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AUTHOR	Cohen, Libby G.; Spenciner, Loraine
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ABSTRACT

There have been few initiatives addressing the improvement of science education for students with disabilities. Funded by the National Science Foundation, Biotechnology Works is a summer institute in immunology and genetics for students with disabilities, high school science teachers, and high school counselors. During the 1998 summer session, activities included developing curriculum adaptations for students with disabilities, mentoring high school science students, developing curriculum materials, and developing career development materials to encourage the participation of students with disabilities in science careers. Student activities included hands-on laboratories. Extended interviews were conducted with the 14 students who attended the 1998 summer institute. The students were 15-18 years old and had physical, emotional, or learning disabilities. Major interview themes related to the students' experiences were limited availability of science courses and science labs, the importance of teacher support, lack of adapted laboratory equipment, the importance of high teacher expectations and standards, and a desire to accomplish the work on their own. The students reported continued difficulties in their own science education programs, with the most striking finding being the few laboratory experiences available in either regular education or specialized settings. A variety of common adaptations and assistive technology used in the summer institute are listed. (SV)

Libby G. Cohen
University of Southern Maine
303 Bailey Hall
Gorham, ME 04038

Loraine Spenciner
University of Maine at Farmington
Merrill Hall
Farmington, ME 4938

BIOTECHNOLOGY WORKS!

"...there are clear indications that students with disabilities are not provided the equality of opportunity for science learning" (Stefanich, 1994, p. 57).

For most students with disabilities, the current approach to science education is dismal. Very little attention has been paid to improving science education for students with disabilities (Palmer & Cawley, 1993). Cawley, Kahn, and Tedesco (1989) reported that between 50% and 70% of all students who take science may receive grades of "D" or lower. Stefanich (1994) described the role of students with disabilities in science classroom as that of passive observers. For the most part, high school science laboratories have not been adapted to meet the needs of students with disabilities (Lovitt & Horton, 1992). Stefanich (1994) concluded that teachers of science have had very little training on how to teach students with disabilities. Scruggs and Mastropieri (1994) wrote that since teachers are not knowledgeable about teaching students with disabilities, they fall back on traditional methods of instruction, using textbooks, lectures, and worksheets. Since most students with disabilities receive their science education in inclusive classrooms, it is perplexing as to why there have been only a few initiatives that have addressed the improvement of science education for students with disabilities.

Justification for Focus on Biotechnology

Biotechnology combines a focus on immunology and genetics. Contemporary applications of biotechnology include cloning, DNA fingerprinting, and stem cell research. The study of biotechnology is at the cutting edge of science and "will continue into the twenty-first century as a major frontier of science" (National Science Education Standards, 1994, V-139). The National Science Education Standards which were published in 1994 states in Content Standard C that as a result of their activities in grades 9-12, all students should develop an understanding of the cell, the molecular basis of heredity, and biological evolution.

Summer Institute In Biotechnology

Biotechnology Works! is a summer institute, funded by the National Science Foundation (NSF), in immunology and genetics for students with disabilities, high school science teachers and high school counselors. Other than Biotechnology Works!, there are no other NSF sponsored projects that have focused on developing materials for high school science teachers and guidance counselors in the area of immunology and genetics.

The outcomes of the Biotechnology Works! project are to effect long-term changes in the: 1) participation of persons with disabilities in the sciences; 2) methods, materials, and curricula used in high school science classes, particularly in chemistry and biology; 3) practices and preparation of high school science teachers; and 4) practices and preparation of high school guidance counselors. During the summer of 1998 the following activities were conducted:

- developed curriculum adaptations for students with disabilities in immunology and genetics
- mentored high school science students
- developed curriculum materials and information for high school science teachers
- developed career development materials and information for high school guidance counselors on promoting and encouraging the participation of students with disabilities in science careers.

The daily activities consisted of classroom time, laboratory time, informal meetings with scientists, lab tours, and informal recreational activities. Hands-on laboratories that were offered included: immunodiffusion, enzyme linked immunoadsorbent assay (ELISA), agglutination, electrophoresis, DNA extraction, DNA digestion using restriction enzymes, and horizontal gel electrophoresis.

Methodology

Subjects

Each of the 14 students who attended the 1998 summer institute participated in extended interviews. The students ranged in age from 15 to 18 years old. They included 7 females and 7 males. All students were in high school or had just graduated from high school and all had identified disabilities including physical disabilities, learning disabilities, emotional difficulties, attention deficit hyperactivity disorder, blindness, low vision, and deafness.

Interviews

Interview questions were developed based on an extensive review of the existing literature on the participation and inclusion of students with disabilities in science education. Successive drafts of the interview questions were reviewed by special education faculty, special education teachers, and school counselors. The questions were piloted with a small group of students and revised again. Finally, the interview procedure was reviewed by school counselors and two interviewers, who were school counselors, were trained.

Procedure

Permission to participate in an interview was obtained from each student and parent or guardian, when appropriate. Each student was interviewed individually by one of two school counselors. All of the interviews were audiotaped and transcribed.

Data Analysis

The qualitative analysis was guided by the work of Bogden and Biklen (1992), Miles and Hubernman (1994), Glaser and Strauss (1967). This approach to data analysis facilitates the "progressive building up from the facts" (Glaser & Strauss, 1967, p. 35). Two principles were followed during the data analysis. First, rigorous and systematic procedures were used. The investigators engaged in precise, line-by-line analyses of the interview transcripts. Transcriptions were read and reread several times. To increase reliability, two investigators carefully reviewed the transcripts and confirmed the identified themes. Secondly, the data analysis was iterative and on-going. As themes emerged they were checked and refined. The themes were noted and transcriptions were reread and sorted by themes.

Results

An analysis of the interviews found several themes related to the students' experiences. The lack of advanced science courses and science laboratories emerged as a predominant theme. In instances

where science courses and laboratories were available, the subthemes of classroom environment, teacher expectations, and personal initiatives by students were interwoven. These themes are delineated and illustrated.

Availability of Science Courses and Science Labs

One striking theme that emerged was that students had few or no experiences with science labs in their local high schools. A common point that students made was the limited exposure to lab experiences. One student reported that, "This year in physics we did two labs total." Students who were enrolled in special education residential settings had similar experiences with the lack of lab experiences. One student commented, "We didn't even have a lab at _____(a special education school). Limited experiences and lack of opportunity with hands-on lab activities created problems for some students. "People look at me and say are you bored? I said, 'yes,' but I never get bored with the activities. But I get bored with the lectures."

Classroom Environment

Without a doubt, the classroom teacher is responsible for creating a positive learning environment. Three students mentioned the importance of teacher support. One student commented about the general lack of commitment to students by the teacher. "My teacher just didn't care about anything. She didn't care about any of the students." Another student felt that the lack of concern was more directly related to him, "I didn't feel that I was included in my high school science class." In contrast, one student reported very positive experiences in the classroom and described her teacher with admiration, "Mr. C. is like my best friend ...people are very respectful of him." Although all students had individualized education programs, none of the students mentioned special education teachers and the support that they may (or may not) have provided.

Seven students had an identified learning disability and four of these students had a compounding attention deficit hyperactivity disorder. These students reported that frequently their special learning needs went unmet. One student with a learning disability and an attention deficit hyperactivity disorder explained, "They tell you how to do it. I won't remember what you said 30 seconds later. How do you know that I understand what you just said. It is just really easy to lose track of what you are doing. I have a real short term memory."

Students reported that some of their learning needs were met by obtaining special equipment, materials, or support personnel. As one student stated, "The lab is always such an uneasy place for anybody with a disability because it is so technical and fine." Yet, the supports and accommodations that the students identified were traditional and ordinary. Equipment needs included a lap top computer and low tech pencil grips. None of the students reported use of adapted lab equipment. No high tech equipment such as word prediction software for lab reports or talking thermometers for science units was mentioned. Materials that were provided to students with visual impariments included brailled textbooks, audiotaped textbooks, and raised diagrams. Students with visual impairments reported that brailled materials often arrived at the end of the unit. Personnel who provided support were readers, recorders, tutors, and teacher aides.

Expectations

The majority of students mentioned how the expectations of counselors and teachers had influenced their own experiences in science. One student with low vision described the impact of how her counselor affected her career path. "My counselor, I have known her for a really long time...and I said 'I really want to be an environmental engineer'. She said, 'You know you can't do that.' And that is something nobody, nobody, I don't care who you are, nobody should ever hear 'you can't.' She said, 'You can't do that' and I said 'Why?' She said, 'Well, your vision isn't good enough.' She gave me all

these reasons and totally shot me down. I pouted and I was really upset. My mother said, 'Well, if she said that you can't do this, I am sure she knows....I wouldn't want you to go through this and find out no, you can't.' So I shopped around for a new career idea...."

Students found that teachers were more than willing to let them take the easy way out. "In science it is so hard and people were more willing to just let you not do things. It is easier for them to just say 'well, if this is hard for you just don't do it'. That is what I got a lot. I got a lot of that in high school, '...if this is hard for you, just don't do it'." Some teachers passed students on. "I don't do any homework hardly for any of these classes but I still pass--so it works."

Three students mentioned with pride their experiences with teachers who held high standards and expectations. "Mr. _____ said, 'Well, if this is hard for you we can fix it and make it easier so that you can do it." ("Easy" here means that the materials are accessible—not standards were lowered.) To have him say 'if this is hard for you, we can fix that. We can make it different.'...and that is just great. It was good to know that somebody cared enough to do that and take time to do that."

Another student reported, "Science is pretty great actually because of the teacher. He was really willing to make adaptations and he listens and that just makes it easier when somebody is willing to listen to what you need. He still had some pretty hard labs...."

Similarly, "I got not very good grades in science and this teacher took me aside and said, 'You know you have real potential but you have to use it because the world does not owe you anything. You must take things into your own hands and use them yourself because I will not pass you if you sit in my class and do nothing.' He was tremendous...."

On My Own

In addition to high teacher expectations, students discussed the need for doing the work themselves. "I really do not prefer (to have) people read things to me because reading is a thing that is subject to interpretation. Some people make interpretations of what they read; therefore, I like to read (it myself)."

Taking notes was another area that students identified. "...I really don't like taking the easy way out. I feel like if I get someone's information, I don't' feel like I end up understanding the information that is represented in the lab. I wish that instead of just having to get somebody's paper and basically copying it they'd figure out a way that I could be doing something and use my own energy.

Discussion

Despite recent science education, students with disabilities report continued difficulties in their own science education programs. The most striking findings are that students have few, if any, science laboratory experiences in both regular education and specialized settings. Although students were eager to fully participate in science and to take advanced science courses, these experiences were limited or simply were not made available to them in their own schools.

At each point in their pursuit of science education, students encountered frustration and lack of accommodations and supports. When students did participate in science labs, they had difficulty in obtaining adapted materials and equipment. Brailled materials, when requested, did not arrive on time. Braille labels were not provided for common laboratory equipment. Laboratory equipment that could help make the laboratories accessible was not provided. Teachers gave a long series of directions orally, rather than demonstrating procedures. Commonly available assistive technology and augmentative communication devices, which could provide much needed assistance, were not mentioned or were not available.

Students frequently talked about their science teachers' expectations. Students valued teachers who held high standards and had equally high expectations for them as learners. Even though students acknowledged that science classes were "hard," they valued teachers who were willing to help them access the material and the equipment. Students did not seem to be concerned that their teachers might

not be familiar with particular disabilities; rather, the most important factor was that the teacher was willing to work with them to make the necessary accommodations. Special education teachers who could provide support and resources were not mentioned by the students.

Finding ways to become less dependent on others was a theme that was discussed. Students wanted to find ways to complete assignments and lab activities by relying less on others for the information. A wide variety of common adaptations and assistive technology now exists to make this possible.

In the Biotechnology Works! summer institute adaptations were made to science laboratories so that all students could participate and, more importantly, so that each student could experience the "Ahah's" of science. Commonly used adaptations that were developed and implemented included:

- In the pre-lab session for each lab, each student and teacher received a notebook with the purpose, list of materials, procedure, and an illustrated flowchart. A large point size, simple font style, and double-space lines were used.
- All the sign language interpreters were given teacher notebooks at the beginning of the week so that they could review some of the technical scientific concepts and vocabulary.
- A variety of written formats for explaining the labs: overhead projector, green chalkboard with yellow chalk, cream-colored chart paper with wide black markers, student and teacher notebooks, and braille.
- Definitions of all terms were posted for everyone to see and were read out loud during the pre-labs. Questions that students or teachers asked during the labs were abbreviated and posted, along with abbreviated answers.
- Test tubes and other laboratory equipment were color-coded whenever possible.
- Braille labels were affixed to laboratory equipment whenever appropriate.
- The aisles of the classrooms were kept free of clutter for easy accessibility; we planned where the various heating and refrigeration units would be located to maximize traffic flow.
- All overheads for the pre-labs and the actual labs were photocopied on paper and given beforehand to the deaf students, who were then able to take notes more easily as they watched the sign language interpreters.
- A variety of pipettors were available during each lab so that each student could select one that was comfortable to use. Furthermore, the pipettor holder designed and built by Don's high school biology students was in constant use.
- A slip-resistant surface ("Benchcoat") was used at each lab station.
- Large-sized petri dishes and simple templates were used whenever appropriate.
- The staff tried to be as specific as possible when giving an explanation. The teacher presenters and the lab assistants made a concerted effort to eliminate vague phrases such as "this," "over there," and "just like this one" from their vocabulary.
- Many models and analogies were used to explain the general concepts for each lab. For instance, soil sifters with different-sized openings and objects were used to demonstrate the agarose gel electrophoresis of different-sized pieces of DNA. Plates of cooked spaghetti and tomato sauce helped to clarify the concept of spooling DNA for DNA extraction.
- Each lab was placed in context (for instance, using a description of a crime scene or comparing a specific procedure to a pregnancy test) so that there would be a reason for doing each lab.

There is still much more work that needs to be done. Strategies that make science, at all educational levels and in each domain, accessible need to be developed and shared with educators. Science teachers and special education teachers should be encouraged to have high expectations for all students, including students with disabilities. Including students with disabilities in science makes sense; including students with disabilities makes science richer.

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Signature: Diane Montgomery

Position: Associate Professor

Printed Name: Diane Montgomery

Organization: Oklahoma State University

Address: 424 Willard Hall
Stillwater, OK
74078

Telephone No: (405) 744-9441

Date: April 8, 1999

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