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ABSTRACT

This paper examines various topics and issues related to the teaching of science to orthopedically handicapped students. It includes: (1) brief descriptions of programs and materials for orthopedically handicapped students in elementary ("Elementary Science Study" and "Science A Process Approach II"), middle ("Science Activities for the Visually Impaired and Science Education for Learners with Physical Handicaps--SAVI/SELPH"), and secondary schools; (2) some general considerations of orthopedically handicapped students, guidelines for working with these students, and an illustration of how a life function impairment assessment could be used to develop appropriate mitigative strategies for a particular student; (3) case studies of individuals who have successfully overcome the physical and/or attitudinal barriers of their handicap; (4) a discussion of safety concerns, considering the duties of the teacher and the meaning of the phrase "reasonable and prudent judgment"; (5) information about career education programs for orthopedically handicapped students; and (6) a discussion of computer assisted instruction for handicapped students. A list of software (with title, grade level(s), source, and description) suitable for these students is included. (JN)

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Addressing Orthopedic Handicaps in The Science Classroom

by

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NEED FOR AN ADAPTIVE SCIENCE PROGRAM

Everyone needs to be accepted for herself/himself, to be included, and to be allowed to serve as support and inspiration to others. A teacher must be knowledgeable and competent in meeting the special needs of disabled students. To successfully build a handicapped child's self-image, a teacher must first help other children develop healthy and positive attitudes toward these children.

Science can do much to create a level of understnading through a thoughtfully conceived program that is enjoyable, instructional, and will lead to a deeper understanding of the nature of physical limitations. This monograph is directed toward providing a greater acceptance and awareness of orthopedic handicaps for educators who have a limited background and understanding of the problems of and the compensations necessary for such handicaps.

A 1975-76 AAAS survey directed by Martha Ross Redden investigated nationwide science opportunities for physically handicapped youth. The project indicated that handicapped students receive little instruction and what they do receive is not academically adequate to allow them to pursue further science education, or instruction in science-related fields leading to possible careers (Redden, 1978, p. 4). The absence of appropriate science education for the handicapped is further evidenced by a dearth of handicapped persons within various scientific fields. Herbert Hoffman (1978), a meteorologist affected with cerebral palsey states, "...teachers will often let studies decline to a point that they think should be a level at which their physically handicapped students can perform." Parents of the severely disabled support this lowered expectation of teachers for two basic

reasons: 1) a lack of confidence that their handicapped child may someday be able to find employment and become a useful part of society and 2) a hesitancy to place increased demands on the child because they perceive that the hard work and time necessary for adequate academic functioning would deprive the child of leisure time activities or physical therapy.

The tragedy of low expectations is explicitly expressed by Robert Menchel (1978), a deaf physicist currently employed at the National Center for Employment of the Deaf, who states that handicapped youth do not enter science fields because by the time they reach the high school grades, they have not had a science education equal to that of a normal child. When they enroll in high school science, without the fundamental building blocks, they are turned off. It is too hard, they do not understand it, they do not like it, and they will find one way or another of avoiding it.

Robert Rehwoldt (1978), a paraplegic chemist, delineates the lack of sufficient consideration given to providing a physical environment in which the handicapped can participate. He states,

> "Most high school science laboratories are not constructed so that the orthopedically handicapped students can participate in experiments. Limited resources and a lack of imagination may have actually prevented handicapped high school students from experiencing science in a positive and constructively challenging fashion."

This statement is certainly true in most elementary and junior high school settings as well. Rehwoldt agrees with Menchel and Hoffman in his perception of frequent underestimation of a handicapped person's ability by teachers, peers, and family. He states,

> "...Self asessments are derived previously from past experiences and from judgments and expectations of teachers, peers, and family of student's

performance in various spheres of activity. The student's perception of various careers and post-secondary education, [illegible] strongly influenced by the views and belief of others" (Rehwoldt and Samoff, 1978, p. 131).

The preceding statements clearly illustrate areas of difficulty experienced by the few handicapped persons, who, through exceptional ability and persistence, have pursued scientific fields in spite of these barriers. These areas of difficulty for the orthopedically handicapped may be summarized as follows:

1. Science instruction is not considered an important component of the curriculum during the early years of school.

2. Stereotypes and limited expectations by advisors and parents limit participation during the later years.

3. Structural accessibility limits the exposure to tactile manipulative experiences which are critical to basic science learning.

4. Present programs and instructional strategies have not been adapted to meet student needs in both special groups and mainstreamed science courses.

5. Many orthopedically handicapped students are being barred from laboratory experience by teachers with negative and/or fearful attitudes, overly cautious counselors, apprehensive parents, etc.

6. Mainstream teachers generally have not been adequately provided with insight, special materials, skills, and/or techniques to effectively help the physically handicapped student learn science.

7. Little agreement has been reached on the part of educators as to what new skills and knowledge science teachers should possess to

be competent to meet the learning needs of orthopedically handicapped students who enter regular classrooms.

8. Many teachers and counselors have inaccurate expectations of orthopedically handicapped students which often result in poor student performance (Hofman, 1978: 176-185).

Science Materials Appropriate for Orthopedically Handicapped Youth

For the most part, instructional materials used with orthopedically handicapped youth will be the same as those used in a traditional classroom setting. In some situations furniture modification and/or prosthetic aids will be needed. There are, however, a few programs which contain elements that have greater utility for orthopedically handicapped youth.

The programs noted in this monograph are not designed to be used only with orthopedically handicapped youth. Instructional materials designed with consideration for the needs of the handicapped are of great value for all students. In general, they give greater attention to multimodal instruction and to using the full range of talents and abilities of all students.

Brief descriptions of programs at the elementary level are noted in the following paragraphs.

Elementary

Elementary Science Study. The Elementary Science Study is an adaptable K-9 science program currently being used by over 3 million students. The program is an interdisciplinary approach to learning, using mostly hands-on experiences consisting of 56 independent units.

The flexibility within the program provides an ideal format for the

inclusion of orthopedically handicapped students. Materials and supplies tend to be inexpensive, non-toxic, and generally non-breakable. The materials can be handled comfortably, not requiring a high level of fine motor control, and offer many opportunities for varied grouping patterns and shared decision-making between handicapped and non-handicapped students.

Science: A Process Approach II. Science: A Process Approach II is designed to encourage student application of higher level reasoning skills through interaction with concrete materials. It is designed for use in K-6 and is packaged in a format of fifteen suggested modules for each grade.

SAPA, like ESS, is a hands-on program; it provides, however, a more rigorous content base and a more highly structured teaching strategy. The program is ideal if a high degree of accountability is required within the framework of an Individualized Educational Program (IEP).

The lessons are very structured and highly teacher-directed. The prerequisite lessons and following lessons in the hierarchy are provided on the cover of each exercise guide. The program, although very practical and pedagogically sound, may require adaptation for students depending upon the limiting condition.

Middle Level

Science Activities for the Visually Impaired and Science Education for Learners with Physical Handicaps (SAVI-SELPH). The materials developed in SAVI-SELPH are intended to assist visually and orthopedically impaired children between the ages of 9 and 12 in using the senses at their disposal, carrying out experiments, making predictions, and drawing

conclusions from outcomes. It is a hands-on program intended to assist students in developing the basic science processes of observing, recording data, measuring, classifying, interpreting data, inferring, and predicting.

The approach and content of the activities are intended to enhance disabled children's experiences with their environment as well as to foster personal interaction between the disabled and their non-disabled peers. Although the overall thrust of the materials as oriented towards the visually impaired there are suggestions for use with orthopedically handicapped and learning disabled youths.

Health Activities Project (HAP). The HAP program is an activity-oriented health program which helps each child learn more about the functioning of the body. Activities are easily adapted for handicapped children. The manipulatives are durable, are generally usable by individuals with limited motor control or movement, and were designed in an independent lesson sequence format.

Secondary

Specific programs at the secondary level are not noted, but this does not diminish the need for the adaptation of instruction for orthopedically handicapped youth at this level. Because science is often elective rather than required, the importance of active intervention and encouragement becomes even more critical.

The Wallops Island Program in Marine Science for the Physically Handicapped conducted by Dr. E.C. Keller, Jr. is illustrative of how the professional educator can better meet the educational needs of students with a limiting condition. He states,

"From the experiences of the Wallops Island Program in Marine Science for the Physically Handicapped, it was extremely beneficial

for the students and staff to spend the first few days in what was called a communications laboratory or workshop, where blind students learned tactile finger spelling, deaf students learn to visually recognize Braille alphabet, and the staff (one of whom was handicapped) learned both. Exercises and games were devised using parts of all the communications systems (auditory, tactile, and visual). Not only was this activity extremely worthwhile in helping the students get to know one another, but was of great use in promoting cooperation between the deaf and blind students throughout the program. The buddy system of mixing handicapped and nonhandicapped students is very useful and helpful to the teacher as well as the students" (Keller, 1979:8-9).

The initial problem is to make the field experience accessible for the orthopedically handicapped. Physical access is then generally available and improved for all students. Access for the wheelchair-bound students to tidal flats and wet marsh (or bog) areas was achieved with minimal environmental damage by the use of snow fencing. A sled instead of a wheelchair could be used in sandy areas. A four-wheel drive vehicle was useful for the program in marine science. Temporary (and portable) ramps of 4' X 8' X 3/4" plywood were useful in improving access to the beach and dune areas, to the boats, to a museum, to a movie theater, and to other areas. Portable metal ramps and wheel tracks are commercially available. Brass ring tie-downs for the wheelchairs were very useful on the boats during transit. Buses can be equipped with these or other tie-downs. Portable sit-down height observation and equipment tables were useful in the field.

General Considerations

The Orthopedically Handicapped Individual

The orthopedically handicapped child is one who has a crippling impairment which interferes with the normal functioning of bones, joints, or muscles. Included in this category are: (a) children who are born with such handicaps, and (b) children who acquire a crippling condition later in life. Examples in each category are listed below.

1. Prenatal handicaps: (a) clubbed hands and feet, (b) absence of arms or legs, (c) defects in legs, neck or hips, (d) cerebral palsey.

2. Persons who acquire a crippling condition later in life: (a) poliomyelitis, (b) muscular dystrophy, (c) arthritis, (d) tuberculosis of the bone, (3) osteomyelitis.

It should be stressed that the orthopedically handicapped child is generally not affected in the way she/he learns. The adjustments necessary are physical rather than educational. There is probably no greater dejection for a handicapped person than to begin to engage in an activity only to have a normal person intrude and do it for them. It should be stressed in helping the orthopedically handicapped student that patience, rather than assistance, is what is needed. The school should assume responsibility for providing an environment which allows the orthopedically handicapped to be as independent as possible, and which promotes freedom of movement and physical activity. In addition to the modifications necessary in the gross physical environment, the teacher should always look for ways to provide aids and devices which can assist the child in functioning independently. Because of the heterogeneity of orthopedic handicaps, it is impossible to describe devices appropriate for an individual child.

Many compensations can be made by providing the orthopedically handicapped student with special equipment that allows them to function independently. Some of the more common items are: (a) books racks for students who cannot hold books, (b) ceiling projectors for children in bed in hospitals and/or home, (c) electric typewriters, (d) automatic page turners and pencil holders (Kirk, 1972). An effort should be made to secure equipment similar to those listed and also other prosthetic aids for locomotion, life support, personal grooming, and communication, suitable for use in the school environment.

Understanding Special Students General Guidelines for the Orthopedically Impaired

There are unique problems in integrating any special student into the classroom. Nevertheless, there are simple straightforward approaches that have proven to be helpful with most students. In addition to the general considerations noted, specific concerns relating to those students with orthopedic handicaps include:

--Obtain and read all relevant academic and health background information available on the student.

--Spend time educating yourself on the physical and/or psychological nature of the handicap, and how it affects the student's potential for learning.

--Determine the source of special help which can be made available to you through the resources of a "special education" expert.

--Determine the special equipment needed by the student for your academic area.

--Talk with the student about limitations due to his or her handicap and about particular needs in the science class.

--Establish a team of fellow teachers (including resource teachers

and aids) to share information and ideas about the special students.

--Nonhandicapped students are often willing to help special students; use them, but discretely monitor their joint activities for possible redirection.

--Be aware of barriers, both physical and psychological, to the fullest possible functioning of the disabled student.

--Consider how to modify or adapt curriculum materials and teaching strategies for the disabled student without sacrificing content.

--Do not underestimate the capabilities of the disabled student. Teachers' perceptions of a student's abilities have a way of becoming self-fulfilling prophesies. If these perceptions are negative, they may detrimentally affect the student and your ability to create new options for him or her.

--Use the same standards of grading and discipline for the disabled student as you do for the rest of the class.

--Develop a trusting relationship with the disabled student.

--Educate the other students about handicaps in general, as well as the specific handicaps of students in their class. It is wise to confer with the disabled student before making a decision to take this action.

--Eliminate architectural barriers.

--Become familiar with basic mechanics and maintenance of braces, prostheses, and wheelchairs.

--Understand the effects of medication on students and know the dosage.

--Obtain special devices such as pencil holders or reading aids for students who need them.

--Learn about the symptons of special health problems, and appropriate responses. (Bybee, 1979:23-24).

Innovative Accomodation
Sample Assessment
E.C. Keller, Jr.

Following is an example of how a life function impairment assessment could be used to develop appropriate mitigative strategies for a particular student. The student has spina bifida and is, for the most part, wheelchair-bound. He is a high school sophomore interested in engineering. The assessment of this student which is shown on Table 1, indicates one general health problem and high mobility limitations, few communication problems, some social/attitudinal problems, and a moderate degree of cognitive/intellectual problems (probably not directly associated with his disability). The instructor would probably focus first on the mobility aspects in planning his/her mitigative teaching strategies, along with consideration of the minor health problems. The instructor would be alerted to the behavior difficulties from the assessment; some of which are related to the student's disability and some related to other causes, perhaps including the previous lack of home and classroom discipline.

Because impairment of mobility could be high, the instructor would need to consider physical access to the educational environment. Since the student would probably be using a wheelchair, ramps or an elevator would be necessary to enable the student to enter the classroom or laboratory. Low laboratory benches as well as wheelchair accessible restrooms would be needed. The amount of time needed for testing and testing format would have to be evaluated and carefully guaged to facilitate a high success capability.

TABLE 1: LIFE FUNCTION IMPAIRMENT ASSESSMENT FOR A PARTICULAR MALE SPINA BIFIDA STUDENT[1]

Life Function		General Disability Area			
	Motor/ Orthopedic	Behavior	Chronic Disease	Auditory	Visual
Health	Some Problem[2]				
Mobility	Severe Problem[3]				
Communication	No Problem				
Social/ Attitudinal	Significant Problems[4]				
Cognitive/ Intellectual	Some Problem[5]				

[1]This example assessment is for a specific student, it is NOT a general assessment for all students with spina bifida.

[2]Use of urine bag is necessary. Time must be scheduled for emptying.

[3]Most of the time is wheel-chair bound. Can use crutches for short distances and can transfer to chair or bench from wheelchair.

[4]Has great difficulty making and keeping friends. Part of the problem is that urine odor causes avoidance by peers. Uses wheelchair aggressively, makes inappropriate use of vulgar language. Disrupts class with outbursts and unrelated information. General lack of self-discipline and respect of authority.

[5]Problem of depressed grades, despite average I.Q. No indication that this problem is directly due to disability, but he was a home-bound student through the 4th grade.

The chart is not intended to be a fixed matrix, but is presented as an illustration of how one can prepare an inclusive paradigm for dialogue and decision-making. Perhaps one or two cells of major concern can serve as a focus for improvement, with lesser attention to other factors. Change is not easy for any human being, and over-whelming a person with multiple suggestions for adaptation produces frustration and withdrawal. Priority items need to be selected and, over time, one can cascade into refining behaviors or adaptations which relate to overall presonal adjustment.

Among the most important essential elements are supportive, caring adults -- individuals who not only provide opportunity for orthopedically impaired students but also expect achievement from them. To ignore a behavior which needs remediation is in many ways more cruel than to expect immediate correction. A balance is needed, one which has a plan for improvement, but at the same time recognizes the limitations inherent in bringing about changes in behavior patterns that may have developed over many years.

Case Studies for Handicapped Individuals

A review of case studies involving individuals who have successfully overcome the physical and attitudinal barriers imposed by our society can provide some insights into better serving or addressing the needs of orthopedically handicapped individuals in the classroom.

Personal Views From Wheelchair Level

Barbara Mendius (poliomyelitus)

I acquired my entire formal education while in a wheelchair. Since sixth grade my major academic interest has been science; this culminated

with a M.S. of Biology from the University of Illinois in October, 1977.

In considering my own education, I firmly believe that my laboratory experience was most important in shaping my scientific ability. The first major obstacle for the handicapped student of science is getting the hands-on laboratory experience so important to engender scientific expertise.

I feel lucky indeed as I recall the variety of lab work which I performed in school. I have thought carefully about the factors which contributed to my successful scientific education; it all comes down to people -- parents, administrators, teachers -- willing to cooperate in my behalf. Realizing the value of scholarship, my parents took an active interest in my education. Active, but not pushy. Beginning in fourth grade I attended the local public school. For class field trips, mom would drive one of the groups to the museum, or to the nature center--for laboratories are not only found in schools. Dad went to all the parent's nights, talked with my teachers, and came home glowing about my progress. Impressed with my parents' interest and my ability, school administrators were wonderfully cooperative. For some of the administrators, I was their first and only handicapped student.

That all changed in high school. There, all of my parents' interest, and all of the administrators' cooperation would have been wasted were it not for enthusiastic science teachers who gave me the freedom to do as much as I could of what everyone else was doing. Sometimes it only meant putting a microscope or analytic balance on a low table. Sometimes it meant rearranging the greenhouse so I could get down the overgrown aisles. In one case it meant encouraging this shy student to enter the state science fair and helping me choose an appropriate experiment which I could carry out myself. My teachers were the ones

who ultimately placed science within my reach.

But we worked together, so my stubbornness and perseverance deserve some credit also. Science had piqued my brain; I was determined to learn as much as I could, actually doing as much as I could. I realized that if I wanted to do the acid/base experiments I would have to show that I could carry solutions around in my lap without spilling. If I wanted to fire-polish my own glassware I had to show I could use a Bunsen burner without setting myself aflame. If I needed to move a microscope to a lower table, I had to show that I could do that without smashing it to smithereens. I had to prove myself all along the way, but my teachers accepted my physical abilities and, although I often caught a watchful eye on me, they did not stifle my enthusiastic investigations.

In summary, my major recommendation for science education is to involve the orthopedically disabled student in laboratory experiments. Visual, auditory, tactile, olfactory, and gustatory clues can elucidate scientific principles; ingenuity and perhaps some extra work are all that are required.

The Price of Being Born Disabled
Herbert H. Hoffman (cerebral palsey)

When one is born with a disability severe enough that society shoves him into special educational and social programs, (which are developed by non-handicapped persons,) one becomes separated from 'normal' peers. Teachers will often let studies decline to a point that they think should be the level at which their physically handicapped students can perform. Parents of the severely disabled generally agree with the teachers for two basic reasons: 1) the lack of confidence that their child may find employment and become a useful part of society, and 2) the parent feels sorry for the child and does not want to see him study so hard when he

could be enjoying the outdoors or doing his physical therapy which would enable him to do more for himself.

Most sociologists agree that children learn mainly from parents and peers. Most parents of handicapped children do not give their child the encouragement needed to overcome other fear of not becoming useful. Teachers and peers do not offer encouragement because they too are unable to see any successful handicapped people who graduated from their school. Perhaps this is why handicapped persons who develop drive and won't take 'no' for an answer are the only ones that beat the system and go on to make something out of their lives. However, these persons are often labeled by teachers, parents, and rehabilitation specialists as 'special,' thus putting them above or below the other students. Most of the other students do not feel they will ever be 'special' and therefore, they are not encouraged by these few 'special' persons.

The teachers who are handicapped themselves make the greatest contribution to disabled students. If they are lucky enough to teach in a school that contains both 'normal' and handicapped students, the contribution is even greater. These teachers can teach the handicapped students from their own experiences, and will often make the students work twice as hard as 'normal' teachers do, for they know that if a handicapped child is ever going to get ahead in society, he will have to be twice as knowledgeable as a 'normal' student that disabled persons are the same as anyone else except that they are physically limited. When these students grow up and find employment, they will have more understanding toward the physically handicapped and perhaps will try to change societal attitudes toward disabled persons.

It might seem ironic that three teachers who had the most impact upon my career, as well as my life, were all handicapped. The first was an elementary school teacher in an all-handicapped school who had the understanding that I could contribute more if I were allowed to type with my foot in class, (which I did at home). The other two handicapped teachers were a high school English and a high school science teacher. Since I was always interested in science, I guess I worked rather hard at it, and even though I could not use my hands for lab experience, I watched my fellow students. Sometimes I was able to tell them how to conduct an experiment. My science teacher, who has handicapped himself, understood this concept the best; it is more important for a scientist to know how and why an experiment is done than to physically go through the motions, which a robot can do. This teacher also encouraged me to enter science fairs, and spent many long hours with me going over the science papers I wrote. I became the first handicapped student to attend a city and state-wide Science Fair -- but not with the approval of the school principal. Since my speech defect made it hard for persons to understand me, when it became time for me to explain my science project, I found a fellow student to talk for me. Many hours were spent training him about my project and what to say.

I feel a new dawn is breaking for handicapped persons with the implementation of Section 504 and of Public Law 94-142 regarding the teaching of the disabled. There is, however, a danger that the schools will not follow the intent of the law. For example, schools could make only a few classes barrier-free, and hire a few special education teachers who will develop programs especially for handicapped students. These programs will take the disabled student out of the classroom, thereby increasing the

isolation problem. If school officials are allowed to substitute non-laboratory classes, laboratory sciences are likely to be eliminated because modifications will take the longest. Also, some science teachers and department administrators might not like the idea of having the severely handicapped students in their laboratory classes where physical limitations may prevent them from carrying out some experiments. It is up to the handicapped scientists to encourage teachers and handicapped students and to aid in the development of modified courses so that maximum education is possible. We should give our knowledge freely to those who want it and those that do not want it.

Once we educate handicapped persons in science, we have to see to it that science will give them employment. We are asking society to pay for the education of handicapped students in science, and we have to answer to them if the graduate is unable to find employment. Handicapped scientists be willing to act as role models and research persons, keeping in mind that the disabled person might only have one chance at employment, for a disabled person can't pump gas or wait on tables while they are waiting for the right job to come along. Because education has allowed them to know what it is like to be as independent as possible, severe depression will overcome the disabled student if he has to return where he is not useful. Suicide is often thought of, and depending on the individual's drive, can lead to a deadly end. Employment must follow education.

Disabling Condition: Spina Bifida
Ronald J. Anderson, Ph.D.

The presence of a physically disabled student in a science classroom can cause considerable concern for the science teacher. The concerns are generally focused on the disabled student's ability to participate

in laboratory activities associated with the course. While the science teacher's concerns are often justifiable, they can often be dealt with if specific steps are taken to compensate for the student's disability.

In my experience as a student, teacher, and teacher educator, it is clear that many of the obstacles that seem to prevent physically disabled students from participating in science laboratory activities can be accommodated. Three important considerations include: 1) communication with the student regarding perceptions of individual activities and limitations, 2) identification of potential problems in the laboratory, and 3) field trips.

The first and most critical factor for teachers is establishing communication with the student. My past student experience in science classes suggests that teachers often make assumptions relating to the student's capabilities, that is, teachers frequently assume that disabled students cannot perform in laboratory situations. In a number of cases, however, such assumptions clearly are not valid. In order to make a determination concerning the disabled student's capabilities, the teacher must initiate communication with the student. It is important to note that the student is the best source of information needed by the teacher, and can pinpoint the specific necessary accommodations.

After discussing the student's capabilities with the student, the teacher would be well advised to take an inventory of the laboratory course requirement to identify potential problem areas and/or requirements. Once the inventory has been conducted, the instructor should then discuss his/her findings with the student. Through discussions with the student, it is likely that a number of the major difficulties can be resolved. The most common problems that are identified in science laboratories include: a) tables that are too high or too low for students who use wheelchairs, b) equipment that is difficult to move to accomodate

mobility-impaired students, c) equipment and materials that require fine motor coordination for students who have manual dexterity impairments, and d) participation in field experiences. Accommodating students with physical disabilities requires combining communication between the student and instructor concerning the potential problems identified in the laboratory and with course requirements. Using a communication-inventory approach, for example, measuring height, the instructor identifies the table height problem and discusses the problem with the student. The outcome of the discussion between the student and the instructor might be moving the laboratory equipment to a lower table or by elevating the lab table by placing blocks of wood under the table legs. In some instances solving the mobility problems of the student using a wheelchair may be as simple as rearranging desks and tables in the laboratory. During my secondary school years, I found that, in retrospect, my teachers were willing to make the accommodations they saw necessary. Only one of my instructors, however, took the time to conduct an inventory problem in the laboratory. In most cases, I had to point out the problems. Once I had set the tone for pointing out problems in the laboratory, my instructors then began to try to anticipate any difficulties. I must say that as I look back at my experiences in my science classes, I felt very uncomfortable about drawing the instructor's attention to my particular problems and needs. By pointing out my problems, I felt that I was drawing attention to myself, and that I would be "singled out" when I was trying so desperately to be a part of my peer group. I also felt at times that identifying my problems to the instructor also identified my inadequacies related to my disability. Over time, my sense of discomfort both with my peers and instructor began to disappear, because

any accommodations that needed to be made become a matter of routine.

As I recall, the "buddy-system" was a great method of providing assistance to me in the science laboratory. The advantage of the "buddy-system" in terms of physical assistance was obvious. The peers that I worked with were more than willing to fill in for me when it was physically very difficult to perform certain aspects of an experiment. More often than not I had little difficulty conducting an experiment independently. In some cases, however, I had more problems with retrieving the needed equipment for experiments. In addition to the physical assistance, the "buddy-system" helped me feel more a part of my peer group. The social benefits, as I look back, were enormous. The out-of-classroom activities such as field trips provided me with opportunities to investigate my environment.

Safety Concerns

A major concern of educators who will have handicapped students in their science laboratory classes is the issue of safety, particularly safety in the laboratory. In the past, qualified physically disabled individuals were frequently discouraged or even prohibited from taking courses because of educators' apprehensions concerning the physical capabilities of handicapped persons (Blumenkopf, 1980).

The reluctance of educators to permit disabled individuals' participation in science laboratories was cited as the major stumbling block placed in the paths of those handicapped students who later became professional scientists (Blumenkopf, 1980). Educators' fears were often based on the mistaken notion that physically disabled students would pose a considerable hazard to themselves or to their co-workers in a laboratory. In fact, the majority of physically handicapped individuals pose no greater risk and no greater hazard in a laboratory setting than do

their able-bodied counterparts.

In the past, various arguments have been invoked to exclude qualified handicapped students from participating in the laboratory sciences. Contentions that the insurance rates of educational institutions might skyrocket, or that insurance companies might prohibit handicapped persons from working in laboratories, are unjustified (Sears, 1974; and Brantman, 1979).

The argument that Occupational Safety and Health Administration (OSHA) regulations may not allow handicapped students to participate in chemistry laboratories is likewise invalid.

Safety measures recommended for disabled students are the same as those required for their able-bodied counterparts. Any extra safety precautions which should be observed because of the presence of handicapped students in a laboratory represent a small addition to safe laboratory practice. They include:

A. Reasonable and Prudent Judgement

If the standard of care has not been specifically established by statute, the actions or inactions of an individual will be measured against what a hypothetical, reasonably prudent individual would have done under the same circumstances (Stearner, 1975). Obviously there can be legitimate and complex questions regarding the course of action which a prudent person can take under a given set of circumstances.

One important aspect of the conduct of the reasonable person is anticipation. A reasonable person is expected to be aware of the foibles of human nature and be able to anticipate where difficulties might arise. The reasonable teacher must be able to anticipate ordinary events and, in some cases, even extraordinary events (Gerlovich, 1981).

B. Duties of the Teacher

The classroom teacher has three basic areas of professional responsibility of safety in the sciences. These are the duty of instruction, the duty of supervision, and the duty of proper maintenance and upkeep of equipment used by students.

Science teachers have responsibility for all three duties. Students in classroom, field, or laboratory settings should not be allowed to engage in an activity without first receiving complete instructions from the teacher. The teacher should include in such instructions an explanation of the basic procedure involved, some suggestions on conduct while performing the activity, and the identification and explanation of any risks involved.

One of the most frequent causes of an accident at school is the failure of personnel to instruct properly and to supervise sufficiently. When the educator has been derelict in his/her duty, and this dereliction is the proximate cause of the accident, then the injured party may sue for damages. On the other hand, failure to instruct and supervise that is not the direct cause of an accident will carry no liability (Hudgins, 1976).

Science teachers cannot ensure the safety of another from equipment or material defects. They are expected, however, to take reasonable precautions, and take necessary and appropriate steps to correct deficiencies. (Hudgins, 1976).

At least one student laboratory station should be provided to accomodate the physically impaired. This would necessitate that a 30-inch clearance exists between the bottom of the work surface or apron and the floor. This space must also be 18-inches deep and a minimum of 30-inches wide. Hot water pipes in this space should be

insulated. Faucets and utility outlets at these stations should be side-mounted rather than rear-mounted and be equipped with wristblade or lever handles. The aisles in this area should be a minimum of 36-inches wide and clear of obstructions (Gerlovich, 1981).

Yuker, Revenson, and Fracchia (1968) suggest the following design considerations for a science laboratory: work areas mounted at wheel-chair height along the perimeter of the room; a student work area of 4-feet, with 8-feet between sets of gas, water, and electrical outlets; storage alongside the work area and beneath the work surface; and a sink installed with the lowest edge at the height of 27-inches, with recessed plumbing. Faucets with gooseneck spigots and batwing taps are suggested since they require less strength and dexterity to operate.

The previously described facilities, although making it easier for the handicapped student to function, do present some concerns for the safety of the student. The students using these desks will generally be sitting and thus become exposed to several potentially dangerous situations. First, due to sitting the student has the apparatus and equipment at face level. Second, any spills have the potential to end up in the student's lap. To protect the student's face, neck, chest and lap it is recommended that the student be provided with an approved full face and neck shield when holding or working with potentially dangerous materials or chemicals, and appropriate body cover depending upon the type of handicap.

Consideration must also be given to students who may have prosthetic limbs, artificial hands, hooks, and other artificial body parts. In addition, students who are subject to seizures or who, due to their handicap, tire easily must also be provided for. Some or all of these students may need help in getting in and out of their protective clothing and equipment. A few may need someone to sequence the activities so that they can see how

to use and practice the procedures necessary to complete the assigned activity. A stool should be provided for students who become easily fatigued. It is recommended that a bar be placed across the front of the laboratory station so that students who may have a seizure or become suddenly fatigued will not fall directly into the apparatus on the laboratory table.

There is a need for encouraging handicapped students to gain independence in the laboratory situation. This will be facilitated if separate accessible shelves are provided for their use. Electric hot plates should replace Bunsen burners whenever possible (Hofman, 1978). A technique suggested by Tombaugh is that the handicapped student be paired with a "normal" student or another handicapped student whose strengths can compensate for the other's handicap. (Tombaugh, 1968).

Obviously the handicapped student may not be able to perform every experiment that other students can do. However, the following quote sums up general feelings on the subject: "Occasionally a modification will need to be made in assignments, such as using a microscope. Such modifications should be the exception rather than the rule, however, rather than substitution which is easier and/or irrelevant" (Gerlovich, 1981). The science teacher's common sense has to be the final judge of what is or is not allowed, while still keeping the intent of P.L. 94-142 and Section 504.

Prior to the beginning of the laboratory course, the laboratory instructor and the handicapped student should discuss any additional safety precautions which are advised. Local safety officers can be consulted at this stage in the discussions. Keep in mind, however, that while safety officers are good sources of information concerning safety regulations, they may have neither experience nor knowledge regarding physical abilities

of handicapped individuals. The instructor and student should arrange "contingency plans," such as evacuation of the laboratory. The use of a "buddy-system" among pairs of students to provide each other immediate aid in an emergency is a wise safety measure for handicapped and able-bodied students alike. The handicapped student and his instructor should discuss physical limitations which the student encounters during the laboratory course, and should come to agreement regarding the best way for that student to handle the situation safely. It should be kept in mind that each handicapped student is an individual; hence needs, physical limitations, and abilities should be considered on an individual basis.

The American Chemical Society advises that for any students, "Laboratory work should not be conducted anytime unless there are at least two people present in the laboratory and the instructor is aware the work is underway" (Swanson, 1981).

Laboratory safety equipment should be accessible for use by students with mobility handicaps. Lightweight fire extinguishers should be readily available near the handicapped students' work station. Emergency showers should be equipped with a pull chain within easy reach (within 48-inches of the floor) of a person seated in a wheelchair. Eye washes should be low enough to allow use by a seated individual, or an emergency spray hose should be provided. Ideally, mobility impaired students' work stations should be located near an accessible exit, and aisles should be kept free of obstructions to allow accessible paths of egress, (Swanson, 1981). Unobstructed aisles afford greater safety for all individuals in the laboratory. Proper clothing, eye, and face protection should be worn at all times

by disabled and able-bodied students. Seated students, including those in wheelchairs, should wear heavy rubber aprons to protect against chemical spills; this is especially important for those who have no sensory preception in the lower half of the body. Provisions should be arranged by the mobility-handicapped student and the instructor for evacuation from the building during fire drills, when use of elevators is not permitted or is not safe.

Safety education should be integrated into regular laboratory instruction, and students should be made thoroughly aware of contingency plans for laboratory emergencies. In addition, a "buddy-system" among pairs of students is recommended to provide immediate evacuation in an emergency.

Students should receive adequate safety instruction. This should be documented in writing. Copies of safety rules, contingency plans, and any other safety instructions which are given to students should be kept on file in a location away from the laboratory. In the words of James R. Gass, a chemist and attorney with expertise regarding liability of educators, "This is 'defensive teaching' and your safety consciousness and teaching should be documented in your lesson plans and experiment instructions" (Swanson, 1981). If a faculty member's request to the administration for the purchase of needed safety equipment is rejected, both the request and the refusal should be documented in writing and placed in safe-keeping.

A good practice is to administer a written examination during the first or second week of the laboratory course. The examination should be designed to provide written evidence that the students have a thorough understanding of laboratory safety rules, potential laboratory hazards, location and use of safety equipment, contingency plans in the event of various minor or major laboratory emergencies, and evacuation routes.

Essay-type questions are preferred, some of which can be phrased "What should you do if...?" and students can be required to draw a floor plan of the laboratory identifying the locations of all safety equipment and routes of egress. The examination can be of the "take-home" variety, or students can be required to re-take the examination until they can answer all questions correctly. Each page of the examination should be signed and dated by the student, and the completed documents should be preserved in a location removed from the laboratory. Any special precautions or contingency plans which have been arranged regarding handicapped students in the laboratory should be similarly documented and preserved.

Career Implications

Judy Egelston-Dodd and
Barbara Mendius

Overview

The underrepresentation of handicapped persons in science careers can be traced to a number of causes. Perhaps the most obvious of these causes is the lack of effort on the part of government, industry, and education institutions to recruit this minority. It is probably true that this lack of policy has deprived our country of the services of some very talented persons.

The creation and implementation of a policy is not an easy task, but neither is it impossible. The policy must be very specific in purpose although not necessarily in tactics. The overall objective must be to create paths and opportunities for handicapped persons to enter science careers if they choose, but yet not entice them into areas which they may only have marginal interest.

One must recognize that there are restrictions related to disabilities and restrictions arising from misconceptions concerning careers in science.

It is imperative that handicapped persons be helped to distinguish between these two types of factors. It is only after such a determination is made that an individual can formulate realistic career goals. When unwarranted hesitancy on the part of a potential employer, or an undue lack of confidence on the part of either the handicapped or the non-handicapped person are permitted to exaggerate the negative effects of physical disabilities, science may be deprived of potentially valuable contributions and a handicapped person may be denied a challenging and productive life.

It is usually during the latter part of an individual's secondary school experience that the first serious decisions are made regarding college alternatives. Certainly the decision of whether or not to attend college is an issue during the last several years of high school. For the handicapped and non-handicapped person alike, these decisions are based on self-assessments--analyses of individual needs, desires, and capabilities --and on evaluations of the potential benefits and the potential negative aspects of various careers and of various post-secondary educational options. Again, in the case of both handicapped and non-handicapped high school students, self-assessments are derived primarily from past experiences, and from the judgements and expectations by teachers, peers, and family of the student's performance in various spheres of activity. The student's perceptions of various careers and post-secondary education, too, are strongly influenced by the views and beliefs of others.

Drawing from the experiences of Barbara Mendius, she states: In examining my entire science education, I note almost a complete lack of career counseling related to my physical abilities. By pursuing a science education, I realized that I could become a science teacher,

a doctor, or that wonderfully nebulous creature called a scientist. Specific other careers were fairly unknown to me. Knowing full well what a science teacher and a doctor had to put up with, I opted to become a scientist fully confident that when I became one I would know what my job was. I maintained that painfully naive view almost to the end of my undergraduate years. As a senior I dove into the on-campus interviewing process applying for those jobs for which my coursework qualified me, mostly laboratory assistant positions. As interview after interview ended with, "It's been nice talking with you -- we'll contact you if necessary," I realized I was going to be an unemployed biochemist (and moving back to the safe but suffocating home nest) if I didn't get my act together very soon.

The handicapped student who is serious about studying science should be exposed, as early as possible, to the variety of jobs which are available in the sciences. The student should also be encouraged to think about what types of careers would be compatible with his/her particular handicap, or alternatively, how to overcome various physical problems which might arise in a less obviously compatible career. A little guidance at an early age can set the stage for continued mature planning throughout the student's education.

Just as an athlete prizes and develops his/her body, the handicapped student must be encouraged to prize his/her mind and develop his/her mental abilities. A strong mind is the handicapped student's strongest asset in job competition. In order to accomplish that, the handicapped student should be cautioned to seek a career which will use those mental abilities fully. If an advanced degree is required for a desirable job, the student should prepare for those extra years. If a job loses its challenge, one should change jobs. Choosing a career is a hard decision for everyone; for the handicapped student it can be especially frustrating and frightening. With some assistance in planning and some guidance in one's personal

value, career choosing can be exciting.

An Intervention Program

Handicapped persons face many barriers to successful career development in science and technology. The most notable include the lack of role models, deprivation of science content in their school, and descrimination based on negative societal expectations and personal aspirations.

A science career education program can be infused into the existing secondary curriculum offerings using these four basic channels: 1) the self, 2) the conceptual, 3) the informational, and 4) the experiential, (Munson, 1971). Briefly, each of these can be differentiated as following: 1) Self exposures focus on the individual and his or her "being," and deal with the many component concepts of self that comprise the total self-concept of the individual. Activities can be designed to provide students with opportunities to explore their values, attitudes, abilities, aspirations, personally held sterotypes, and personal traits in the perspectives of the limits of their handicap. 2) Conceptual exposures contribute to the individual's general understanding of the nature of work, work functions, and work roles, and also emphasize the development of attitudes and understanding that permit the individual to think realistically about the role of work in their lives. 3) Informational exposures provide for input of a factual nature and deal basically with expanding the student's knowledge about specific science-related jobs and career opportunities in the world of technical and scientific occupations. The informational channel must provide the very special information about job duties, work requirements, and qualifications so that an individual has the needed knowledge for problem-solving and decision making activities associated with his or her career development. Students cannot be exposed to all the career information which they may eventually need. They can learn how to locate information about the general duties of a job, typical work

situations, the physical demands and conditions of an occupation, the personal qualifications, and preparation requirements. 4) Experiential exposures permit individuals to evaluate their feelings toward and skills in specific science-related jobs or work role relationships. This potent channel is rarely tapped in the typical science education program.

Attempts to recruit successful career models have proved to be effective. There are a number of highly successful administrators, engineers, physicians, and others who graphically portray the rewards to be gained by the severely handicapped person and the problems one faces in attaining educational and career goals. They are living proof that the opportunity structure is more open than many disabled persons have been led to believe. The directory of handicapped scientists maintained by the American Association for the Advancement of Science, 1776 Massachusetts, Ave., N.W., Washington, D.C. 20036, provides an accessible reference base to assist students in exposure to science careers and career opportunities. In 1975 this agency began its Project on the Handicapped in Science in order to further the opportunities and increase the participation of handicapped persons in the sciences. This office has helped organize a resource group of more than 1000 physically disabled scientists and students across a wide range of disciplines. This group represents a source of experience and expertise of handicapped persons in the sciences. The matter appears to be largely one of education and receptiveness of individuals within the education community to take the extra step or walk the extra mile in order to insure equal opportunity for all students.

Computer Assisted Instruction

In the electronic schoolhouse of the 1980's, the ability to convey information is not dependent upon reading a book or listening to the teacher. A microcomputer, coupled with an assortment of specially designed input and output techniques, can become a "voice" for those who have none, "eyes" for

those who are sightless, and "ears" for the deaf. Benefits of learning can be equally dramatic when microcomputers are used with students who have physical limitations.

A "joy stick" can be used to control the interface with a computer, thus eliminating the need for a keyboard, which is often an obstacle for handicapped persons. Future refinements will hopefully make it possible for persons with movement in one direction to use a one-movement "joystick," and quadriplegics to use nothing but voice commands to control the computer.

A California electronics company, TASA, Inc., has developed a low cost flat-surface keyboard using solid state circuitry. This provides a large target area so a handicapped person with limited finger dexterity can touch the appropriate area more easily.

Students in general seem to find computer programs challenging, helpful, and preferable to conventional textbook assignments. It also appears that students will run computer drills several times when they encounter difficulties the first time through. They may, as a result, do more problems. More importantly, their mistakes will be pointed out when they are made, instead of hours or days later when it may be too late to learn from them.

Teachers looking for exciting new ways to teach science should, in this writer's opinion, consider simulation programs. They provide a means of group interaction and practice in problem solving and decision making. A real-life situation is presented, and the student must make a choice among the various courses of action. The variables of the problem are randomly selected, but interactions are controlled by a realistic model. Students can perceive the relationships between variables, and follow the results of the choices made.

The following programs have been selected for use in science because they appear to combine good instructional content, while making maximum use of the computer's potential.

Name of Program	Source
A2 Three-body Orbits Level: High School	Edu-Tech 634 Commonwealth Ave. Newton Centre, MA 02159

Description

A series of simulations and lessons in astronomy and physics. Displays the motion of three bodies interacting gravitationally in 4 different modes. Information is stored on all 9 planets.

Name of Program	Source
Ecology Simulations II: Pollute Level: Middle School/Jr. High	Creative Computing Software 39 East Hanover Avenue Morris Plains, NJ 07960

Description

Considers the problem of waste products on the oxygen content of a body of water and its impact on the fish population. It evaluates the effect that water temperature, amount of waste, and the type of waste treatment has on the pollution level.

Name of Program	Source
Volcanoes Level: MS/JH, High School	Earthware Computer Services P.O. Box 30039 Eugene, Oregon 97403

Description

This program presents a great deal of information about volcanoes, while teaching diverse attitudes and skills using a game format.

Name of Program	Source
Ecology Simulations II: Rats Level: MS/JH, High School	Creative Computing Software 39 East Hanover Ave. Morris Plains, NJ 07960

Description

The student plays the role of a health inspector to devise an effective plan to reduce the rat population in either a city or apartment building. The choices are to eradicate them by slow or quick poisons, or to control the refuge they feed on, or various other combinations.

Name of Program

Complete

Level: High School

Source

Conduit
Box 388
Iowa City, IA 52244

Description

There are 7 investigations in this program which concern the interaction between flowering plants. It is designed around real experiments, simulated experiments, and second-hand data in the form of graphs and tables. Through this computer simulation, students can carry out investigations without the long delay usually found in growth experiments.

Name of Program

Odell Lake

Level: Elementary

Source

Minnesota Educational Computing Consortium
2520 Broadway Drive
St. Paul, MN 55113-5199

Description

This simulation allows students to role play fish found in Odell Lake. Students are introduced to the ecological concepts in the food web.

Name of Program

Solar Distance

Level: Elementary

Source

Minnesota Education Computing Consortium
2520 Broadway Drive
St. Paul, MN 55113-5199

Description

This program teaches the names of the planets and the distances between the planets and earth: and teaches the concept of speed.

Name of Program

Cell Membrane

Level: Elementary

Source

Minnesota Educational Computing Consortium
2520 Broadway Drive
St. Paul, MN 55113-5199

Description

This simulates the interaction between a cell and its environment. The user controls six factors in the cell's environment in an attempt to keep a cell alive until it divides into two daughter cells.

"Education," as Alvin Toffler wrote in Future Shock, "must shift to the future tense." The programs included here are just beginning to tap the potential of the microcomputer in the science classroom. Imaginative new software programs appear to have a definite place in the future of education.

Equipment adaptations for some handicapping conditions make it possible for microcomputers to be used with very few, if any, restrictions making this a particularly useful learning medium for the orthopedically handicapped.

The tremendous growth in the high technology field in both hardware and software will make much of the information presented in this monograph dat even at the time of printing. What needs to be emphasized is that the microcomputer, as an educational tool, provides tremendous potential for individualizing educational programs for those students who, in the past, have wasted much time in educational settings because they had a physical or mental limitation which preve ted total involvement in the mainstreamed educational program.

The microcomputer can do much to augment classroom instruction but will never replace the value of a concerned, caring classroom teacher who, while adapting instruction so that each student can succeed, also monitors and controls student involvement. Students must not be allowed to remain passive in an educational setting. The importance of positive expectations cannot be overemphasized. If the learning opportunity is appropriate the human element becomes critical. When we expect one to succeed, he/she generally will, and when we expect one to fail, the expectation is often varified. This finding has been found in numerous studies of effective schooling and is particularly critical when educating the handicapped.

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