers"including: parents, classroom teachers, science teachers, special education teachers, guidance counselors, and administrators, who directly and/or indirectly limit students with motor/orthopedic impairments from reaching their full potential.

    a. Recommendation. A nation-wide staff development initiative should be supported which will ensure that every educational building has an advocate for students with disabilities.

    b. Recommendation. Administrators must serve as active instructional leaders to redirect the teaching behaviors of individuals reluctant to change teaching methods which are not responsive to the needs of students with motor/orthopedic or multiple impairments.

c. Recommendation. Government agencies and professional organizations must remain vigorous in their efforts to enforce and implement laws reflecting equity of opportunity for individuals with motor/orthopedic impairments.

d. Recommendation. Funding is needed to provide a data base for science teachers, to develop consistent terminology, to develop standards for laboratory safety, and to provide avenues for networking opportunities for teachers, administrators, and students.

Hearing Impaired

Strengths

1. The increased availability of new technology, captioned films, computers, and voice mail allow for greater student participation.

2. Publications, suggestions offered in teacher guides, resource teachers in special education, and networking opportunities provide a much enriched information base.

3. New strategies and materials including full-inclusion, hands-onscience, cooperative learning, and adapted science materials for the hearing impaired are available.

4. Legislation and public sensitivity have resulted in more monies for schools and teachers for technical assistance and instructional equipment.

5. More professional associations have task forces and committeescharged with addressing the requirements of students with specialneeds.

Limitations and Recommendations

1. Limitation. There are still many hearing impaired students whoare not provided with quality learning experiences because: 1: they have not been identified, 2) persons providing services arenot available or are distributed over too many clients, 3) parentsand/or teachers are not aware of rights and responsibilities, 4)no one is serving as an advocate for the child or student.

   a. Recommendation. Continuing efforts to ensure that there are sufficient resources both human and material to secure equity of opportunity for the hearing impaired student must be sustained.

b. Recommendation. Programs for administrators, teachers, and parents on legislative action and rights of the hearing impaired should be offered at the local level and coordinated with professional associations and government agencies.

c. Recommendation. Workshops and institutes on strategies, equipment and supplies which will allow full participation of hearing impaired students in the science classroom and laboratory should be easily accessible to all science teachers who have hearing impaired students. These opportunities should be provided on a continuing basis through local and area educational agencies.

Visually Impaired

Strengths

1. New technology has become available for the visually impaired andaccessibility to new technology has improved.

2. Instructional aids, such as tactile displays, are being used more extensively in the classroom, and many more resources areavailable.

3. The National Clearing House, professional associations, and government agencies have provided improved opportunities for networking, better career access and increased opportunities for participation by visually impaired students.

Limitations and Recommendations

1. Limitation. Visually impaired students continue to have limited opportunities for reaching their full potential.

   a. Recommendation. Camps and special programs in science for students with visual impairments should be supported through National Science Foundation Funding along with support from public and private agencies and foundations. These programs, in addition to providing sound science concepts, should stimulate excitement about science learning, assist students in building confidence and self-esteem as a learner in science, assist with coping skills, and increase career awareness and contact with adult role models.

b. Recommendation. Museums, science centers, nature trails, and public areas should be accessible and adapted to allow visually impaired individuals to participate in learning opportunities.

c. Recommendation. Alternative format testing and follow through on assessment to ensure equity for visually impaired students are needed.

d. Recommendation. There should be continuing follow-through between teachers and students to ensure visually impaired students are equipped with learning aids, resources, equipment and supplies which allow full participation of visually impaired students.

e. Recommendation. Laboratory guides, standards on laboratory safety and methods, opportunities for visually impaired students and their teachers should be developed and supported.

f. Recommendation. State Boards of Education, administrators, and school committees should be targeted through staff development programs which make them cognitive of legislation and the need for full inclusion of the visually impaired.

Learning Disabled

Strengths

1. The quality of programs preparing teachers for students with learning disabilities has improved considerably. Specific improvements include: teachers are more capable of identifying learning disabilities, special education is now offered as agraduate only program at some institutions; teachers are receiving more information on strategies for students with learning disabilities; team teaching is a more common practice in schools; and, many teacher training programs place students in classrooms with mainstreaming during student field experiences.

2. There are improved technology aids for learning disabled students.Specific items include: self-paced software with the capacity to back track until the student attains mastery, motivational software, word processing opportunities to help students produce legible work, lower cost hardware and software, spellers,calculators, and laser discs.

3. More textbooks and teacher guides contain specific suggestions for teachers in order to better accommodate students with special needs.

4. A greater variety of instructional materials designed specifically for students with learning disabilities is becoming available in the marketplace.

5. Students with learning disabilities are receiving more acceptance by other students. Many are showing evidence of improved self-esteem.

6. Students with learning disabilities are accessing institutions of higher education at higher rates.

7. Many community colleges are designing courses responsive to the needs of students with learning disabilities.

8. Advances in neurological research are increasing the knowledgebase about learning disabilities. Medical means for minimizing the effects of specific abnormalities are becoming more common.

Limitations and Recommendations

1. Limitation. Specific areas needing improvement are: teachers in training often lack experience in mainstreamed classrooms; college and university personnel are unable to model appropriate practice; suggestions for making adaptations and modifications in instruction for learning disabled students are not included in teacher training programs for subject area or general classroomteachers; few teachers are aware of the rights of students with learning disabilities and the responsibilities of professional educators in meeting their needs.

   a. Recommendation. Professional development is needed for science methods instructors. Science education professors should be: aware of instructional interventions appropriate for students with learning disabilities; capable of effectively modeling multisensory instruction; knowledgeable in how to develop language through science learning; aware of techniques for effective collaboration between specialists and classroom teachers; knowledgeable in approaches to classroom management which optimize student learning; knowledgeable of cooperative learning strategies;

and capable of employing evaluation practices using authentic assessment.

b. Recommendation. Science educators need to be made aware of legislation and of their responsibilities as professional educators to students with learning disabilities.

2. Limitation. There are still many learning disabled students who are not provided with quality learning experiences because: 1) they have not been identified, 2) persons providing services are not available or are distributed over too many clients, 3) parents and/or teachers are not aware of rights and responsibilities, 4) no one is serving as an advocate for the child or student.

    a. Recommendation. Programs designed to provide parents, administrators, and teachers of information on legislation and rights of learning disabled students, and responsibilities of educators toward meeting these rights should be provided. These should be offered at the local level and conducted in cooperation with professional associations and government agencies. Every building should have at least one teacher who serves as an active advocate to insure equity of opportunity for students with learning disabilities. Attitudes and prejudices which are harmful to learning disabled students intellectually, socially, and emotionally should be addressed.

3. The learning disabled label is becoming a "dumping ground" for students with other problems

    a. Recommendation. Funding is needed to develop: a consistent terminology for types of learning disabilities along with appropriate modifications and instructional strategies for different types of disabilities; standards for laboratory safety; and a means for networking among teachers, parents, administrators, and students with learning disabilities.

    b. Funding should be provided to assist with: equity of assessment, mentoring opportunities, dissemination of information, identification of adult role models for students with learning disabilities, and reducing the amount of paper work and documentation.

General Limitations and Recommendations

Limitations and Recommendations

1. Limitation. Teacher training programs provide little preparation for regular classroom teachers on working with students with disabilities. An exposure, when provided, is usually through an isolated course which is descriptive rather than interactive. As a result the majority of college graduates in teaching are not prepared to respond to the needs of students with disabilities.

    a. Recommendation. Professional development is needed for professors in science disciplines on modeling and addressing the needs of students with disabilities; and teacher educators in science methods, to provide them with the knowledge and skills to teach prospective teachers appropriate methodology for differentiating and adjusting instruction for students with disabilities.

    b. Recommendation. State departments must be vigorous in requiring all institutions certifying teachers to provide students in teacher preparation programs with training in meeting the needs of students with disabilities.

    c. Recommendation. All teachers of science methods should include a unit on multi-sensory instruction, developing language through science, and suggestions for collaboration between specialists and regular teachers.

2 Limitation. The majority of classroom teachers are not prepared to address the needs of students with disabilities particularly with new initiatives toward full inclusion

    a. Recommendation. Research on the impact of decreasing funding for special needs students is needed.

    b. Recommendation. Professional development for all teachers on the school site, or strategies and responsibilities in meeting the needs of special students should be a major national initiative.

    c. Recommendation. Educational leaders must become vigorous in directing all teachers to assume responsibility for adjusting and differentiating instruction so all students can be successful.

    d. Recommendation. Institutes for teachers including short courses, full seminar programs, and academic year institutes should be developed and offered through National Science Foundation support.

3. The current models of teacher preparation and staff development are inadequate for accomplishing our educational outcomes through full inclusion. Preservice teachers do not have an adequate foundation ofexperience to fully appreciate strategies and approaches for accommodating individual differences and experienced teachers receive a sporadic program of staff development.

   a. Recommendation. Models of teacher induction where beginning teachers receive continuing contact with professionals who provide guidance during their first few years of teaching should be investigated and supported through National Science Foundation and Office of Education Agency funding.

   b. Models of staff development which include coaching and mentoring for experienced teachers should be investigated and supported through National Science Foundation and Office of Education Agency funding.

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REASONS FOR PARTICIPATING IN THE CONFERENCE

1. The U.S Dept. of Energy is preparing to enhance programs so students with disabilities will be able to participate.

2. Teaching inservice teachers—demonstration of most effective classroom techniques that need to be used with students with special needs.

3. Enhancement of science teaching to students with special needs.

4. Gain of new knowledge.

5. Increase of expertise because of involvement in a project entitled "Designing Technology for people with Disabilities."

6. Writing a book on disability rights revolution, in conjunctlon with Columbia University Oral History Program.

7. Involved in writing science curriculum materials for elementary grades (3-6).

8. Involved in "Homecoming" program of Essex Middle School, and has found ways to integrate both disabled students and design thematic curricula.

9. Involved in writing science curricula materials for elementary grades (3-6), and needs information about disabled students.

10. Identifying the critical factors that contribute to entry and advancement of persons with disabilities in science, math, and engineering.

11. Developing materials of use for different audiences involved in facilitating the participation of all individuals in mainstreamed science classes.

12. Sharing information.

13. Incorporation of gained knowledge into the plans of a project aimed at retraining elementary science teachers.

14. Involved for over 24 years with regular and disabled students.

15. Expanding knowledge of teaching strategies and use of alternative assessment measures to meet needs and interests of hearing impaired students.

16. Expanding knowledge in order to meet the needs of visually impaired and blind students.

17. Working on a committee and rewriting the curriculum guide for learning disabled classrooms—Recipient of the 1990 of the President Award for excellence in Teaching Elementary Science and Mathematics.

18. Involved in preparing grant proposals, working with teachers, Board of Regents, consulting—wants special knowledge.

19. Awarded an Eisenhower grant to train teams of special educators, elementary teachers, and paraprofessionals.

20. Working for the past 3 years on a project aimed at developing guidelines f or facilitating mainstreaming in science for students with disabilities (K-8).

21. Teaching a graduate and inservice course entitled "Special Topics in Elementary Science: Teaching Science to Children With Special Needs."

22. Integrating students with disabilities into a science class.

23. Working as coordinator of a project involving the development of supplementary classroom activities for high school biology students. There will be a modification of the activities both for disabled and gifted students.

24. Developing a new high school program for students with disabilities.

25. Interested in replicating many of the adapted science activities in university classes.

SUMMARY OF STRENGTHS, LIMITATIONS AND RECOMMENDATIONS OF THE WORKING GROUPS AT THE CONFERENCE ON SCIENCE FOR PERSONS WITH DISABILITIES HELD IN KANSAS CITY, MISSOURI

March 30 -31, 1993
Motor/Orthopedically Impaired

Strengths

1. Independent physical accessibility is improving in the public sector, private sector, and in schools.

2. Role models have become more active and more visible in all aspects of society.

3. There is improved availability of new technology and applied science technology (robotics).

4 Schools are moving towards full inclusion of students with motor/orthopedic impairments in all aspects of the educational program.

5 Constructivist paradigms and the integration of disciplines, particularly through whole language initiatives and multisensory instruction, are providing student with increased opportunities to be successful in science.

Limitations and Recommendations

1 Limitation. There are still many "negative gatekeepers"including: parents, classroom teachers, science teachers, special education teachers, guidance counselors, and administrators, who directly and/or indirectly limit students with motor/orthopedic impairments from reaching their full potential.

   a. Recommendation. A nation-wide staff development initiative should be supported which will ensure that every educational building has an advocate for students with disabilities.

b .Recommendation. Administrators must serve as active instructional leaders to redirect the teaching behaviors of individuals reluctant to change teaching methods which are not responsive to the needs of students with motor/orthopedic or multiple impairments.

c. Recommendation. Government agencies and professional organizations must remain vigorous in their efforts to enforce and implement laws reflecting equity of opportunity for individuals with motor/orthopedic impairments.

d .Recommendation. Funding is needed to provide a data base for science teachers, to develop consistent terminology, to develop standards for laboratory safety, and to provide avenues for networking opportunities for teachers, administrators, and students.

e. Recommendation. Laboratory guides, standards on laboratory safety and methods, opportunities for visually impaired students and their teachers should be developed and supported.

f Recommendation. State Boards of Education, administrators, and school committees should be targeted through staff development programs which make them cognitive of legislation and the need for full inclusion of the visually impaired.

Visually Impaired

Strengths

1. New technology has become available for the visually impaired and accessibility to new technology has improved.
2. Instructional aids, such as tactile displays, are being used more extensively in the classroom, and many more resources are available.
3. The National Clearing House, professional associations, and government agencies have provided improved opportunities for networking, better career access and increased opportunities for participation by visually impaired students.

Limitations and Recommendations

1. Limitation. Visually impaired students continue to have limited opportunities for reaching their full potential.

    a. Recommendation. Camps and special programs in science for students with visual impairments should be supported through National Science Foundation Funding along with support from public and private agencies and foundations. These programs, in addition to providing sound science concepts, should stimulate excitement about science learning, assist students in building confidence and self-esteem as a learner in science, assist with coping skills, and increase career awareness and contact with adult role models.

b. Recommendation. Museums, science centers, nature trails, and public areas should be accessible and adapted to allow visually impaired individuals to participate in learning opportunities.
c. Recommendation. Alternative format testing and follow through on assessment to ensure equity for visually impaired students are needed.
d. Recommendation. There should be continuing follow- through between teachers and students to ensure visually impaired students are equipped with learning aids, resources, equipment and supplies which allow full participation of visually impaired students.
e. Recommendation. Laboratory guides, standards on laboratory safety and methods, opportunities for visually impaired students and their teachers should be developed and supported.
f. Recommendation. State Boards of Education, administrators, and school committees should be targeted through staff development programs which make them cognitive of legislation and the need for full inclusion of the visually impaired.

Hearing Impaired

Strengths

1. The availability of new technology, greater availability of captioned films, computers, and voice mail allows for greater student participation.
2. Publications, suggestions offered in teacher guides, resource teachers in special education, and networking opportunities provide a much enriched information base.
3. New strategies and materials including full-inclusion, hands-on science, cooperative learning, and adapted science materials for hearing impaired are available.
4. Legislation and public sensitivity have provided more monies for schools and teachers through technical assistance and instructional equipment.
5. More professional associations have task forces and committees committed to addressing the needs of students with special needs.

Limitations and Recommendations

1 Limitation. There are still many hearing impaired students who are not provided with quality learning experiences because: 1) they have not been identified, 2) persons providing services are not available or are distributed over too many clients, 3) parents and/or teachers are not

aware of rights and responsibilities, 4) no one is serving as an advocate for the child or student.

a. Recommendation. Continuing efforts to insure that there are sufficient resources both human and material to insure equity of opportunity for the hearing impaired student must be sustained

b . Recommendation. Programs for administrators, teachers, and parents on legislative action and rights for the hearing impaired should be offered at the local level and coordinated with professional associations and government agencies.

c. Recommendation. Workshops and institutes on strategies, equipment and supplies which will allow full participation of hearing impaired students in the science classroom and laboratory should be easily accessible to all science teachers who have hearing impaired students. These opportunities should be easily accessible on a continuing basis through local and area educational agencies.

Learning Disabled

Strengths

1. The quality of programs preparing teachers for students with learning disabilities has improved considerably. Specific improvements include: teachers are more capable of identifying learning disabilities, special education is now offered as a graduate only program at some institutions; teachers are receiving more information on strategies for students with learning disabilities; team teaching is a more common practice in schools; and, many teacher training programs place students in classrooms with mainstreaming during student field experiences.

2. There are improved technology aids for learning disabled students. Specific items include: self-paced software with the capacity to back track until the student attains mastery, motivational software, word processing opportunities to help students produce legible work, lower cost hardware and software, spellers, calculators, and laser discs.

3. More textbooks and teacher guides contain specific suggestions for teachers in order to better accommodate students with special needs.

5. A greater variety of instructional materials designed specifically for students with learning disabilities is becoming available in the marketplace.

6. Students with learning disabilities are receiving more acceptance by other students. Many are showing evidence of improved self-esteem.

7. Students with learning disabilities are accessing institutions of higher education at higher rates.

8. Many community colleges are designing courses responsive to the needs of students with learning disabilities.

9. Advances in neurological research are increasing the knowledge base about learning disabilities. Medical means for minimizing the effects of specific abnormalities are becoming more common.

Limitations and Recommendations

1. Limitation. There are still many learning disabled students who are not provided with quality learning experiences because: 1) they have not been identified, 2) persons providing services are not available or are distributed over too many clients, 3) parents and/or teachers are not aware of rights and responsibilities, 4) no one is serving as an advocate for the child or student.

   a. Recommendation. Programs designed to provide parents, administrators, and teachers of legislation and rights of learning disabled students and responsibilities toward meeting these rights should be provided. These should be offered at the local level and conducted in cooperation with professional associations and government agencies. Every building should have at least one teacher who serves as an active advocate to insure equity of opportunity for students with learning disabilities. Attitudes and prejudices which are harmful to learning disabled students intellectually, socially,and emotionally should be addressed.

2. The learning disabled label is becoming a " dumping ground" for students with other problems.

   a. Recommendation. Funding is needed to develop: a consistent terminology for types of learning disabilities along with appropriate modifications and instructional strategies for different types of disabilities, standards for laboratory safety,and a means for networking among teachers, parents, administrators, and students with learning disabilities.

   b. Funding should be provided to assist with: equity of assessment, mentoring opportunities, dissemination of information, identification of adult role models for students with learning disabilities, and reducing the amount of paperwork and documentation.

General Limitations and Recommendations

Limitations and Recommendations

1. Limitation. Teacher training, particularly for the regular classroom teacher generally is inadequate or non-existent.

   a. Recommendation. Professional development is needed for higher education personnel in providing an awareness of, and responsibility to, students with disabilities.
   b. Recommendation. State departments must be vigorous in requiring all institutions certifying teachers to provide students in teacher preparation programs with training in meeting the needs of students with disabilities.
   c. Recommendation. All teachers of science methods should include a unit on multi-sensory instruction, developing language through science, and suggestions for collaboration between specialists and regular teachers.

2. Limitation. The majority of classroom teachers are not prepared to address the needs of students with disabilities particularly with new initiatives toward full inclusion.
   a. Recommendation. Research on the impact of decreasing funding for special needs students is needed.
   b. Recommendation. Professional development for <u>all</u> teachers on the school site, or strategies and responsibilities in meeting the needs of special students should be a major national initiative.
   c. Recommendation. Educational leaders must become vigorous in directing all teachers to assume responsibility for adjusting and differentiating instruction so all students can be successful.
   d. Recommendation. Institutes for teachers including short courses, full seminar programs, and academic year institutes should be developed and offered through National Science Foundation support.

3. The current models of teacher preparation and staff development are inadequate for accomplishing our educational outcomes through full inclusion. Preservice teachers do not have an adequate foundation of experience to fully appreciate strategies and approaches for accommodating individual differences and experienced teachers get a sporadic program of staff development.

   a. Recommendation. Models of teacher induction where beginning teachers receive continuing contact with professionals who provide guidance during their first few years of teaching should be investigated and supported through National Science Foundation and Office of Education Agencies.

b. Models of staff development which include coaching and mentoring for experienced teachers should be investigated and supported through National Science Foundation and Office of Education Agencies.

A WORKING CONFERENCE ON SCIENCE EDUCATION FOR PERSONS WITH DISABILITIES

MARCH 30-31, 1993

QUESTIONNAIRE

In order to evaluate this NSF sponsored project, we would like you to fill out this questionnaire about the conference activities. Your input will be valuable to help us determine whether we have reached our goals.

Thank you.

Greg Stefanich and George Davis, Conference Co-Directors

Section I - Facilities

A. Facilities: Good _____ Fair _____ Poor _____

Comment(s)

B. Assistance for Persons With Disabilities:

Good _____ Fair _____ Poor _____

Comment(s)

Section II - Background Information

A. Check the basis for your primary interest in this conference:

1. _____ Science Educator
2. _____ Scientist
3. _____ Parent
4. _____ Student
5. _____ Special Educator
6. _____ Career Educator
7. _____ Counselor
8. _____ Other (specify)

B. Check the disability of greatest interest to you:

_____ Visual
_____ Auditory
_____ Orthopedic
_____ Learning Disabled
_____ All

C. What did you hope to accomplish by attending?

Section III - Outcomes

A. Did you achieve your purpose for attending the conference?

_____ Yes _____ Somewhat _____ NO

B. What part of the conference did you find to be most productive. Please describe why:

C. What part of the conference did you find least productive. Please describe why:

D. What did you perceive the goals of the conference to be?

E. Were these goals achieved? _____ Yes _____ Somewhat _____ No

Comments:

F. If a similar conference were held in the future, what change(s) would you recommend?

General Comments:

SAPD QUESTIONNAIRE EVALUATIONS
QUESTIONNAIRE TALLY

SECTION I

A. Facilities

Good	Fàir	Poor
42	2	0

B. Assistance for Persons with Disabilities

Good	Fair	Poor
18	4	1

Comments:
appeared to be satisfactory - 2
information not accessible to LD's, needed visuals for visual processors

SECTION II

A. Basis for primary interest in the conference:

Science educator	28
Scientist	2
Parent	1
Student	2
Special educator	12
Career educator	0
Counselor	0

Others:
adapts materials for use by all
math/science
science resource - many districts
program development
research regarding education of disabled (2)
trains researchers to teach science to disabled students
LEP teacher
school psychologist
service provider
technology institute out reach to "at-risk" (includes students with disabilities)
classroom teacher
resource for teams

trainer for teams

B. Disabilities of greatest interest:

visual	5
auditory	3
orthopedic	3
learning disabled	14
all	27

C. What did you hope to accomplish by attending?

1. become associated with others that shared my interest and have input in a national standards policy for science education for persons with disabilities.
2. information to help a blind student in science.
3. how can I be a good science teacher for LD students?
4. learn how to work more efficiently with special needs students.
5. acquiring information to use when out school districts inservice our teachers.
6. to learn as much as possible on how to implement handicapped students in my classes.
7. to learn more about the special needs of persons with disabilities and how I can provide preservice and inservice to teachers of science.
8. networking - implementation.
9. I hoped to get lots of information and teaching ideas and techniques that I can pass on to my colleagues and use in the training of teachers of disabled children.
10. a wide range of methods to assist teachers to teach science to students with disabilities.
11. inc. knowledge on modifications and adaptations.
12. to reconnect with and to network with others having this interest.
13. what are the needs that education - science education is not meeting for the students? What do other educators feel/think?
14. work with other people, discussing, prioritizing and planning strategies for working with students in normal classrooms.
15. knowledge, education, contacts, networking, papers, meeting people, sharing knowledge
16. to find strategies for coping with instruction of science for students with learning disabilities
17. to learn more about what is being done and what needs to be done in the classroom for persons with disabilities.
18. I want to learn some strategies to help all the students in my future science class.
19. become aware of the needs of students with special needs.
20. I hoped to learn what was going on in other parts of the country and Canada. I also wanted to know what other educators were thinking with regard to teaching students with disabilities.
21. methods for teaching children with disabilities.
22. to gain a better insight into the problems/obstacles involved in the education of the

visually impaired individual.
23. to learn of strategies and materials to incorporate into materials and activities to allow the handicapped to be able to work in regular setting with peers as much as possible.
24. I wanted to learn what was happening around the country with students with disabilities with science and math education. I also wanted to learn techniques for working with students with learning disabilities.
25. Awareness - where are we at in science education for the disabled? Nuts and bolts strategies for the classroom teacher.
26. To become aware of the goals for science education for my hearing impaired students and take an active part in achieving them. It's great to be involved at the grassroots level.
27. broader knowledge of resources.
28. to learn how to adapt science and engineering education for students with disability.
29. teaching science to persons with special needs.
30. strategies for helping challenged students.

SECTION III - OUTCOMES

A. Did you achieve your purpose for attending the conference

Yes	Somewhat	No
27	16	1

Comments:
1. I feel I have both provided and received support for educational change for equity and inclusion of all people for science literacy.
2. I would have liked some hands-on demonstrations of technology to help teachers adapt activities to students who are disabled.
3. need more specific guides for my project teams.
4. I doubt that "everyone" is doing hands-on science and I wonder about the number of students with disabilities who are included with non-disabled students. (I fear it may be fewer than has been suggested here.)
5. I shifted my focus from just strategies to the whole outlook.

B. What part of the conference did you find to be most productive?

1. Dialogue with the variety of educators present working towards the same goal. Good networking. Names and addresses made it easy to add what particular information I will send them. Structured and unstructured time all excellent (breaks and lunch were unstructured times for exchange of ideas.)
2. Small working groups. Should have spent half of the total time.
3. the group discussion Tuesday afternoon on Hearing Impaired was excellent (worth my cost of attendance!).
4. Recommendations for implementation of strategies for science education for

students with learning disabilities.
5. papers, meeting people, sharing knowledge
6. Wednesday morning developing implementation action plan.
7. Everything!! I was given the opportunity to gather great information and important information.
8. Discussion sessions. The collecting of ideas.
9. Small groups and comments about available resources, books, etc.
10. Small group.
11. Listening to the speakers describe their ways of compensating for their disabilities. The teaching of ideas!
12. Papers and reactions.
13. All were of benefit to me. I would not be able to prioritize.
14. Making sure participants are aware of the advancements that are being made and the standards being used.
15. The LD because that is the type of students I presently have in my class.
16. Lots of information. Role models.
17. Meeting with individuals on a 1 to 1 basis.
18. Small discussion group — everyone was able to express their ideas.
19. The presenters.
20. I found working in the groups to develop strengths and recommendations most beneficial because I helped develop an ideal classroom. By doing this I will be more likely to do this in my class.
21. Presentations.
22. I thought that the papers and the responses were excellent. I enjoyed speaking with other educators and I found these conversations very productive.
23. Small group meetings and Harry Lang and Judy Egelston-Dodd.
24. As this is my year in working solely with impaired students, I found the speakers and reactors providing me with some different perspectives, but also affirmation in my present approach to my classroom activities.
25. Hearing about what is going on in other parts of the nation.
26. The small group discussions (5 people max.) because I could participate more instead of listen. Also most of the presentations Tuesday were excellent because speakers based what they said on personal experiences.
27. Small group.
28. Presenter presentations and answer sessions.
29. Reactors comments added perspective.
30. The awareness of all the sources of information available, as well as the expertise. I don't feel as though the reinvention of the wheel is necessary to develop/adopt materials to be used by all students.
31. Paper presentation.
32. Presentations and resources to advocate for other disability areas.
33.Presentations were excellent.
34. Small group discussion and "Valentine" report.
35. Discussions with other people on how they are working with people with disabilities.
36. Strategies mentioned by LD and visually impaired speakers.

37. Group discussions — one can express their individual responses and be heard.
38. Group discussion — opportunity to exchange ideas.
39. Group recommendation development.
40. The paper and reactors' statements on the science education of hearing impaired. Elizabeth Stage's talk was very exciting and enlightening. The small group sessions were more focused the second day.
41. Networking opportunities for future actions and information.
42. The talks at the beginning where people told their stories and what made them successful. The stories of the role models were wonderful.

C. What part of the conference did you find least productive and why?

1. The groups at the end of the first day. The break up of the groups according to disability was not a good way of dividing.
2. Perhaps there just wasn't enough time.
3. Small groups — since many people were not working with hearing impaired, the focus of groups got off topic. Many concerns and frustrations of hearing impaired were not addresses.
4. Reactors were not necessary — they just gave mini papers.
5. Reading of papers.
6. Some of the reading done by presenters.
7. Reaction speakers. Possibly more productive to the audience reaction and interaction.
8. People reading their papers and the reactors reading papers.
9. O.K.
10. We needed more discussion time or a follow up.
11. Reactors didn't react but patted each other on back and presented.
12. Trouble hearing in group (an acoustic problem, not a conference problem).
13. This was something that could not be controlled. One person had their own agenda in the small group meeting I was in. I personally felt it was in bad manners and not in tune with the purpose of the conference. I was here to learn as much as I could about how and where to find help adapting activities for those with disabilities.
14.Some talks rambled.
15. Group discussion not near enough time per group. We need a full week in my opinion.
16. Time. Need time for reflection, then interaction.
17. Large group discussions (15-20) in which it was hard to have an opportunity to participate.
18. Some of the small groups.
19. All was productive for me.
20. Some of the speakers — not really more than general, common knowledge.
21. Some of my questions were not answered (for example, what can be done about the fact that vested interests (e.g. special education teachers, school administrators) have an incentive to maintain the status quo.)
22. Small group sharing — too large and couldn't hear.
23. The first groups because we needed to keep a better focus. Questions might be a

better way to lead the discussion.
24. The group meetings — not enough time was allowed. Groups should have been formed according to general interest.
25. I thought all preceded fairly well. At first it bothered me that I wasn't able to be in my area of interest, however everything was quite global, so I believe I actually learned more.
26. All helped.
27. None.
28. The extra time given to the participants. Allow more time in the schedule if handicapped participants are involved.
29. None.
30. Large group sessions. Groups were too large and acoustics not conductive to group interaction. I had trouble hearing.
31. Nothing was without value.
32. Persons who monopolized group time with personal agenda.
33. Papers (even though I gave one). Maybe we could have shortened the time or gotten papers out before and then not given them orally.
34. Papers and reactions. I can read. I was bored. I am frustrated with college professors lecturing about hands-on educations while I sit for hours.
35. Not enough time to share with all the participants.
36. I was frustrated not to have read the papers ahead of time. The critics assumed we had heard or read the paper as they had, but some presenters didn't read or cover the content of their papers. We could have read those ahead of time.
37. The reaction papers reflected more personal as opposed to be truly reactions to the paper. More like a panel than what it was supposed to be.
38. Waiting to get started — it wasn't terrible but I personally don't "wait" well.

D. What did you perceive the goals of the conference to be?

1. Develop criteria and plans to implement integrated science classes including all learners — disabled included.
2. Discuss needs of science education for disabled students, how to accomplish the task, what science educators can do, and materials currently available. To promote science education for all students.
3. Reunion with former working conference participants. Recharge participants for original mission and renewed focus. Meet new leadership in the field. Clarification of standards and the implementation of plans.
4. To provide science learning strategies for everyone attending.
5. Working together — combining information. Knowledge, education, contacts, networking.
6. Before coming: developing a plan of action for aiding disabled learners; discussing standards.
7. How we can make a difference and change education for our kids! Networking and support. Science for all.
8. To reconnect or connect persons and to raise awareness (again) nationally.
9. Recommendation for change.

10. Global ideas for improvement to bring all students to their fullest potential.
11. To promote awareness of the need for science education for the disabled student.
12. Identify strengths and problems for students with special needs in studying science. Make recommendations for special needs in science.
13. To create a foundation or platform from which to build on for instructing science students with disabilities. To motivate and energize those of us in the audience, and the presenters, to begin to spread information. To plan for the future.
14. A forum to give information based on certain areas of disability.
15. To share the results of research.
16. To be well informed about the problems related to disabled students.
17. Standards.
18. reorganization of original group ideas and to implement old ideas with more force.
19. The goals were to motivate the group to teach all students and to be aware of the strengths and limitations and the recommendations for classrooms.
20. To be aware of the needs of students with special disabilities.
21. I felt that the goal was to affirm a sense of community. I also felt the purpose was to share ideas and make critical judgements.
22. To articulate concrete goals and mechanisms for improving teacher awareness of how to teach disabled and to raise awareness of education for physically challenged.
23. Awareness of what exists now and setting of new guidelines to ensure optimum opportunity for disabled students to learn.
24. Science for everyone and setting goals for a national direction.
25. Learn strategies for adapting science activities and labs to make them accessible by persons with all types of disabilities.
26. Recommendations to include special need students in science education.
27. Learning how to tell my teacher how they can help me with aide or time.
28. Sharing the state of the art in science for special needs students.
29. Develop action agenda.
30. To determine the best way to educate science teachers in how to have their students achieve their highest potential and develop a "can do" confidence for themselves.
31. To present a current position statement for the SAPD.
32. Global education of other disability areas and global views of science issues.
33. Begin to form a network.
34. To develop guidelines and recommendations. To form a network of concerned professionals.
35. To help teachers learn how to do a better job of teaching science to people with disabilities.
36. To introduce us to the physical and learning challenges and strategies for intervention.
37. Science and the disabled student.
38. Address issues, problems, and potential solutions.
39. To come up with recommendations.
40. To learn the direction of science education, strategies for the classroom, and assessment.
41. Awareness, sharing, future recommendations.

42. To improve the teaching of science to students with disabilities and to figure out how to encourage them to go into science.

E. Were these goals achieved?

Yes	Somewhat	No
24	18	0

Comments:
1. The problem is not only improving teaching of science to students with disabilities but improving it for all students.
2. Now that we agreed on a philosophy — let's work on practical strategies.
3. Too much time was spent with speakers (although interesting) not dealing with my perceived goals.
4. The stipend was very helpful and a critical factor in my decision to participate.
5. Through group discussion I think enough information was given to be effective.
6. A sound beginning. The teachers need to be heard from, especially those resistant to change. We have to disturb their compliance and realize all the "Locked" minds that slip through their fingers each year.
7. Don't know.
8. Time constraint.
9. Although I didn't learn that many specific strategies, what I learned about general issues relating to people who are disabled was extremely valuable.
10. (I wish we talked more about the learners (learning) as opposed to the educators.) Again, because of time limits some questions were not pursued to the extent I wished. (For example, differentiating between issues of pedagogy and initiative of educators and those issued that were more relevant to political awareness.)
11. I believe they can be. It will take continued commitment.
12. I learned a lot. Thanks.
13. As far as I am concerned it did. I learned a lot. I have come to appreciate the skills of the disabled by listening to their problems and triumphs.
14. I am concerned about implementation of idea.
15. Wonderful conference.
16. Terrible to cut off questions to Elizabeth Stage! When we got here we should have had her for luncheon or start earlier to get to hear her variety of concerns. This is the first chance I've had to dig into these and it's very important to disabled students and their teachers.
17. More philosophical than practical methods of science education.
18. More positive than negative.

F. If a similar conference were held in the future, what change(s) would you recommend?

1. The groups at the ends of the first day should be broken up on broad issues or concepts.
2. Have the adaptive equipment and materials available for preview. Session on solid

modification strategies for teachers.
3. I would like to see the focus on specific examples on exemplary programs and practices for the classroom teachers (i.e. examples of portfolio assessment, mainstream strategies, networking, involvement in grant projects).
4. No reactors — material to review sent out in advance.
5. Break up formal presentations with opportunities for small group reactions and discussion.
6. More money for attendees and housing arrangement for all. Visits to sites represents the different disabilities.
7. More time for speakers. Ask speakers to direct us to materials and services available to us — (this was done somewhat).
8. Teach us how to!
9. Some students panels who are handicapped. More federal guidelines explained.
10. Extend the length a bit or hold a full 2 days. Perhaps have an option evening discussion or extend even into Thursday morning. Put phone numbers and Bitnet on the participant list. Form interest groups such as : college profs, classroom teachers, etc. for some discussions.
11. More time on focused. Recorders should write what is hear/not reinterpret. Better facilitators.
12. Perhaps reactors time should be allotted more time in the schedule (3-5 minutes too short). But please do not have papers read.
13. Somehow get some of the most entrenched people in to see how it works. Or plant trained role models (non threatening) in such school atmospheres.
14. Change the balance of time toward consensus building.
15. Intersperse interactive time with presentations. Would like to have read the articles before the conference.
16. More time.
17. More time to read, reflect, interact then make recommendations.
18. I would have liked some hands-on demonstrations of technology to help teachers adapt activities to students who are disabled. Learn strategies for adapting science activities and labs to make them accessible by persons with all types of disabilities — such as outlining drawings with liquid colored glue for students who are visually impaired.
19. All the speakers should not be a person with a disability and an ax to grind.
20. Basically same format.
21. More time for "short course" on "hints" for teaching each of the types of disabilities — classroom hints that work.
22. Instead of separating into groups based on disability, groups should be formed around different significant questions.
23. Less presentations and more time for small group work with time for reflections. A session on "future agenda" would be helpful.
24. I would allow more time for discussions with focus questions. I would also recommend that the articles be available before the convention.
25. Two full days to meet. Presenters papers provided in advance. Better organized and accessible materials.
26. Focus on how to take what we already know and teach the "people."
lore teachers involved.

28. Extend to 2-3 days. More interaction around teachers/education.
29. Allow time for audience reaction rather than a few selected reactors.
30. Smaller groups for interaction. Better sound system. Better acoustics.
31. More talks on practical teaching strategies from teachers and students.
32. Much more input from regular elementary school teachers and from special education teachers who are directly involved with content area teachers.
33. Make it 2 full days. To reconnect with and to network with others having this interest.
34. None.
35. Include more people from engineering, school psychology, counseling education.
36. Get papers mailed for pre-conference reading.
37. Ways to implement the changes we believe in!!
38. Tell people to use the evening time for reading the notebook and handouts. Many would have read these if we could get ahead of time (I would have appreciated that!).
39. Two day conference. break out groups by disability as well as by science (biology, chemistry, etc.) to discuss and demonstrate methods of education for students with disabilities (what works well with visually impaired, LD, etc.). Available materials, text books.
40. Expand the base — for many this was an "exposure lesson" — a real "eye opener" after reflection they will speak to implementation and probably need to review and expand their perspective yet again while we add to our audience to be effective disseminators of our perceptions change to total inclusion.

GENERAL COMMENTS:

1. Although there was not enough time for action planning, I believe this would have been very valuable and should be included in future meetings. Overall, this was a rewarding experience. I feel good things will come from it. I'm grateful to have attended.
2. I would have liked to learn more about how children with different disabilities are educated in different parts of the countries.
3. Overall — excellent job. Thank you! Even though there was an overwhelming interest in LD, we should have formed small groups — I need more information.
4. There are many ways to find funding for participants to attend this conference. Explain how Eisenhower funds could be used.
5. Overall good job with a difficult situation!
6. I would have liked to see some of the modifications made and hear some ideas of others as to modifications.
7. Great — glad to have come.
8. Let's get together again soon. Let's not wait 15 years! Let's keep in touch.
9. I would like to share an excellent Team Teaching Model used in Janesville Public Schools K-12 developed with Dr. Robin Warden at the University of Wisconsin at Milwaukee.
10. Great! So glad I came.
11. Appreciate your trying to keep to the schedule. I learned so much. I truly feel if

education were approached this way with all students, our educational dilemma would vanish. Thank you!

12. Time well spent during the conference. Don't know if I am displeased or pleased with the fact that I did not learn about specific adaptations for specific disabilities. It is good in that "fixing" science education will automatically improve things for all the disabled. That means more resources will be devoted to improving things. On the other side, I would like to learn more about specific things for special needs people. Perhaps that could be next time.
13. Would like to see this turn into an annual meeting at the very minimum.
14. Using red and green paper for divisions would be confusing for people who are color blind! Also — where are the divisions for visually impaired persons? Braille programs available? Provide E-mail (Bitnet/Internet) CompuServe - AOL?) numbers? — Organize notebook in order of presenters — (i.e. reaction paper following actual paper). Representation by administrators, scientists, college prof. and students! Have laptop computer and printer and copy machine be available so that "summaries" from groups could be available to all participants at the conferences.
15. The people who participated in this conference were very warm and accepting. I really enjoyed the experience and learned a great deal. Thank you!
16. Don't forget the classroom teacher has many children. Many of whom will start actin out while you wait for the disabled student to respond. Mainstreaming is the way to go but there are many problems to work out. All children have rights, even the average child.
17. 2nd day small group was much better in smaller work groups.
18. Please follow through on suggestion for NSF (NSTA) and State Association) to sponsor workshops for teacher inservice in methods of teaching handicapped. Lang and E-Dodd, et al, should work up a program syllabus.
19. The significant issues apply, across the board, to most people with disabilities (and often to students in general). I am also concerned about the connections that are too often ignored between science and the other disciplines (in other words, students should come to know that these categories are artificial.).
20. Great conference! I am very motivated!
21. Excellent workshop! Learned a lot to take back to my school.
22.When future conferences are held to invite these same participants. The conference was most informative.
23.An excellent conference. We need an annual meeting at a minimum.
24. Great experience. Loved meeting all these wonderful people. Learned a lot. Got lots of information and handouts. Wonderful conference. Congratulations on a job well done.
25. Very good start.
26. I enjoyed networking.
27. Great job!
28. A fine conference, it was. Very fine!
29. I would prefer to have had the papers and reactions mailed for preconference reading. We could then have utilized the awesome amount of talent and expertise in developing a plan of action.
30. I really appreciate the opportunity to be here to listen and learn from all the

incredible, gifted, brilliant presenters.

31. Great conference! I also want to promote the 4 Monographs which ERIC published in 1986. These were edited by Greg Stefanich, Judy Egelston Dodd and not one presenter referred to them in their bibliographies.

32. Ask Kathleen Lindaas (address on orange page) about their high school transition house for disabled as they move from high school to college or career — outstanding! She is part of the thinking of this group but only just found us. She speaks well — will apply to present in Anaheim. Contact Weisman Center at Madison Wisconsin for the excellent software they already have begun for adaptive devices.

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