The Ontogeny of Inclusive Science

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Rather than being an original composition, many of the chapter segments contained in this book were modified and edited from dissertations and professional papers of students I worked with at the University of Northern Iowa. In addition, other professionals who possess similar goals towards educational equity for all students have allowed me to include elements of their work in this publication. In the process of putting the book together, items have been moved and pieced together. Therefore, I have elected to indicate the contributing authors alphabetically below. In cases where an author’s significant segment is included, I have tried to make a notation in the book. Contributing authors are:

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In addition there are places in the book where I have received permission to include a specific element of work from another resource. Pages 54-59 were extracted from a paper prepared by B. Duerstock and J.P. Robinson. The accommodation model presented in Appendix (A) was modified from the publication: Sheryl Burgstahler (Ed.), A Resource Guide for Teachers and Teacher Educators. Much of the material in Chapter 5, entitled Safety, was modified from the work of C. Johnson, as was the Science Safety Checklist in Appendix (B).
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Preface

The first decade of the 21st century has the potential to afford high quality educational access to all children, something previously impossible in the annals of education. Inclusive mandates such as IDEA and other legislation such as the No Child Left Behind Act have had major direct impact on educational practices in schools. Educational research is becoming more refined and a research base on successful strategies based on differences between learners is emerging. Advances in technology have made hands-on science learning accessible for persons with motor and sensory impairments. This book is an effort to explore the connections between knowledge and practice applied specifically to science, with a focus on students with disabilities learning in a common educational setting with a heterogeneous and diverse group of peers.

Chapter 1 provides a context to issues related to inclusive education today by sketching a brief history of special education, including early legislative initiatives. Contemporary legislation setting forth the rights of persons with disabilities is discussed, with special attention to the Individuals with Disabilities Education Act (1990, 1997, 2004) and its salient features.

Chapter 2 presents an overview of learning theory models and emphasizes constructivism, the dominant application theory in science theory education. The chapter contains a synthesis of kinds of knowledge, the cycle of learning, and implications for the teaching of science.

Chapter 3 brings the research base on best practice and effective schools into the science classroom. Highly effective schools and highly effective teachers have common attributes that have been teased out through meta-analyses. More specifically, the research has been extended into studies of students with disabilities in science classrooms. Suggestions are shared about when to make adaptations and types of adaptations teachers can make.

Chapter 4 introduces the concept of universal design specific to science learning and science laboratories. Associated with this information is an assistive technology screening guide in Appendix C.

Chapter 5 addresses safety. When asked about teaching students with disabilities in science, more than 50% of science teachers expressed concerns about safety, particularly in the laboratory. Characteristics of a good safety program are shared including legal considerations and suggested teaching procedures. A science safety inspection checklist is shared in Appendix B.

Chapter 6 is multi-faceted and addresses assessment and evaluation relating to students with disabilities. Issues including legal ones are discussed. Testing accommodation suggestions are offered. The chapter also addresses broader forms of educational evaluation and assessment affecting teachers and educational practice. Viewpoints relating to teacher and administrator accountability and public oversight in the context of equity are shared.

Chapter 7 addresses teaching as a collaborative effort in which science teachers utilize the expertise of other educators in planning instruction and solving problems. Different approaches to collaborative teaching partnerships are discussed, and a planning guide for setting up collaborative teaching arrangement is included.
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Chapter 1  
Historical and Legal Foundations

Special Education History

Special education in the United States has a complex historical tapestry, with roots in the 1700s and 1800s. Research has indicated that inclusionary settings were rare, but some did exist in the early years of our country. Nora Ellen Groce (1985) reported a unique situation on Martha’s Vineyard in the 18th and 19th centuries where the population had a 200-year history of a high incidence of hereditary deafness. The communities adapted to the situation by creating a sign language, and most residents learned and used it successfully. The Vineyarders did not see deafness as a handicapping condition. They made modifications and lived full and meaningful lives.

Other initiatives in U.S. history have helped individuals with disabilities. In 1817, Thomas Hopkins Gallaudet began the American Institute for the Education of the Deaf and Dumb, later changed to Gallaudet University for the Deaf. The House of Refuge was founded in New York City in 1825, the first refuge for juvenile delinquents and those with behavioral maladies in the United States. Samuel Gridley Howe started the New England Asylum for the Blind in 1832. In 1848 Howe also founded the Massachusetts School for Idiots and Feebleminded Persons. Edward Sequin founded the first professional organization, the Association of Medical Officers of American Institutions for Idiots and Feebleminded Persons, in 1876 (Barr, 1913; D. D. Smith, 1998). This organization has remained viable since the original charter although the group’s name changed to the American Association on Mental Deficiency, and today exists as the American Association on Mental Retardation. In 1878, the Cleveland Public Schools were the first in the nation to open two special education day classes (Sarason & Doris, 1979). Philadelphia claims the first hospital for the physically disabled, Home of the Merciful Savior, established in 1884. The National Education Association (NEA) began a division for persons interested in children with special needs in 1897, but it disbanded in 1918 to allow for reorganization. Elizabeth Farrell started non-graded classes in New York City in 1898 to serve “backward students” in a settlement house setting to serve the poor, unskilled, less able, and also to assist immigrants. She joined forces with the city superintendent of schools to foster the cause of students who did not meet grade-level criteria for one reason or another. She founded the Council for Exceptional Children, a professional organization still in existence today (Smith, 1998).

The 20th Century

Legislation and improved educational practices resulted in marked improvement in the quality of life for persons with disabilities during the 20th century. Initial efforts towards inclusion provided opportunities in the private sector, with impetus towards vocational rehabilitation coupled with more extensive reforms stimulated by civil rights legislation. Special education found its present profile and substance through federal law, civil rights movements, and resulting court cases, as well as the evolutionary influences of politics and society (Friend & Bursuck, 1999; T.E. Smith, Polloway, Patton, & Dowdy, 1998).

In 1918 the Soldier's Rehabilitation Act was passed which provided for vocational retraining of disabled veterans. The Vocational Rehabilitation Act of 1920 extended the same vocational benefits to civilians. Initially limited to those with "physical disabilities," the Act had to be renewed annually until 1935 when rehabilitation received permanent status under the Social Security Act. The Vocational Rehabilitation Act of 1943 expanded services to include medical and physical restoration devices and those with mental illness. With the emergence of the Department of Health, Education, and Welfare in 1953, along with improved services through state and community rehabilitation programs, it became viable for persons with disabilities to function as an included constituency in American society.
In the 1950s, the country experienced civil rights movements as minorities demanded equal treatment under the law and in society. These movements represented a major catalyst for questioning and examining the rights of persons with disabilities who emerged as a powerful faction of American society (Friend & Bursuck, 1999; Rothstein, 1995). Effective parent organizations gathered impetus in the 1950s, joining forces with concerned professionals in education, medicine, and the social sciences. Power yielded influence. As confirmed by the outcome of Brown vs. Board of Education in 1954, the Fourteenth Amendment of our federal Constitution was cited to protect the right of all citizens against discrimination of any kind (Rothstein, 1995; Yell, 1995). This decision confirmed that practices which discriminate against children of color, forcing separate schooling, are against the law. Soon after, the same law was applied to protect the rights of persons with disabilities. The courtroom became the emancipator and, to date, the stage where the rights of those with disabilities are championed and preserved.

The Vocational Rehabilitation Act of 1954 provided opportunities for adult Americans with disabilities to receive educational opportunities commensurate with their interests and abilities. In 1965, Public Law 333 established behavioral disabilities and cultural and economic deprivation as handicapping conditions, enabling these individuals greater access to training, rehabilitation services, and self-help programs. The Rehabilitation Act of 1973 opened many doors for persons with disabilities. Under Section 502 of this legislation, the Architectural and Transportation Compliance Board was established which helped reduce architectural barriers and provided technical assistance. Section 504 prohibited discrimination in education and employment, and required equal access to programs and services for persons with disabilities.

Much stronger legislation, the Americans with Disabilities Act (ADA) of 1990, provided employees with disabilities legal protection against discrimination in public and private arenas. Through ADA, the responsibility for reasonable accommodation rests clearly upon employers. Those who fail to comply can be sued for compensatory damages. This legislation provides more than 43 million people with disabilities the same civil rights protections provided on the basis of gender, race, and religion. For the regular education teacher, this law meant that students will be served as much as possible in the regular education classroom (Smith et al., 1998). Goals of the law are to end discrimination against individuals with disabilities and bring this group into the economic and social mainstream of American life, to provide enforceable standards addressing discrimination, and to ensure that the Federal government plays a central role in enforcing these standards on behalf of this group.

As is often the case, resources for educational inclusion lagged behind actions initiated in the private sector. Until the 1950s most persons with disabilities were kept at home, not educated in any formal way, or sent to institutions or private facilities for custodial care. It took over 50 years from the Vocational Rehabilitation Act of 1920 to reach the needs of all children in our schools. In 1973, Education of All Handicapped Children Act (EHACA) was passed, also called PL 94-142. This was implemented beginning in 1975. The legislation guaranteed free, appropriate public education for all children with disabilities. The passage opened the door for a free and appropriate public education (FAPE) for more than 4 million children with disabilities in the U.S. who were not receiving “appropriate education services which would enable them to have full equality of opportunity” (Tucker & Goldstein, 1991, 1992).

Contained within this legislation were the rights of children to receive an education in the least restrictive environment. The passage of this law mandated integration of students with disabilities into regular classes with nondisabled peers. The very name of the law reflected the language of the day, and required states to educate all students regardless of disability (Lipsky & Gartner, 1997). The major components of this landmark legislation included guarantee of free and appropriate education for all ages
6 through 17; mandates for the creation, review, and revision of an Individual Education Program (IEP) for each student receiving special education services; a guarantee of placement in the least restrictive environment; and details outlining parents’ rights (Sherwood, 1990; Tiegerman-Farber & Radziewicz, 1998; Ysseldyke, Algozinne, & Thurlow, 1992). Public Law 94-142, a turning point for those with disabilities, addressed the issue of where this population would be educated, not simply if they would be educated, as was the case a quarter of a century earlier.

These mandates make it clear that a person with disabilities has a right to access regular education programs, if such programs are appropriate, with the addition of supplementary aids and services. The law requires that to the maximum extent appropriate, individuals with disabilities (including children in public/private institutions or other care facilities), must be educated in the regular classroom setting. Special classes, separate schooling, or the removal of children with disabilities from the regular environment occurs only when the nature or severity of the handicap is such that education in the regular classes with the use of supplemental aids and services cannot be achieved satisfactorily.

As a result of PL 94-142 passage, many students with mild disabilities began a new era in the regular classroom and saw success. The nondisabled setting became known as the least restrictive environment (LRE) (Power-deFur & Orelove, 1997; T.E. Smith et al.; 1998, Takes, 1993). School districts created accommodations in the form of separate classes and separate schools for those with more severe disabilities, which, at the time, was considered a move forward because these students with greater needs had previously been denied public education in any form. This law set the groundwork for the inclusion movement, even though the term “inclusion” does not appear in the law itself (Power-deFur & Orelove, 1997).

The Regular Educator Initiative (REI) was generated from the research findings of the special education academic community following implementation of PL 94-142. In 1990, PL #101-476 reauthorized, amended, and renamed PL #94-142 as the Individuals with Disabilities Education Act (IDEA). Its primary developments were to initiate the inclusion movement, to change terminology from “handicapped children” to “children with disabilities,” and to confirm two new categories of disability -- traumatic brain injury and autism -- as eligible categories for special education services. Service provision for those in preschool and in post secondary transition were outlined and mandated into law (Tiegerman-Farber & Radziewicz, 1998; Ysseldyke et al., 1992).

The legislation also affected testing. The tests used to evaluate a child's special needs must be racially and culturally nondiscriminatory in the way they are selected and the way they are administered, must be in the child’s primary language or mode of communication, and no one test procedure can be used as the sole determinant of a child's educational program. Accommodations that may be provided include an architecturally accessible testing site, a distraction-free space, an alternative location, test schedule variation, extended time, the use of a scribe, sign language interpreter, readers, adaptive equipment, adaptive communication devices, and modifications of the test presentation and/or response format (Thurlow et al., 1993).

This initiative is viewed by some as a major first step in the inclusion movement (Fuchs & Fuchs, 1994; Schumm & Vaughn, 1991; Will, 1986). REI launched the inclusion phase of students with special needs into the arena of regular education. The difference between the integration phase and the inclusion phase was that under inclusion it was assumed that students with disabilities belonged there. Although the students who benefited were primarily those with mild disabilities (Lipsky & Gartner, 1997), a great step had been successfully taken, a major milestone achieved.
The impetus of the regular education initiative movement led to the IDEA Amendments of 1997 which affected the roles and responsibilities of the regular educator as a member of the IEP Team in several ways:

1. Regular educators are members of the IEP Team. This requires them to be an active participant in the development, review, and revision of the IEP of students with disabilities served through collaborative measures.

2. Regular educators will help develop, review, and revise the IEP as member of teams comprised of parents, administrators, and students themselves in collaborative interactions. This requires them to maintain open lines of communication, participate in IEP Team meetings, and implement interventions and adaptations recommended by Team members.

3. Placement in the regular education classroom with access to the regular classroom and regular curriculum is strongly mandated by law from federal, state, and local level. This requires the regular educator to adapt and modify classroom expectations to meet the needs and ability levels of the students with disabilities in the regular classroom.

The reauthorized statute of IDEA in 2004 became effective on July 1, 2005. It continues to provide legislative support advancing equity for students with disabilities. Four areas likely to impact science teachers are: alignment with No Child Left Behind (NCLB), teacher qualifications, secondary transitions, and assessment.

Related to NCLB, schools are allowed to utilize funds reserved for state activities to support the development and provision of appropriate accommodations for students with disabilities or the development of alternative assessments that are valid and reliable for assessing the performance of students with disabilities. State personnel development plans are required to identify and address state needs for the preparation and professional development of personnel who provide direct supplementary aids and services to students with disabilities. The plans must be integrated and aligned, to the maximum extent possible, with state plans and activities under the Elementary and Secondary Education Act (ESEA) of 1965, the Rehabilitation Act of 1973, and the Higher Education Act of 1965.

Under teacher qualifications, the secretary of the Department of Education is authorized to provide personnel development grants to improve services and results for children with disabilities through grants that ensure the regular education teachers have the necessary knowledge and skills to provide instruction to students with disabilities in the regular classroom. The grants also encourage increased focus on academics and core knowledge in special education personnel preparation programs. The requirements also align the “Highly Qualified” standards of IDEA with the standards of ESEA-NCLB, relating to teacher qualifications.

Legislative changes in the secondary transition requirements in the Individualized Educational Program (IEP) require that the IEP be in effect when the child is 16. Every year thereafter must include appropriate measurable postsecondary goals and the transition services necessary to assist the student in achieving those goals. The transition services shall be within a results-oriented process to facilitate the child’s movement from school to post-school activities including post-secondary education, vocational education, integrated employment (including supported employment), continuing and adult education, adult services, independent living, or community participation.

In assessment, all children with disabilities must be included in all state and district-wide assessment programs, with appropriate accommodations and alternative assessments where necessary and as indicated in their respective IEPS. These assessments must be aligned with the state’s challenging
content standards and challenging student achievement standards. Reporting requirements must include
the number of students participating in regular assessments and the number of students provided
accommodations. The performance of special education students on regular assessments and alternative
assessments must be reported and compared with the achievement of all children on those assessments.

The legislation increases expectations and raises qualification requirements for teachers of science
and for special education teachers involved in science instruction. It provides the following opportunities:
for increased utilization of both federal and state funds to better serve students with disabilities; increased
responsibility on educators in preparing students with disabilities for transitions into post-secondary
education and employment; and schools to be accountable for collecting and sharing assessment data on
all students, specifically sharing discrepancies between students with disabilities compared with all
students taking the assessment. Lastly it provides funding opportunities through professional preparation
grants for educators and educational institutions that are committed to improve the quality of educational
services to students with disabilities.

The requirements of the legislation are clear. However, less clear is how states and local school
districts have implemented the law and how educators' reported beliefs and reported practices affect the
implementation of the laws in local schools. Legislation is lacking in how schools are going to provide
inservice and provide teachers with the time necessary to accomplish successful collaboration in the
regular classroom (Crockett & Kauffman, 1998; Lipsky & Gartner, 1998). Studies have indicated that
many teachers do not attempt to meet IEP guidelines or do not adapt any classroom procedures or
expectations for any students with disabilities (Ysseldyke, Thurlow, Wotruba, & Nania, 1990). Other
researchers have indicated that adapted techniques may be highly desirable, yet practice does not follow
the belief in some classrooms with mainstreamed students (Lipsky & Gartner, 1987, 1997; Reynolds,

Issues and Concerns Related to Inclusion

A significant number of education researchers and practitioners have challenged the dual system of
special education and regular education in the 1980s. Supporters of the inclusion movement cited such
claims as basic rights of all individuals to have equal opportunity to live normally and attend school with
non-disabled peers, to participate as fully as possible (Ferguson, 1995; McNulty, Connolly, Wilson, &
Brewer, 1996). Many researchers claimed that all students would benefit from having students with
special needs in the regular classroom (Ferguson, 1995; Fuchs & Fuchs, 1995; Lipsky & Gartner, 1998;
McLeskey & Waldron, 1996; Ryndak, Downing, Morrison, & Williams, 1996; Stainback, Stainback, &
Stefanich, 1994; Vaughn & Schumm, 1995). It was found that teaching methods and strategies utilized in
special education classrooms did not differ so drastically from those used in regular classes (Mercer,
Lane, Jordon, Allsopp, & Eisele, 1996). Service models which required the students to leave the
classroom for prescriptive services denied the students much valuable instructional time and socialization
in the regular classroom (Sapon-Shevin, 1996). Leaving the class to attend resource or pullout programs
put a label or stigma on students, a further handicap for them (Wang & Reynolds, 1996).

Findings in educational research appear to support inclusion as a more desirable alternative than
segregated instruction for students with disabilities. Ferguson and Asch (1989) found that the more time
children with disabilities spent in regular classes, the more they achieved as adults in employment and
continuing education. This held true regardless of gender, race, socioeconomic status (SES), type of
disability, or the age at which the child gained access to general education. Research reviews and meta-
analyses known as the special education “efficacy studies” (Lipsky & Gartner 1989, p. 19) showed that
placement outside of general education had little or no positive effects for students regardless of the
intensity or type of disability. In a review of three meta-analyses that looked at the most effective setting
for educating students with special needs, Baker, Wang, and Walbert (1994) concluded that “special-
needs students educated in regular classes do better academically and socially than comparable students in noninclusive settings” (p. 34). Their review yielded the same results regardless of the type of disability or grade level.

Regarding students with severe disabilities, Hollowood, Salisbury, Rainforth, and Palombaro (1994) found that including these students was not detrimental to classmates. Other researchers (Costello, 1991; Kaskinen-Chapman, 1992) found such inclusion enhanced all students’ learning (e.g., Cole & Meyer, 1991; Strain, 1983; Straub & Peck, 1994), yielded social and emotional benefits for all students, and improved self-esteem and attendance for some students considered “at-risk” (Kelly, 1992). This research, coupled with strong public pressures to change current models of delivery in schools, provides a strong impetus for major educational reform. A question the courts will certainly address is the extent and degree of responsibility educators have in accommodating the educational needs of students with disabilities.

The educational trend to move away from separate classes for those with special needs has gained favor with many educators. Normalization was viewed as an essential dimension of special education. Nirge (cited in D.D. Smith, 1998), refers to a normal life pattern, normal day, year, and life rhythms. Tieggerman-Farber and Radziewicz (1998) explain normalization for the child with disabilities in terms of “identification of activities, educational experiences, and social interactions that simulate realistic and ongoing environmental events” (p. 4). Placing students with disabilities into regular education classrooms achieved the means and the end to provide the most normal experience for them.

Professional organizations have voiced their concerns over the inclusion issue. The spectrum of support for inclusive education ranges from total and unrestricted support from the Association of Persons With Severe Handicaps (1994), to cautious regard for continuum of services while supporting inclusion (Council for Exceptional Persons, 1993), through concern for the provision of needed services (Learning Disabilities Association, 1993), to the guarded caution of the American Federation of Teachers (1993) and the National Education Association (1994) in support of appropriate inclusion (Lipsky & Gartner, 1997; Vaughn, Schumm, Jallad, Slusher, & Saumell, 1996). The American Federation of Teachers (1994) called for a moratorium on inclusion in response to expressed concerns about lack of teacher preparation addressing the needs of students with disabilities in a regular classroom.

Teachers’ negative attitudes have been cited regarding feelings of incompetence, fear, anger, and frustration about being forced to accept included students (Tieggerman-Farber & Radziewicz, 1998; Vaughn & Schumm, 1995). Some teachers have qualified their negative feelings toward this movement, citing the fact that the choice they made was to teach regular education, not special education (Vaughn, et al., 1996). A study done in a Texas school district where most of the students with special needs attended regular classes indicated that this practice altered the content and scope that teachers could teach, methods they used, and nature and duration of student-teacher interactions (Baines, Baines, & Masterson, 1994; Villa & Thousand, 1995).

Studies at the secondary level have indicated that while the majority of regular education teachers feel successful in teaching students with disabilities in the regular classrooms, over one-third of them have received no prior or ongoing preparation or professional development for this collaboration, and less than one-half have been involved in development of the IEP (Rojewski & Pollard, 1993). Other findings have indicated that teachers willingly made specialized adaptations when the IEP Team advised them to do so and supported the teachers (Fuchs, Fuchs, & Bishop, 1992; Sapon-Shevin, 1996). The role of the regular educator in the development, implementation, and evaluation of IEPs has become a critical issue in response to compliance efforts of schools to IDEA 1997 (Fuchs & Fuchs, 1994; Sapon-Shevin, 1996).

Practitioners consistently state the need for inservice opportunities to promote successful inclusion for both students with special needs as well as effects on non-disabled peers (Sapon-Shevin, 1996). Research
has indicated that the need for teacher inservice and skill development in serving students with disabilities through collaborative efforts is one of the most important aspects of the regular educator’s role in serving identified students as well as non-disabled peers (Stainback et. al., 1996; Sapon-Shevin, 1996).

Many teachers believe that they are skilled, accommodating, and willing to serve on IEP Teams in all aspects of planning and implementation of appropriate education for students with special needs (Friend & Bursuck, 1999; Power-deFur & Orelove, 1997). However, mechanisms are lacking to capitalize on their skills and respect their professional talents and limitations. They find themselves to be fringe players on IEP staffings when they do participate. In addition, staffing meeting times frequently conflict with other responsibilities or duties limiting teachers’ participation.

Although some progress has been made in more use of technology, little significant progress has been made to familiarize general classroom teachers with their responsibilities toward meeting the needs of all students. Interventions such as creating and using adaptive materials, modifying lessons and strategies, modifying the laboratory environment to allow full participation, and adapting evaluation of students with disabilities are still perceived as responsibilities left to special educators.

Interventions and modifications needed range widely across the types of disabilities. About 23% of the 5,573,000 (1,310,000) students with disabilities consists of individuals with physical impairments. Approximately 78% (1,022,000) of these students have speech and language impairments that require minimal accommodation in a science classroom or laboratory. The other 72% (4,291,000) of students with disabilities manifest cognitive, social-personal, or intellectual disabilities and often experience difficulty with science in secondary and post-secondary education. Some do have potential for the highest levels of science achievement but need assistance in overcoming their disabilities in order to have a science, mathematics, or technology career. Seventy percent of school-age children with disabilities have learning disabilities, serious emotional disturbances and/or behavior disorders, mild developmental delays, and/or attention-deficit disorders. For each of these categories, if the input-output processing deficit can be alleviated, we should expect achievement commensurate with others in the regular population of students. Women and/or minorities with disabilities face even more obstacles to obtaining quality education because of the compounding effect of the disability with other actions of discrimination and/or low expectations.

Contemporary Legislation Covering Rights of Persons with Disabilities

Congress has enacted many laws designed to deal with the rights of people with disabilities, but it’s taken a long time to get there. A postpolio quadriplegic who began classes at the University of California at Berkeley in the fall of 1962 and fellow disability rights leaders challenged “widely held myths that people with disabilities were incapable of being educated, working, caring for themselves, or becoming contributing members of society.” They challenged the notion that persons with disabilities were deserving of lesser lives. It took almost another 30 years before this new self-identify was reflected in law with the passage of the Americans with Disabilities Act (ADA) (Shapiro, 1994).


Section 02 Amendments, 1978 & 1979 affects universities: (1) They authorized federal agencies to provide grants to any designated state unit overseeing work with people with disabilities to establish and operate comprehensive rehabilitation centers to provide a broad range of services, and made the
remedies, procedures and rights (of Title VI, Civil Rights Act, 1964) available to section 504 discrimination victims. Remedies include payment of attorney’s fees, payment of expert-witness fees, injunctions, back pay for intentional discrimination, and other equitable remedies at the trial court’s discretion.

Section 504 Amendment, Civil Rights Restoration Act of 1987 [CRRA] Amended the definition of “program or activity” to mean all of the operations of a college, university or other postsecondary* institution; or a public system of higher education. When federal financial assistance is extended to any part of the afore mentioned, all of the operations of the institution or educational system are covered. [*Postsecondary is a term for any institution—vocational, business, or secretarial—which offers education beyond the twelfth grade.]

Individuals with Disabilities Education Act [IDEA] 1973 Public Law 94-142 (PL 94-142) Guarantees to all youth with disabilities a free, appropriate education in the least restrictive environment. Accountability was to be demonstrated through individualized education plans, nondiscriminatory evaluations, support services, parental involvement, and due process.

Education for All Handicapped Children Act [EAHCA] 1975 Requires states to provide all children with disabilities with a free, appropriate public education.

President George H.W. Bush signed into law the Americans with Disabilities Act of 1990. This law required employers to make certain accommodations deemed reasonable and necessary for persons with disabilities to work and use public transportation and facilities (Friend & Bursuck, 1999). The act is considered a landmark decision and provided another major stepping stone in the journey of those with disabilities for equal and fair treatment under the law (Rothstein, 1995; Yell, 1995).

Americans with Disabilities Act [ADA] 1990. Title I Employment, Title III Public Accommodations, and Title IV Telecommunications are important elements of advocacy that teachers should communicate to all students who might be impacted. Title I-Employment: “Employers may not discriminate against an individual with a disability in hiring or promotion if the person is otherwise qualified for the job. Employers can ask about one’s ability to perform a job, but cannot inquire if someone has a disability or subject a person to tests that tend to screen out people with disabilities. Employers will need to provide accommodations that impose ‘reasonable accommodation’ to individuals with disabilities. This includes steps such as job restructuring and modification of equipment. Employers do not need to provide accommodations that impose ‘undue hardship’ on business operations…” (Americans with Disabilities Act Requirements Fact Sheet, U.S. Dept. of Justice). Title III-Public Accommodations: “Private entities such as restaurants, hotels, and retail stores may not discriminate against individuals with disabilities…Auxiliary aids and services must be provided to individuals with vision or hearing impairments or other individuals with disabilities, unless an undue burden would result. Physical barriers in existing facilities must be removed, if removal is readily achievable. If not, alternative methods of providing the services must be offered, if they are readily achievable. All new construction and alterations of facilities must be accessible” (ADA Requirements Fact Sheet). Title IV-Telecommunications: “Companies offering telephone service to the general public must offer telephone relay services to individuals who use telecommunications devices for the deaf or similar devices…” (ADA Requirements Fact Sheet.)

Post Secondary Implications and Implementation of ADA

The ADA extends the anti-discrimination prohibition to all private and public colleges and universities, whether or not they receive federal funds. However, the provision of services to disabled students in postsecondary education places legal obligations on the disabled student (rather than parents), postsecondary institution, and sometimes the state vocational rehabilitation agency (Frank & Wade, 1993, p. 26). A qualified student with disabilities must meet all academic and nonacademic criteria for admission and continued participation in spite of the disability. This language serves to protect both the student and the institution.

Title 34, Code of Federal Regulations, Part 104, has the effect of implementing Section 504 of the Rehabilitation Act of 1973. (1) The institution may not make preadmission inquiries as to whether an applicant for admission is disabled. Confidential inquiries about disabilities may be made, after admission, in order to provide accommodation for the student. (2) The institution may not make use of any test or criterion for admission that has a disproportionate, adverse effect on applicants with disabilities. If the applicant has impaired sensory, manual, or speaking skills, the test will actually measure the applicant's aptitude or achievement level, rather than reflecting the person's impairment.

Steps of Identification

(a) The postsecondary institution has the obligation to inform students of the availability of academic adjustments and auxiliary aids; (b) the student must then identify and document the disabling condition, provide current (less than 3 years old) professional evidence documenting the disability, and request of the instructional staff appropriate academic adjustments and auxiliary aids on a timely basis; and (c) the postsecondary institution must then determine what, if any, academic adjustments and auxiliary aids are appropriate for the disabling condition considering the nature of the educational program (Frank & Wade, 1993). The academic requirements shall be adjusted as necessary to ensure that these requirements do not discriminate or have the effect of discriminating against the qualified applicant or student.

Academic Adjustments and Auxiliary Aids

Postsecondary institutions legally must provide academic adjustments and auxiliary aids, yet it is not discriminatory to not provide these when they are the same as essential course content. (Example: Should a reading-related academic adjustment or auxiliary aid be provided when the major course content is reading?) Decisions concerning the appropriateness of specific academic adjustments and auxiliary aids for students with certain disabilities, especially learning disabilities, depend upon detailed knowledge of the specifics of the disabling condition and of the essential skills and subskills that comprise the course content. The primary decision-makers are the disabled students and responsible institutional officials. Each decision must be on a case-by-case basis (Frank & Wade, 1993).

Academic Adjustment Examples

Students with visual impairments must be provided readers when taking exams; students with severe hearing impairments would be provided sign language interpreters in classrooms; and students in wheelchairs must have physically accessible programs. Less straight-forward examples may need to have a student affairs official determine the most creative accommodation which best suits the individual (Frank & Wade, 1993).
**Auxiliary Aids**

The auxiliary aids will ensure that students with impaired sensory, manual, or speaking skills are not subject to discrimination. "Camenisch v. University of Texas (1981) involved a deaf graduate student who sought to compel the university to provide him with a sign-language interpreter for his classes. The Fifth Circuit affirmed the lower court’s grant of a preliminary injunction in Camenisch’s favor, ordering the university to procure and compensate a qualified interpreter to assist Camenisch in his classes" (Tucker & Goldstein, 1991, 1992). Wynne v. Tufts University School of Medicine (1991) involved a dyslexic student who was dismissed from medical school after failing several courses of his first-year program. Wynne claimed that the medical school was obligated under Section 504 to alter the examinations to accommodate his cognitive difficulties. The district court ruled in Tufts’ favor stating that Wynne was not otherwise qualified for the medical school program since he was not able to meet the school’s requirements. This decision was reversed by the First Circuit Court stating that Tufts "offered no evidence explaining why multiple-choice examinations, as distinguished from all other written examinations, test a student's ability to assimilate, interpret and analyze complex written material. In particular, we find it hard to understand why essay examinations would not meet the same objective." Tufts had not shown that multiple-choice tests were so vital that it could insist on using such tests to the detriment of dyslexic students. The First Circuit Court agreed that the decisions of academic personnel deserve deference, but held that Section 504 required courts to scrutinize academic decisions to ensure that they did not mask even unintentional discrimination against people with disabilities (Tucker & Goldstein, 1991, 1992).

**Non-academic Programs and Services**

No qualified student with disabilities shall, on the basis of the disability, be subjected to discrimination under any academic, research, occupational training, housing (shall be comparable to the nondisabled, convenient, and accessible), health insurance, counseling, financial aid, physical education, athletics, recreation, transportation, other extracurricular, or other postsecondary education program or activity (Tucker & Goldstein, 1991, 1992). Employment opportunities shall be made available in a manner that does not discriminate against the student with disabilities.

**Accommodations at Postsecondary Institutions**

"The ultimate expression of the independent-living philosophy is the Americans with Disabilities Act. This sweeping piece of legislation…not only banned outright discrimination against people with disabilities but also made providing accommodations, like ramps and wheelchair desks in the workplace, the law" (Shapiro, 1994).

The law is complex and has many conditions that must be carefully examined. For example, it is not discriminatory for postsecondary institutions not to have all types of aids available at all times. Flexibility is permissible in choosing the methods by which academic adjustments and auxiliary aids will be supplied. The institutions do not have to provide attendants, individually prescribed devices, readers for personal use or study, or other devices or services of a personal nature. Personal needs are the responsibility of the student or state vocational rehabilitation agency if the student is sponsored by that agency.

**Payment of Accommodations**

The question of who must pay for the accommodations provided may cause dispute. If the vocational rehabilitation services are available to the student under Title I of the Rehabilitation Act, the state Department of Rehabilitation rather than the educational institution is required to pay. The institution is
required to provide and fund auxiliary aids when funds are not available from the state Department of Rehabilitation. It has been ruled that the institution may not deny the provision of auxiliary aids to students with disabilities based on their ability to pay or their enrollment in specific programs. The university is required to be the primary provider of these aids for students, faculty, or staff with disabilities and cannot require students or employees to request technical assistance from vocational rehabilitation centers (the university must take this action) (Tucker & Goldstein, 1991, 1992).

**Implications and Implementation of IDEA 1997**

The IDEA of 1997 reaffirmed the educational rights of individuals with disabilities in educational settings. The Amendments state:

Disability is a natural part of the human experience and in no way diminishes the rights of individuals to participate in or contribute to society. Improving educational rights for children with disabilities is an essential element of our national policy of ensuring equality of opportunity, full participation, and independent living, and economic self-sufficiency for individuals with disabilities. (20 U.S.C. & 1400 ©(1)).

The education of children with disabilities can be more effective by:

(A) Having high expectations for such children and ensuring their access in the general curriculum to the maximum extent possible.

(B) Strengthening the roles of parents and ensuring that families of such children have meaningful opportunities to participate in the education of their children at school and at home.

(C) Coordinating this Act with other local, educational service agency, state, and federal school improvement efforts in order to ensure that such children benefit from such efforts and that special education can become a service for such children rather than a place where they are sent.

(D) Providing appropriate special education and related services and aids in the regular classroom to such children, wherever appropriate.

A priority in the IDEA 1997 legislation lies in the improvement both in the performance and achievement of this population of children with disabilities now to be served primarily in the regular curriculum in regular classrooms of the public schools (Yell & Shriner, 1997a, 1997b). At all levels, federal and state, the IEP components are consistently listed and described. The IEP is a written statement for each child with a disability that is developed, reviewed, and revised by the IEP Team no less than annually to include: (a) present level of educational performance, (b) annual measurable goals and objectives, (c) special education and related services, (d) description of the least restrictive environment and the plan for participation in the regular curriculum with non-disabled peers, (e) dates, frequency, location, and duration of services, (f) assessment methods, (g) transition plan for those over 14 years of age, and (h) process monitors and parent reporting procedures.

The IDEA of 1997 requires that the IEP Team include the following:

4. The parents of the child with a disability
5. At least one regular education teacher (if the child is, or may be, participating in regular education)
6. At least one special education teacher or, if appropriate, at least one special education provider of the child
7. A representative of the local education agency (LEA) who meets certain specified requirements such as ability to represent the agency and local school authority to justify the team recommendations and maintain compliance to the law

8. An individual who can interpret the instructional implications of evaluation results

9. At the discretion of the parents or agency, other individuals who have knowledge or special expertise regarding the child, including related services personnel

10. If appropriate, the child

Most state and local agencies define the role of the special educator on the IEP Team as the person responsible for implementing the IEP. This participant may be the teacher qualified to deliver special education in the student’s area of suspected disability or another special education provider of service. The regular educator is also required to assume an active role. The regular education teacher of the student with disabilities is a member of the IEP Team, and shall, to the extent appropriate, participate in the development of the IEP of the child, including determination of appropriate positive behavioral intervention strategies, and the determination of supplemental aids and services, program modifications, and support for school personnel.

The IEP Team is obligated to assess whether or not the child’s behavior impedes learning and to propose intervention strategies. They must propose and implement behavioral accommodations and consider special factors for behavior. The IEP Team shall in the case of the child whose behavior impedes his or her learning, or that of others, consider, when appropriate, strategies, and supports to address the behavior, including positive behavior interventions and strategies.

If the child’s behavior is a major concern and need, the IEP Team must consider legal and appropriate options to address this need, which must then be documented by a statement in the child’s IEP. Behavior considerations are causing school systems to follow the law closely to ensure the rights of all students (Yell & Shriner, 1997a, 1997b).

Once the IEP Team has been assembled and the IEP has been developed, IDEA 1997 directs that “children with disabilities are educated with children who are not disabled, and that special education, separate schooling or other removal of children with disabilities from the regular education environment occurs only when the nature or severity of the disability is such that education in regular classes with the use of supplementary aids and services cannot be achieved satisfactorily.”

These supplementary aids and services may include other supports to be provided in regular education classes or other regular education-related settings. The purpose of these would be to enable children with disabilities to be educated with nondisabled children to the maximum extent appropriate. Least restrictive environment considerations require that five pertinent questions regarding the student’s participation in the regular curriculum be addressed. These reflect the criteria required in IDEA 1997 and include the following:

- What accommodations, modifications, and adaptations does the individual require?
- Why can’t these accommodations, modifications, and adaptations be provided in the general classroom?
- Is there a potential detriment to the individual if served in the general classroom?
- How will the individual’s participation in the general classroom impact other students?
- What specific/systemic supports are needed to assist the teacher and other personnel to provide these accommodations, modifications, and adaptations?

This last question provides opportunity for the regular education teacher to receive relevant and necessary information and support to assist students with special needs in their classroom. Research has
identified “lack of time to collaborate” as one of the major barriers to successful collaboration in schools. Lack of communication, limited or nonexistent planning time opportunities, and lack of administrative support were identified as primary barriers to collaboration success (McCorry & McLeskey, 1997; Reeve & Hallahan, 1994; Vaughn, et al., 1996).

“Service rather than a place” implies dynamic planning, review, revision, and evaluation of education efforts for students with special needs. This is the thrust of the new law, encompassing the drive and impetus of the laws which preceded it in the history of special education since mid-century, as noted earlier in this review of the literature. The law reaffirmed the assumption that the students belong in the regular classroom, as espoused by Will (1986) and others throughout the late 20th century history of special education legislation.

Least Restrictive Environment (LRE) stated that to the maximum extent appropriate, children with disabilities, including children in public or private institutions or other care facilities, are educated with children who are not disabled, and that special classes, separate schooling, or other removal of children with disabilities from the regular educational environment occurs only when the nature or severity of the child is such that education in regular classes with the use of supplementary aids and services cannot be achieved satisfactorily (20 U.S.C. & 1412(A)(5)a)).

The words to the maximum extent appropriate have been the target of attack by several national professional organizations representing parents and teachers since IDEA 1990 in their opposition to blanket inclusion for all students (American Federation of Teachers, 1996, 1997; Council for Exceptional Children, 1993, 1997; Crockett & Kauffman, 1998; Learning Disabilities Association, 1993; National Education Association, 1994; Shankar, 1994). A continuum of alternative placements for students with special needs is strongly urged by these organizations and individuals. For LRE, the law required:

(E) high quality, intensive professional development for all personnel to ensure skills and knowledge necessary to enable them –

(i) to meet developmental goals and, to the maximum extent possible, those challenging expectations that have been established for all children; and

(ii) to be prepared to lead productive independent adult lives, to the maximum extent possible.

This component of the law reflected concerns from many researchers and educators as an area which has not been adequately addressed and implemented by national, state, and local education efforts to date.

**Issues and Concerns**

Education is the difference between a life of dependence and unemployment or a life of independence and productivity for persons with disabilities. An appropriate education for students with disabilities depends upon schools with proper and adequately trained staff (administrators, regular classroom, special education teachers, and support staff), plus parental involvement in the educational process. Research supports that strong parental involvement in their children’s educational career results in better student performance (Tucker & Goldstein, 1991, 1992). These two factors, school and parent, are paramount in making a positive difference in the life successes of children. Most parents fail to understand their legal rights and the safeguards available, and few systems take the time to help ensure that the parents understand. Less than 1% of parents whose children have disabilities have requested administrative hearings to challenge the placement of their children in the school systems (Tucker & Goldstein, 1991, 1992). It may be the parents’ “blind trust” of those in authority that precludes their actions.
The public schools' educational process for students with disabilities has shown that the system continues to exclude many children with disabilities, with greater likelihood of exclusion in schools with large numbers of students with special needs. Public school exclusions were facilitated by a number of means: placing the students on long waiting lists; removing students from classrooms due to behavioral problems; poor identification methods; choosing to educate one student group with disabilities over another; providing no educational program for children in institutions; or denying education to some children with disabilities (Tucker & Goldstein, 1991).

Problems affecting students with disabilities in public classrooms include the different treatment of these students; stereotypical categorizing; deficient evaluation, classification, and placement procedures; high student dropout rates; inequity of service; and poor preparation for competency in the work place and job placement following school completion (Tucker & Goldstein, 1991, 1992).

Evaluation procedures, disability classification, and resulting placement decisions are often not related to the student's learning characteristics. Labels assigned to students tend to stick throughout their school career and often play a role in preventing students from being returned to mainstream classrooms. Additionally, disproportionate percentages of minority students are classified as disabled and this disproportion is greatest among black students. The National Council on Disability noted that 16% of the members in the student body are black students, yet over 29% are classified as mental or educable mentally retarded or seriously emotionally disturbed. Thirty percent of all public school students are minority, yet 39% are within these disability classifications.

Compounding the issues relating to disabilities and ethnicity are the teachers. When comparing the science classrooms of black and white eighth graders, black students are much less likely to have a teacher certified in science, four times less likely to have rooms with running water or a laboratory, three times more likely to have a science teacher who will not provide students with a hands-on activity twice a month, and twice as likely to have a teacher who does not emphasize development of data analysis skills (Singham, 2003).

In a survey of teachers and science educators concerning the teaching of science to students with disabilities, Stefanich and Norman (1996) presented the following summary.

Educators at all levels – elementary, middle, high school, and university – said some of their concerns focused on logistical arrangements, instruction, support, sensitivity, and communication. Educators also expressed concern about time issues, i.e. planning time and instructional time, devoted to students who have disabilities.

Concerns often mentioned by elementary, middle school, and high school science teachers included the following:

11. Inadequate preparation and training to teach science to students with disabilities.
12. Limited knowledge about methods and adaptations for students with disabilities.
13. Lack of time for planning and individualized instruction for students with disabilities.
14. Large class sizes and inadequate space and materials.
15. Lack of ability to handle classroom management and discipline, especially with students with emotional disabilities and behavior problems.
16. Concerns about safety and liability issues.

17. Lack of support from administrators and other teachers, especially special education teachers.

18. Little information/knowledge about expectations, assessment, and grading for students with disabilities.

Other concerns mentioned by these teachers included how to communicate with students who have disabilities, bias against these students, modifications needed for field trips, and extra compensation for teachers.

The survey of regular and special education teachers brought specific comments from teachers that were eye-openers and cries for assistance. Although elementary teachers deal with greater numbers of mainstreamed children than middle school or high school teachers, some of their comments are worthy of extra attention: "Teachers are not trained to work with students with disabilities. I have no training. Train us!!" From another elementary teacher: "Special children take valuable teacher time away from the other 20-30 children in the room. Their education should not be so casually compromised. Lower class size will be needed—a costly item!"

Other comments from elementary teachers included, "Some teachers don’t believe that students with disabilities can learn science. In my experience, most of the time they do just as well as the other students." Unsettling comments from another elementary teacher: "I’ve taught for 27 years and have been the staff development person in my building. The biggest problem is that few students, special education or otherwise, are being taught science at all. That is the main problem. Second, teachers are unable or unwilling to give up their prejudices regarding special education students. They perceive them as more work and the teachers don’t want to be bothered."

Comments on the survey from middle school science teachers were equally revealing: "More effort needs to be put in training of teachers to prepare them for teaching students with disabilities." Another middle school teacher stated, "More funding needs to be available for staff development, science materials, and additional staff to meet the needs of students with disabilities." And another: "There’s an inadequate amount of time to collaborate with on-staff colleagues to get assistance in obtaining methods to provide a quality education for all students." "Sometimes the special education teacher should be in the science classroom to deal with the non-science problems. Just as the science teacher would not expect the special education teacher to be a science specialist, the science teacher shouldn’t be expected to be a specialist for students with disabilities." Other comments focused on the children without disabilities: "Cognition disabilities, seen more frequently due to ‘inclusion,’ detract from the ‘normal’ child’s education in that, in the words of a colleague, ‘We spend 95% of our time/energy dealing with 3% of our student population.’ I’m waiting for a parent revolt to treat the normal child equally."

Many high school teachers were concerned with time, support, and funds: "Time and support-Help! Will this be in addition to everything else? Where will the money come from? We don’t have what we need for regular students." One of the high school teachers voiced concerns about safety: "Students who lack motor skills cannot manipulate lab equipment properly and pose a hazard for themselves in the case of spills." There were also controversial comments, such as, "There is too much ‘worry’ about so-called special students; the mainstream kid doesn’t even exist anymore." On a more positive note, one teacher stated, "A lot of energy is often invested in students with disabilities and I don’t find them any different from my other students."

Collaboration with special educators was suggested: "Dealing with severe disabilities is difficult for a subject area teacher – especially when there are 20-30 other students in the classroom. Team teaching
with a special education teacher may be the only solution. IEPs are also a problem for regular classroom teachers. They don’t have time due to large numbers of students per day."

Another high school teacher discussed empowering students versus preparing them for failure: "Teachers, within reason, should be expected to work harder to help students with special needs. However, these students and their parents must be made aware that with this extra effort on the part of schools, standards will not be compromised (you don’t build high self-esteem by lowering standards!) and we expect both the student and parents to also put in much more time and effort. We want to empower students, not prepare them to fail in the real world. If teachers perceive that students with disabilities are working very hard to overcome their challenges, they will be more receptive to putting in more time for the student."

The inclusion initiatives resulting from ADA (1990) and IDEA (1990, 1997, 2004) also have implications for post secondary education in both content delivery and teacher education. Postsecondary education has three major roles relating to science teaching: 1) adequate preparation of preservice teachers, 2) professional development of practicing educators, and 3) responsibility for accommodating the students with disabilities pursuing a post secondary education.

In a national survey (Stefanich & Norman, 1996), university science educators voiced their concerns. One educator stated, "Every student is different and it is unrealistic to expect precious time devoted to a broad preparation for all ‘special’ circumstances. Time is limited and there is so much to do as it is now. What do we omit? I’m not willing to discuss add without subtract." Another science educator focused on funding: "Funds are needed to provide college faculty inservice training and time to work in special education and inclusive classrooms." One instructor focused on the make-up of college classrooms: "Convince university content and methods faculty to consider the needs of students with disabilities in their teaching."

University science educators had many of the same concerns as K-12 teachers, plus some additional ones:

19. Lack of training related to teaching students with disabilities in undergraduate programs for preservice teachers.

20. Overcrowded methods courses and science teacher education programs leave little time for additional topics and coursework.

21. Lack of space, material, equipment, and funds to use in teaching students with disabilities.

22. Limited research regarding science instruction for students with disabilities.

23. Need for university faculty inservice training and time to work in special education and inclusive classrooms.


25. Need for modeling of science lessons for teaching students with disabilities.

26. Lack of role models in science educators who have disabilities.
Summary

The educational goal for every student is that the student masters the essential educational material or physical skills in question. Educators must examine learning and the evaluation of learning via the framework of input, mastery, and output. This will facilitate determinations of what is variable and subject to individualization, academic adjustments, and auxiliary aids, and what is invariable and essential. All students should be accountable for content mastery and the requirement to demonstrate mastery, although the format and structure may need to be modified to accommodate the uniqueness of the individual.

The following are frequently cited as obstacles to learning that students with disabilities face along with those who guide and direct their learning and development:

27. Negative attitudes of parents and other gatekeepers (teachers, counselors, rehabilitation staff, special education teachers, health personnel, and academic faculty) about the ability of a student with a disability to do science, mathematics, engineering, or science education.

28. The virtual invisibility of role models in science, science education, and engineering for children with disabilities.

29. More limited participation in educational and/or professional activities than non-disabled peers due to the extra challenges a disability may require.

30. Time and energy expended by the student with a disability to develop skills to counteract the system’s negative attitudes and to accommodate to inaccessible environments.

31. Internalized negative stereotypes that the student will not fare well in any sort of competition with non-disabled counterparts.

32. Additional and ongoing costs associated with a disability.

33. Lack of information about the availability of the technology which would help people with disabilities.

It remains unclear who assumes responsibility following the implementation of IDEA and No Child Left Behind. Frustrations continue to mount as educators attempt to respond to the legislative mandates. Special educators perceive their role as providing support through assistance with basic skills, testing accommodations, personal growth, and compliance documentation. Few science teachers have the knowledge base and commitment to develop an in-depth understanding of diversity and accommodation strategies for students with disabilities. Both special educators and science teachers are ill-prepared to offer the services necessary for students with disabilities to receive a high quality science curriculum that includes the necessary accommodations appropriate for their needs. A mounting frustration is evident in educational circles with limited optimism that professional development opportunities and/or services will become available to enable all students to receive educational services in science appropriate to their needs.
Chapter 2  
Nature of the Learner: Constructivism and Implications for Teachers

Some say there has never been an effective teacher -- only individuals who are great facilitators of learning who are acclaimed as effective teachers. This idea of facilitating learning, according to research, is essential for learning to take place. Engaging the learner in the teaching-learning process is a necessary precondition for learning. This action, then, is essential for effective science teaching and learning.

Unfortunately, there is no consensus on the best way to prepare teachers to become facilitators of learning, partly because there is no consensus on how and why we learn. However, three major schools of thought do provide the premises for most educational preparation programs: behavioral theories, developmental theories, and perceptual theories.

Behavioral psychologists believe that learning consists of making connections between events (stimuli) and behaviors (responses). In the early stages, the learner is able to make basic emotional responses through signal learning (like smiling when the voice of a parent is heard). These develop into more controlled responses and connecting stimuli using motor and verbal chains. Further stimulation enables the learner to identify similarities and differences and use discrimination to form concepts. Finally, concepts are blended into schema involving complex interactions used in problem solving and abstract thinking.

Behaviorists believe that it is important for educators to develop clear outcomes and that instruction should be directed toward these outcomes. Correct answers should be reinforced to increase the likelihood of retention. At later stages of development, it is important to expose students to new and different patterns to help them gain new insights and greater skill in problem solving. This approach emphasizes the effects of external events on the individual (Woolfolk, 1993, pp. 156-209).

Developmental psychologists feel that the thinking of children is distinctly different from the thinking of adults. Furthermore, they believe that as individuals progress through life, thinking patterns change drastically over a short period of time and then remain stable for relatively long periods. Although the path to intellectual maturity is the same for everyone, the rate at which one progresses depends upon several factors. They perceive learning as an external process that should be observed directly (Woolfolk, 1993, p.196). Developmentalists feel it is important that teachers provide experiences for students that match the students' cognitive maturity. It’s especially important to include hands-on, tactile activities throughout the elementary grades. Piaget, although a genetic epistemologist, belongs to the developmentalist school of thought, since he approached the problem of knowledge and learning from a developmental perspective. His ideas are discussed later in this chapter.

Perceptual psychologists, reflecting a third school of thought, deal with the ways individuals perceive themselves. The most important role of educators, they say, is helping students develop positive self-images by providing encouragement and structuring learning experiences in which the child can achieve success.

Perceptual psychologists believe that the best road to the production of persistent adults is to provide students with high levels of successful experiences. They believe that emotions are closely tied to learning and that good teachers are concerned with both how a student feels about the learning setting as well as what is learned. These elements appear to coincide with biomedical research using brain probe stimulation. Our current understandings of perceptual psychology come largely from the work of behavioral theorists that originated in Germany with extensive applied research in the United States.
(Woolfolk, 1993, p. 244-245). This research indicated that when memory is triggered, not only is the information learned retrieved, but also the emotional context in which the learning took place.

Recently, however, another school of thought has become very influential within the educational community. According to this school of thought, learning is the result of an interaction between people’s mental processes and their cultural, historical, and institutional setting (Rogoff, 1990; Wertsch, 1991; Wertsch & Kanner, 1993). A fundamental difference between this school of thought—the social learning school, which is based upon Vygotsky’s (1981, 1986) work—and the developmentalist school is the relationship between learning and development. According to the latter, an individual should be developmentally ready (mature) to learn. According to social learning theory, individuals can learn, even if they are not developmentally mature enough, provided that they are challenged and given appropriate help by a more proficient adult. In other words, according to developmentalists, development precedes learning, while according to social learning theorists, learning can take place in advance of development (Berk & Winsler, 1995).

These theoretical models present different orientations to learning and to how knowledge and emotion function in individuals’ minds. Over the past two decades the behaviorist model has been severely criticized on the grounds that positivist epistemology (on which behaviorism is based) was found to be inadequate to explain the problem of human knowledge in general (Chalmers, 1982, 1990) and school learning in particular (Clemenson, 1990). Using a teacher as a disseminator of tacit knowledge, concepts, and relationships is not considered to be an adequate way to convey how individuals learn. These criticisms, as well as the evidence from empirical research resulted in the development of another learning model. According to this model—the constructivist model—learning is constructed within the individual, as a result of direct experiences with objects and events, in metaphors and relationships that are unique to the individual. Resnick (1983) described the fundamental position on which this model is based: Learners construct their understanding; that is, they do not mirror what they are told or what they read. They are always trying to link new information to what they already know. The most important thing about constructivism is that it was a movement against didacticism. It challenged teachers who were, as Osborne (1996) put it, "wedded to a didactic model of transmission" (p. 76).

Learners construct their own understanding in order to make sense of the world, both prior to and after formal instruction. This means that this kind of understanding can be very different from that of the scientific community, and therefore students should be provided with opportunities for changing their ideas. This is the reason why social learning theory has been incorporated into the constructivist model (Driver, Asoko, Leach, Mortimer & Scott, 1994; Hodson & Hodson, 1998). This chapter discusses the constructivist model and salient aspects of Piaget’s work on social learning theory.

### Piaget’s Epistemology and the Development of Mental Structures

The work of Piaget has provided a sound epistemology of the reasoning patterns reflected in human cognition. In rejecting traditional empiricism and the copy theory of knowledge, as well as traditional idealism and rationalism, Piaget proposed that knowledge is constructed through an active interplay of experiences and the developing mental (or cognitive) structures. His ideas are elaborated in his books *Genetic Epistemology* (1970), *Biology and Knowledge* (1971), and *Epistemology and Psychology* (1972).

Starting from the premise that "all reality—biological, physical, psychological, sociological, intellectual—is evolving in the direction of progress" (Kitchener, 1986, p. 6), Piaget explained reason and understanding in evolutionary terms. This evolutionary explanation also led Piaget to adopt the biological terms "assimilation" and "accommodation," that is, two simultaneous processes occurring while the
"organism," and hence the epistemic subject, interacts with the environment in order to satisfy its "epistemic needs." "Equilibration" is a state of equilibrium resulting from the satisfaction of those needs. It is obvious, according to this biological model, that the essence of cognition lies in its adaptive function.

The Piagetian terms “assimilation” and “accommodation” can be used to describe the cognitive processes the learner employed in the classroom environment. Piaget's mental functioning model deals with the adaptation of the learner to this environment (Ginsburg & Opper, 1998). According to this model, learners all develop mental data-processing procedures, which Piaget calls mental structures. Differences in mental structures distinguish one intellectual level from another and allow increased processing of more complex data with an individual's development. A small mental structure, called the schema, is the basic generic unit of the cognitive structure. Assimilation is the process of incorporating data into existing structures and may be done only by the learner (Renner & Marek, 1988). When learners are aware that there is a mismatch between their mental structures and what they have assimilated, they become concerned and enter a state that Piaget described as “disequilibrium.” This state of mismatch may result in new schemata being built or in modification of structures. The entire process that leads to adjustment or change of mental structures as a consequence of assimilation and disequilibrium is called “accommodation.” Assimilation, accommodation, adaptation, and organization are referred to as the functional invariants of intelligence (Piaget, 1963). The process is the same regardless of the age of the learner. The relationships between assimilation, accommodation, adaptation, and organization are called intellectual functions and are inferred to represent the learning process (Renner & Marek, 1988). These mental structures are the systems that transform information received from the environment and give it meaning.

The initial response is at the sensorimotor level. With development, the learner's unintentional actions are replaced by intentional actions. Later, understanding is sought, events are anticipated, and objects are replaced by internalized intellectual processes (Piaget, 1966). Information is primarily acquired through a system of MESS (Mental Experience Storage System) acquisition. Little processing of information occurs; rather the individual is forming a schema, which can be thought of as drawing air into a balloon.

At the next level, preoperational thought, the process of learning continues to emerge, again primarily through the MESS process. Although learners use some internal symbolic manipulations of reality, most learning takes place through the ongoing assimilation of information. Thinking is tied to perception and has a tendency to center on the most outstanding feature of an object. Thought is largely irreversible with little conscious reflective thought (Piaget, 1968).

The third stage, concrete operations, is marked by the commencement of a coherent and integrated system by which external reality is organized and manipulated. The thought process becomes reversible, and the invariance of objects is recognized (Piaget, 1966). The individual begins to employ a MOP (Memory Organization Point) system of learning. Thinking now becomes a continual interaction of MESSs and MOPs in the development of logical thought and reasoning. At the concrete operations stage, cognitive structures are bound to concrete experiences within a schema structure. Use of a concrete operation in one instance does not ensure use of the operation in a different circumstance (Piaget, 1966, pp. 139-147).

The isolation of schemata has significant implications for instruction. In describing the origins of mental structure, Inhelder and Piaget (1969) reported that the order of succession of the stages of intellectual development is invariant. The cognitive structures at one stage become incorporated into the cognitive structures of later stages. This development of reasoning is further explained by Maier (1969), who summarized the transition from sensorimotor to formal operational thought in the following manner: "Intellectual behavior evolves descriptively from activity without thought, to thought with less emphasis
on activity. In other words, cognitive behavior evolves from doing to doing knowingly, and finally to conceptualization" (p. 156).

The ability to draw from a number of schemata in employing logical reasoning patterns begins to emerge with the advent of concrete operations, generally considered common in the reasoning of individuals after age 7. The depth and complexity of reasoning continue to mature as long as a person continues to actively seek new knowledge and new insights. There is a constant interplay, not well understood by the community of scholars of human learning, between content, conceptual-process, and social-interactive knowledge.

Learners at the concrete operations level often experience great difficulty applying reasoning processes when instruction is delivered through written or verbal modes of expression. Such expository modes of instructional delivery by their nature are consistently ineffective.

Students tend to deal with concepts in isolation. They cannot effectively consider a number of isolated examples and apply these to a general theory or principle. They are unable to cognitively process variable time frames or situations that require simultaneous consideration of multiple characters or events.

Finally, at the stage of formal operations, integrated thought processes exist within the learner's cognitive framework. Learners can integrate a number of schemata in order to form statements or propositions about reality. They can apply combinatorial logic and hypothetical deductive reasoning. The learner is able to deal with abstractions and follow literature and social studies concepts that require cognitive processing of variable time frames. The learner returns to a state of equilibrium when structures have been adjusted to accommodate new inputs from the environment.

It should be noted that the Piagetian idea of autonomous construction of mental structures or schemata is based on both heredity and environment. Something must be innate that allows for autonomous development, and external experiences must also play a major role in the interaction between the student and the environment. Piaget (1970) reported that cognitive structures exist even in deaf and blind children, although, due to lack of sensory input, they often develop much later.

The Piagetian Notion of Equilibration

Given the centrality of the notion of equilibration in both the Piagetian epistemology and the theory of intellectual development, it is important to discuss it in more detail. Equilibration, as has already been mentioned, is the process by which mental structures are revised. New learning, being possible because new structures have been formed, depends on accommodation, which is the result of disequilibrium caused by assimilation (Renner & Marek, 1988). Piaget (1977) stated that the driving force of intellectual development is the disequilibrium that the subject experienced. Glassersfeld (1989) believed that the learning theory that emerged from Piaget's work can be summarized "by saying that cognitive change and learning take place when a schema, instead of producing the expected result, leads to perturbation, and perturbation, in turn, leads to accommodation that establishes a new equilibrium" (p. 128).

In describing pedagogical implications relating to equilibration, Piaget (1977) noted three classical factors: the influences of the physical environment (the external experience of objects); innateness (the hereditary program); and social transmission (the effects of social influences) (p. 3). He said that equilibration is a complex interactive process involving an assimilation, in the biological sense of the term, and integration of the external data into the structures of the subject, accommodating to the schemata of the situation. Therefore, even rote assimilation is an integration, whereby subjects are assimilating the object into their schemata and, at the same time, accommodating their schemata to the special characteristics of the object.
In all learning the condition of the subject is sensitive to a stimulus only when the learner possesses a schema that permits the capacity for a response. Knowledge is always the product of interaction (equilibration) between assimilation and accommodation. In the construction of any operational structure, a learner goes through much trial and error that involves in large part self-regulation.

Piaget (1977) described three types of equilibration: In basic reasoning such as conservation, representation involves equilibration between the structures of the learner and the objects. At the pre-operational level after many trials, the learner makes the same errors as at the beginning. However, at the operational level the repetition of the judgment results in a very clear diminishing of the illusion. At a more advanced level, there is equilibration among the subsystems of the learner's schemata. For example, there may be a conflict between logico-mathematical operations (applying mathematics concepts to variables) and spatial operations (describing metaphysical motions such as mechanics in Newtonian physics). These operations often evolve at different speeds. However, to reason well requires coordinating the two, that is, an equilibration of the systems. The third level Piaget (1977) described as fundamental. This is an equilibration between the parts of subjects’ knowledge and the totality of their knowledge. There is a constant differentiation and integration that involves self-regulatory mechanisms.

Equilibration is not passive; it is constantly interactive, and all parts are interdependent. In the viable mind, it is a search for better and better coherence in the sense of an extended field. In a pluralistic society, the complexity and nature of the interactions often become more difficult because the subsystems are not closed, and many aspects are not entirely decidable. In cognitive social systems, the links are the very sources of action, and they are different from reasoning in the metaphysical world in a field such as physics.

**Implications of Equilibration for Teaching**

The different aspects of equilibration must be considered in teaching. On one hand, the teacher serves as a guide to help students develop a sense of confidence in the use of metaphysical knowledge to describe interactions and investigate hypotheses in the physical world. At the same time, students are searching for better coherence of the totality of reasoning by integrating and differentiating social-cognitive schemata that have no equivalence in the physical sciences. Piaget (1973/1985) implied that an equilibrated mental structure and an equilibrated physical structure have abstract properties in common, and the mental program is arranged to value and conserve equilibrated structures in the same way the physical world accommodates certain reasoning operations.

Piaget (1985) described equilibrium as self-regulation, or as an ongoing process that leads to better equilibrium rather than returning to more stable forms of a former equilibrium. Every structure has an influence on structures that follow it and is based on the structures preceding it. The instructional goal of each new assimilation and accommodation is to enlarge reasoning into a more consistent totality, as opposed to a cumulative piling up of information pieces when teaching exists outside of the framework of the learner.

Teachers promote learning by providing students with opportunities for assimilation that will cause disequilibrium (Renner & Marek, 1988). Lawson (1982) presented a detailed discussion of the concept of psychological equilibrium as it relates to usefulness in biology instruction. He described equilibration as "the internal mental process by which individuals develop intellectually." The equilibration process can be used as the route to internalization of external knowledge presented by the teacher. First, the student is prompted to discover that previous ways of thinking are inadequate to assimilate the new information. Then time must be given for mental reorganization (accommodation) of the information, which allows
assimilation of the new material. The teacher's role is to ask questions, provide materials, participate in the exercise, and act as class chairperson and secretary.

In Lawson's view, the teacher gathers class data and solicits its meaning. Most important, the teacher is not a provider of information, but a director of its meaning. Lawson (1982) commented, "How often have you heard teachers complain that their students fail to apply what they have supposedly learned? Perhaps if these teachers took a look at equilibration theory seriously they would have less to complain about" (p. 404).

The learner's adaptation to inputs from the environment is represented by assimilation and accommodation, which causes a change in the learner's mental structures that leads to equilibrium (Renner & Marek, 1988). Piaget used the term “organization” to describe the relationships that exist between a new mental structure and previous mental structures. He called organization the accord of thought with itself. Renner (1979) has provided the following insight:

Knowing an object, event, or situation, then, means that mental structures have been constructed that will enable data from the environment to be transformed by the learner. Learning, therefore, is an active process which is aimed at the construction by the learner of systems of transformations called mental structures. (p. 279)

From a postmodernist perspective on curriculum development, Doll (1993) has acknowledged the centrality of self-organization. Given that order and organization emerge from disorder and chaos, then opportunities for learners to experience perturbations that will in turn lead them to reorganize their ideas should be given a central role in curriculum development. This notion of self-organization is in line with a holistic/ecological worldview as opposed to a mechanistic view. In curricular terms, according to the mechanistic worldview, order and organization are imposed from without, while according to the holistic/ecological view they are emerging from within. The implications, therefore, specifically for instructional practices are that learners are given opportunities to experience disequilibrium and then time to reflect and reorganize in order to restore equilibrium. These opportunities might include concrete (hands-on) activities, computer simulation, and questions that make students aware of explicit verbal discrepancies (Hadzigeorgiou, 1999).

However, equilibration, though critical, is not the sole determinant of the learning process. It is very important that teachers also pay attention to the ways students interpret their experiences and the meanings they create from them. Apparently, these meanings and interpretations are based on students' prior beliefs and expectations. It is the latter that determine to a great extent, if not solely, the outcome of the learning process. Therefore, it is important to review Kelly's theory of personal constructs.

Kelly's Theory of Personal Constructs

An epistemology of the interpretive tradition is at the heart of Kelly's (1955) theory of personal constructs, which stresses the fact that "whatever the world may be, man can come to grips with it only by placing his own interpretation upon what he sees" (Kelly, 1970, p. 2). Kelly’s work (1970) offered a constructivist perspective, since it views individuals as "scientists" who build for themselves internal models in an effort to understand and make predictions about events of the external world. These models are subject to modification, since construction of reality is constantly tested so that better predictions can be made in the future. For Kelly, human behavior is anticipatory rather than reactive. Kelly’s theory is based upon the philosophical position of constructive alternativism, the notion that there are many workable alternative ways for individuals to construct their world. The theory itself starts with the basic assumption, or postulate, that a person's processes are psychologically channelized by ways in which the person anticipates events (Kelly, 1955, p. 560).
Classroom practices based upon Kelly's theory of personal constructs should include discussion of interpretations and meanings and also respect for a variety of views—even differing views. Classroom experiences, therefore, should be organized so that students have the opportunity to articulate their personal constructions and negotiate the personal meanings of such constructions. Science education, from such a perspective, "would be an experimental affair for the student where existing constructs are tested for their ability to predict and control external events" (Fetherston, 1997, p. 804).

Central to the theory of personal constructs is the notion that "the thoughtful man is neither the prisoner of his environment nor the victim of his biography" (Kelly, 1955, p. 560), but instead "an inveterate inquirer, self-invented and shaped, sometimes wonderfully and sometimes disastrously, by the direction of his enquiries" (Bannister & Fransella, 1986, p. vii). According to Holland (1970):

The very idea of construct, as distinct from a concept, is that it introduces criteria of relevance and responsibility. Action can only be subjected to moral judgment in the context of what a man might have done, as a field of choice around what he did, and perceptions, being selective, negate certain possibilities. We are then responsible for our construing since this is the formative structure of our choosing. (p. 125)

It becomes quite apparent that Kelly's theory of personal constructs shares with existentialism a number of features: They are both theories of action; they both treat the individual as a person as opposed to an object or even a biological organism; and they both include responsibility. Kelly himself equated the philosophical position of constructive alternativism with an "epistemological responsibility" (Kelly, 1970, p. 2). In fact, the notion of responsibility is an important one, for as Kelly further remarked, "even the most valuable construction we have yet contrived—even our particular notion of God Himself—is one for which we shall have to continue to take personal responsibility, at least until someone turns up with a better one" (Kelly, 1970, p. 4).

Although Kelly's ideas have immense implications for a wide variety of fields, their consequences for conceptual, or rather "constructive," understanding are significant and far-reaching, too. For accepting the notions of free choice and "epistemological responsibility," the idea that neither the reinforcement nor the motivational methods have worked so far becomes justified. Meaning is constructed by the cognitive apparatus of the learner. It is not communicated by the teacher to the learner. It is created in the mind of the student. We have to recognize that wisdom can't be told (Saunders, 1992). It may even happen without teachers, textbooks, and schools. It is, therefore, important that the classroom becomes a place where students feel free to offer their personal constructions, to be applied and used in new situations to support or alter their or others' previous structures. Teachers, other adults, and peers can enhance learning by facilitating learners in challenging and formulating their own cognitive structures (Yager, 1992). Kelly's theory of personal constructs provides opportunities to both students and teachers for bridging the distinction between personal meaning and the formal knowledge of school science (Fetherston, 1997).

**The Constructivist Model of Learning**

Central to both Piaget's epistemology and Kelly's theory of personal constructs is the idea of the active role of the individual. The constructivist model of learning acknowledges this active role of the learner and the fundamental idea that knowledge cannot be transmitted from a textbook or from the mind of the teacher to the mind of the learner (Driver & Oldham, 1986; Wheatley, 1991).

Roth's (1989) research at the Center for the Learning and Teaching of Elementary Subjects at Michigan State University traced the development of elementary science instruction over the past decades.
and evaluates its philosophies and accomplishments. Roth’s work laid an impressive groundwork for further analysis of the constructivist model.

Roth (1989) perceived the reform movement as divided into three main camps—those advocating use of and the fine-tuning of inquiry teaching methods; those focusing on changing the goals of science teaching; and a third group focusing on changing the methods of instruction in the development of conceptual understanding. Research into this theory of learning suggests one important curricular issue: The science curriculum should focus on developing deep understandings of a few concepts rather than superficial coverage of many concepts (Roth, p. 61). Think of this as "putting down postholes," developing fewer in-depth topics at each grade level rather than covering a large number of topics with little depth and needless repetition as students progress through the grades. The constructivist teacher believes the primary goal of science education is to help students develop a meaningful, conceptual understanding of science and its value through descriptions, explanations, and predictions that come from the learner. Scientific processes and concepts become meaningful only when they are integrated with the learner's own personal knowledge and experiences. The central goal of the teacher is to help students develop their own explanation for the world around them in ways that incorporate concepts and thinking into their frameworks. These frameworks emerge as students explain their own experiences and make sense of their world through interaction and problem solving.

This conceptual change perspective is not a response to social/political conditions, but rather a research-based perspective that grew out of cognitive science studies of learning and knowing in complex knowledge domains (Roth, 1989, p. 65). The conceptual change perspective has attempted to look at both expert and novice knowledge and how that knowledge grows and changes. Glaser (as cited in Roth, 1989), referring to several other studies of learning, concluded that conceptual understanding is at the heart of higher level thinking, problem solving, and self-regulated learning. He suggested that changes in those understandings occur when theories are confronted by challenges and contradictions to one's knowledge. This is known as the constructivist view of cognitive development.

Constructivism emphasizes the role of the learner as an active participant in the learning process. A primary role of the teacher is to help learners make connections between their perceptions and the consistent interactions governed by concepts and principles that predict how objects act and interact in the metaphysical world. The emerging models represent a synthesis of both theoretical and applied research, grounded in the work of Jean Piaget, Lev Vygotsky, Jerome Bruner, Gestalt psychology, and John Dewey (Martin, Sexton, Wagner, & Gerlovich, 1997). Three principles that make up the theory of constructivism are given below.

1. A person never really knows the world as it is. We each construct beliefs about what is real, and knowledge exists within the mind of the learner.

2. What people already believe affects what they bring to a new situation, what they filter out, and how they change the information that the senses deliver.

3. People create a reality based on their previous beliefs, their own abilities to reason, and their desire to reconcile what they believe and what they actually observe. Constructed meanings are based on new experiences compared with existing schemata.

Several views within the educational research community claim to embrace constructivist principles. Each view has a subset embracing a different interpretation of how to best transmit knowledge to the learner. Along the continuum are the following:
Radical constructivists do not believe the world is knowable and suggest that teachers provide opportunities for students to gain an assortment of experiences that will enable them to construct meaning.

Conservative constructivists believe teachers should use activity-based learning with many problem-solving opportunities for students. However, the teacher aids the student in promoting conceptual understandings and attempts to correct misconceptions.

Traditionalists believe we should teach students about the metaphysical world and the principles that apply. Instruction should be more straightforward with laboratory and hands-on experiences that help students verify concepts embraced by the scientific community (Martin, 1997).

According to constructivism, learners respond to sensory experiences by building or constructing in their minds schemata or cognitive structures that constitute the meaning and understanding of their world (Saunders, 1992). These schemata or structures can be viewed as one's beliefs, understandings, and explanations—that is one's prior knowledge of the real world. These structures are used in two ways. First, the learner is empowered to make predictions based on these past experiences; and second, they are able to use them to develop explanations of these predictions. The predictions and explanations may or may not agree with others' perceptions and/or predictions. If agreement is recognized, then the schema remains intact and becomes more firmly believed. If disagreement is found, the learner becomes frustrated, surprised, puzzled, or in Piaget's terms (as cited in Saunders, 1992), disequilibrated. The learner usually selects one of three options.

The "intact schema" option (Saunders, 1992) allows the learner to deny the existence of the sensory data, distrust it by seeing it as invalid or rationalizing it away. It is as if the learner says, "Don't confuse me with the facts; my mind is already made up." The learner chooses (probably unconsciously) to ignore, disbelieve, or explain away the contradicting experiences. Discarding or restructuring one's schema does not come easily. It requires tremendous cognitive energy to restructure the existing schema. For this reason, the learner chooses to retain the "intact" cognitive framework.

The "cognitive restructuring" option allows the learner to revise the schema to agree with the experience. It requires a trust of the data or experience and a revision of the intact schema to facilitate agreement of harmony with the new experiences. It is felt that this is where meaningful learning occurs. Expressions are heard such as "Oh, now I get it" or the "Ah-ha" that Taba (1962) recognized. The light comes on, insight is gained, and understanding is attained.

In cognitive restructuring, the teacher does not convey insight through lecture, but rather students must construct it within their own mind. The teacher can assist (facilitate) students with the cognitive restructuring by leading them into situations in which the predictions do not agree with their schema (disequilibration), but the teacher cannot transmit or convey meaning—only words. The meaning must be constructed and created by the student. Saunders (1992) and Yager (1992) stressed that knowledge can never be observer-independent. It must be attained in a personal sense; it cannot be transferred from one person to another like the contents of a vessel. It requires a personal commitment to question, explain, and/or test explanations for validity.

Apathy, the third option for the disequilibrated learner, allows the learner to cognitively disengage: "I don't know why and I don't care why." Because cognitive structures are sometimes highly resistant to change and are a psychologically active process requiring the expenditure of much mental effort, the learner may choose not to accept the responsibility to understand. Similar categories of dealing with learning disagreement were also reported by Gilbert, Osborne, and Fensham (1982). From their study they found that three possible outcomes of the learning process are the undisturbed outcome (the learner holds on to the initial conception), the two-perspectives outcome (the learner retains both the
preconception and the teacher's explanation as a memorized version), and the mixed outcome (the learner learns some of the taught material but fails to integrate it into his or her conceptual framework).

**Kinds of Knowledge**

Kamii and DeVries (1977, 1978/1993) proposed three different contents of knowledge that are processed within the individual. In accommodative learning, schemata in the form of concepts and generalizations are formulated in the mind of the learner. When individuals respond to a question or situation, their responses are affected by the type of knowledge that the question taps.

**Content knowledge** includes (a) social-arbitrary knowledge, which consists largely of knowledge derived through language (either spoken or written) or conventions (arbitrary learning of rules and cultural mores); (b) physical knowledge which is derived from direct experiences and interactions with concrete objects (these can be described as mental experience storage systems [MESS]); and (c) assimilative learning information which is placed into memory with minimal transformation.

**Conceptual process knowledge** includes (a) conceptual knowledge, input that is transformed and put together by the learner and can be utilized to process and respond to unfamiliar stimuli; and (b) process knowledge, the ability to use the "tools" of scientific inquiry (i.e., observing, describing, classifying, experimenting, formulating hypotheses) to affirm and modify existing schemata. Conceptual and process knowledge can be described as memory organization points (MOP).

**Social interactive knowledge** includes (a) social knowledge, an understanding of the rules and conventions for building and sustaining relationships; and (b) interactive knowledge, the complex process of adapting behaviors to disagree amicably, encouraging productivity from others, getting along, and maintaining pleasant group work situations.

**Implications for Teachers**

The school curriculum has historically evolved using a separate subject structure. As a result, strong influences are asserted to develop one isolated schema framework within the mind of the learner. Learning within each class is generally conceptualized as a separate entity, isolated from experiences outside of that class. Experiences from other classes, home, peer relationships, and nonschool settings all exist in different schemata. One could use the analogy of a large bundle of helium-filled balloons of different sizes. Each balloon is independent, and its size and shape depend upon the amount of learning that has been acquired in that schema. When reasoning, the learner tends to draw only from the knowledge and emotions within a single schema. Because of this isolation, it is logical to assume that learners do not draw upon experiences from outside of school because those experiences exist in different schemata. In school, students will demonstrate a different performance level and reasoning processes in reading and writing in a language arts or English class than in a science or social studies class.

Statements of Piaget (1972), which have been corroborated by other researchers including Epstein (1979) and Shayer and Arlin (1982), consistently reveal that relatively few learners in K-12 are at the formal operational level. When one considers the isolation of schemata at this level, it is unlikely that even the brightest learners will be formal in multiple schemata. It is also likely that students will have some schemata at the preoperational level. The approximate percentages based on Piagetian tests reported by Epstein (1979) are noted in Table 1.
TABLE 1

Percentage of Students at Different Piagetian Levels by Age

<table>
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<tr>
<th>AGE</th>
<th>PRE OP</th>
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<th>CONCRETE MATURE</th>
<th>FORMAL ONSET</th>
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Table Notes and References

1. Level (A) in each category is composed of children who have just begun to manifest one or two of that level’s reasoning schemes, while level (B) refers to children manifesting a half dozen or more reasoning schemes.

2. Table derived by Herman T. Epstein, (personal communication with Donald Orlich, June 8, 1999)


   A Arlin, P. (personal communication with H. T. Epstein)


The contrast in schema development becomes much more profound when students from other cultures encounter an instructional setting established primarily on Northern European values. Soon after beginning school, many students who come from cultures that do not reflect European traditions make a decision that there is no relationship between what they learn at school and the world that exists outside of school. Therefore, everything that exists in the academic learning schema must be built within the framework of instruction. It is not surprising that these students become passive in educational settings. After the second grade, most textbooks and instructional materials assume that students are reasoning at the concrete operational level. Even when new concepts are initially introduced, it is assumed that students can read with comprehension and apply logical thought processes. Given this information, for students to be successful, teachers need to lower the level of instruction to the point at which the student can become a successful learner. We can then progress to higher levels of concept development, often fairly quickly.

The terms MESS (assimilation) and MOP (accommodation) can be used to describe students’ reasoning patterns. When the learner reasons using the mental experience storage system (MESS), little
information processing occurs. Information is assimilated into memory the same way the learner receives it. A MESS system of reasoning dominates learning throughout the first seven years of life and provides an essential database for future learning and higher level thinking. When a new schema (concept) is developed, a MESS must be built before students can be expected to reason effectively. Learners also employ a system of memory organization points (MOP), which become much more prevalent at the level of concrete operations. The MOP system allows one to bring together segments of information from several sources in a process of reasoning and comprehension.

The ability to draw from a number of schemata in employing logical reasoning patterns begins to emerge with the advent of concrete operations, generally considered common in the reasoning of individuals after age 7. The depth and complexity of reasoning continue to mature as long as a person actively seeks new knowledge and new insights. The following paragraphs describe how students might respond to a newly introduced concept. There is a constant interplay between content, conceptual-personal, and social interactive knowledge (see Figure 1).

Looking back to the application of theory to practice, teachers could consider the following instructional approaches. When introducing a new concept, teachers should help students develop a MESS. This is information that is not processed but is assimilated in the same manner in which it is delivered. After being assured that students have a MESS -- some air in the balloon -- teachers can do some MOP'ping, which is the shaping of the balloon into a conceptual schema. The process of instruction must be a continuous oscillation between MESSs and MOPs. If too much time is devoted to building a MESS, MOP'ping efforts will just spread the MESS around. Without a MESS, there will be nothing to MOP. Figure 1 illustrates this continuing process of MESS'ing and MOP'ping.

Always remember that if the student is unable to equilibrate—participate in the learning process—instruction is of little value. Effective teachers must look at instruction through the eyes of the learner. Heredity, experience, and biological maturation must be considered when planning appropriate learning experiences for your students. Piaget consistently presented the position that we cannot demand thinking beyond the student's present stage of cognitive development. We must earn higher thinking through nurturing a series of successively more advanced learning tasks until the student reaches the desired level of performance. Before students will be able to deal with a higher level of reasoning, they must be able to demonstrate mastery at the lower levels.

Teaching must occur in an arena of active manipulation of concrete hands-on experiences. When a concrete experience is impossible, semiconcrete opportunities (e.g., films, simulations, games, illustrations) must be utilized. Teachers must reduce the time spent talking in front of a class with only a few students equilibrating. Keep in mind, the focus is not on teaching. Rather, learning requires active

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**Figure 1. Cycle of Learning.**

(Cycle of Learning diagram showing the interplay between MESS and MOP systems.)
participation on the part of the learner. If the student is passive (not equilibrating), learning does not take place.

Additional complicating factors in intellectual development are isolated schema frameworks within what would normally be considered to be a schema. When teaching a concept naturally the teacher assumes that there is an integration of content, conceptual process, and social interactive knowledge. In the ideal process of healthy development, the learner accommodates the different kinds of knowledge through schema integration and interaction into becoming knowledgeable about details with sound conceptual understanding and effective social interaction abilities. However, there is evidence that this may not be the case for many learners.

Figure 2 is an illustration of a desirable path of cognitive maturity.

The student progresses following a diagonal course from the floor in one corner (reflecting the beginning point) to the ceiling in the opposite corner (reflecting a balance of content, process, and values). The steps, or gradations, in the degree reflect the processing changes associated within each level of cognitive development. If we are to accomplish outcomes of this nature, students must be guided through a balanced curriculum, blending product, process, and attitudes and values through a continuous, integrated curriculum consisting of small steps. This underscores the importance of interdisciplinary teaming, teacher empowerment, and collaborative dialogue.

The following suggestions for teachers reflect a constructivist approach:

1. Encourage student autonomy and initiative. Seek ways to serve as a resource to help students access and utilize sources of information, rather than serving as a disseminator of knowledge.
2. Understand that learners have different learning styles, different abilities, and process experiences at different developmental levels.
3. Use concept maps to represent meaningful relationships between fragments of knowledge.
4. Allow students to direct the learning, shift strategies, and modify their own conceptual frameworks.
5. Inquire about students' understanding of concepts, and provide numerous opportunities for them to share their ideas with peers and their teachers.
6. Withhold telling students. Rather, relate to their experiences before showing your knowledge and/or understanding about a concept.

7. Encourage student inquiry by asking open-ended questions.

8. Engage students in inquiry experiences through the use of discrepant events.

9. Become familiar with research on wait time and employ it in your teaching.

**Summary**

Teachers must become active vanguards against student apathy. The constructivist perspective on teaching and learning can provide food for thought to teachers who want to do something about student apathy. If the main message from the constructivist perspective is that understanding and meaning are constructed by the learner, then attention should be paid to what the learner brings to the classroom. Every effort should be made so that teachers find out what students believe about themselves, about school and education, about their expectations, hopes and fears, and, of course, their ideas about the various natural phenomena. But it would be too narrow to approach learning solely in terms of prior (erroneous) ideas and then concentrate on how to help students revise these ideas. Student apathy and failure can, indeed, be approached through the ideas of constructivism. Opportunities are needed for teachers to approach and get to know every student as a person, and not just as a mind that needs to experience disequilibrium or a mind with some ideas that need to be reorganized and revised. This means that communication and collaboration among teachers, students, parents, and administrators becomes imperative.

For too long us teachers have avoided responsibility by disassociating ourselves from students with apathetic behaviors. We administer failing grades and/or refer these students to other professionals (i.e., special educators). Instead, students must be provided with educational challenges with a high possibility of success. Schools and families should work together. Educators must communicate to students and parents that schools are not only places that provide opportunities for students to learn, but good schools hold students accountable and require personal responsibility. Conditions must be developed to intervene to the degree necessary to ensure active student participation in the school setting. If students can experience success, the heightened emotionality will subside. If not, it is likely that their problems will intensify and a stronger disassociation towards continued learning will result.
Chapter 3
Successful Practice: What the Research Tells Us

This chapter links curricular and instructional adaptations to the research on effective schools. Steps for setting up an inclusive science classroom are presented. Various adaptations in the science classroom are discussed. The findings of research on effective schools indicate that in a variety of instances, it is appropriate for teachers to make adaptations for students in the general education setting. Teachers can follow certain processes to help determine when these adaptations should be made, as well as choose from a menu of adaptation types.

Great teaching emerges from a combination of sound core knowledge and empiricism on the one hand and careful reflection and analysis on the other. It is the intertwining and inseparability of instruction and research that brings about advances in professional practice. Effective teaching is not replicating what was done in the past; it is working to produce new paradigms that meet the needs of today’s learners. Although the challenges are great and the issues are complex, it is critical that practitioners and scholars collaborate to provide visionary insights for improved professional practice. This chapter links curricular and instructional adaptations to the research on effective schools.

Based on surveys of educators’ greatest concerns, steps for setting up an inclusive science classroom are presented. The focus of this chapter is to help science teachers assess what kinds of curricular and instructional adaptations to make for students in the general education setting and when to make them. Four questions in adapting curriculum and instruction for students with diverse learning needs are addressed:

1. What teacher attributes create an effective inclusive science classroom?
2. When do general classroom teachers need to make adaptations for students?
3. What types of adaptations do these teachers need to implement to meet the needs of diverse learners in the general education setting?
4. What are the guidelines for teachers as they plan for an inclusive science classroom?

Students in our schools are educated in inclusive settings now more than ever before. With successful reauthorizations of the Individuals with Disabilities Education Act (IDEA) in 1997 and 2004, many general educators now need to make adaptations for students with special learning needs. Legislation under No Child Left Behind requires that by 2007, 90% of all identified special education students must spend at least 80% of the instructional day in a regular classroom. This presents a challenge for teachers as they strive to create adaptations to meet the learning needs of all students. Fetters, Pickard, and Pyle (2003) note that although many teachers have a sincere interest to meet the learning needs of all students, the current emphasis on inclusion remains a source of frustration, misunderstanding, and distrust. Teachers frequently feel ill-prepared and without the support they need to be successful with the special needs students in their classes.

Teachers in the general education setting are expected to implement both curricular and instructional adaptations in an effort to meet the needs of diverse learners. Curricular adaptations are defined as any adjustments or modifications in learning expectations, curriculum, content, the environment, instruction, or materials used for learning that enhance a person’s performance or allow at least partial participation in an activity (Baumgart et al., 1982; Udvari-Solner, 1992). Deschenes, Ebeling, and Sprague (1994) defined instructional adaptations as “the practice of changing the manner in which instruction is delivered in order to meet the needs of individual students including grouping strategies, formats for evaluation, and methods of presenting lessons” (p. 7).
The research on effective schools provides a rationale for making curricular and instructional adaptations for students. Mauer (1996) states:

An effective inclusive school is a diverse, problem-solving organization with a common mission that emphasizes learning for all students. It employs and supports teachers and other staff members who are committed to working together to create and maintain a climate conducive to learning. The responsibility for all students is shared. An effective inclusive school acknowledges that such a commitment requires administrative leadership, ongoing technical assistance, and long-term professional development. (p.1)

The research on effective schools has generated a list of conditions that correlate with effective schools. Salvione and Rauhauser (1988) cite the following correlates of effective schools:

- Clear school mission
- Instructional leadership
- Safe and orderly environment
- High expectations for all students
- Home-school relations
- Close monitoring of student progress
- Opportunity to learn and time on learning

Marzano (2003) provides a synthesis of the effective schools research along with a ranking by order of impact on student achievement. The synthesis includes a matrix representing the contributions to best practice by Edmonds (1979a, 1979b); Levine and Lezotte (1990); Marzano, Gaddy, Dean (2000); Sammons (1999); and Scheerens and Bosker (1997). These are:

1. Guaranteed and viable curriculum
2. Challenging goals and effective feedback
3. Parental and community involvement
4. Safe and orderly environment
5. Collegiality and professionalism

These two meta-analyses encompass current dispositions regarding successful practice and effective schools. It is important to note that the relationship between the student achievement variable and the noted factors are not necessarily linear. It may be the case that if a positive condition exists at an appropriate level, additional refinements may not yield higher levels of student achievement. It is also important to note that the elements are often emergent. Direct, prescriptive initiatives often do not yield desired results.

**Teacher Attributes in Effective Schools**

Stefanich (1983) has indicated that some characteristics of effective schools are directly related to the classroom teacher. These characteristics can also be linked to teachers who effectively adapt curriculum and instruction to meet the diverse learning needs of students in inclusive settings. The behaviors of teachers in effective schools, as summarized by Stefanich (1983), are as follows:

- Maintain a clear focus on academic goals
- Select instructional goals
- Perceive the students as able learners
- Implement an evaluation system based on individual student learning, rather than on a comparison with other students’ achievements
• Accurately diagnose student learning needs to foster high student achievement
• Prepare lessons (including adaptations) in advance
• Meet students’ needs in both academic achievement and socialization
• Be readily available to consult with students about issues and problems
• Attend staff development courses to continue professional development
• Keep parents informed and involved

Teachers often need to make curricular and instructional adaptations in their efforts to keep students actively engaged in content that is rich with meaningful lessons. School improvement endeavors that center around the effective schools research are based on the notion that all students, including those with special needs, can learn (National Council on Disability, 1989). General education teachers need to know when to make adaptations in curriculum and instruction in order to meet the needs of diverse learners in inclusive settings.

In many instances it is appropriate and necessary for teachers to make curricular and instructional adaptations for students. The research of Scott, Vitale, and Masten (1998) and Mertens and Flowers (2003) indicate classroom practices that are associated with high achievement. These are:

• Teaching practices include modification of specific assignments to allow students opportunities to use reading, writing, and mathematics skills that reflect their level of abilities.
• Teaching practices include modification of instruction to include multiple modalities, varied learning activities, and varied instructional groupings.
• Teaching practices include modification of assessment to include formative assessment, progress in monitoring, and reflective critical thinking by students.

Adaptations are often needed if special education students are to receive appropriate instruction in the content areas. In fact, Stainback, Stainback, and Stefanich (1996) have reported that learning core subjects such as social studies, science, and math with peers is beneficial in the long term for students with disabilities, including those with severe disabilities.

But to do this in content areas, such as science, a match needs to exist between the student’s abilities and learning style and the curriculum and instructional methodologies. Stainback et al. (1996) state: "Some students exhibit learned helplessness when there is not a good match between learning objectives and student attributes" (p. 14). In these cases, it is important for that match to exist, and making adaptations for students is one way to create that match. Salisbury et al. (1994) note:

The reality of today’s society is that each child, on any given day, can be a child with special needs. It is therefore important that schools tailor curriculum and instructional practices to fit the diversity of students’ needs and abilities represented in their classrooms. Adapting the "standard" to fit those who may not fall within expected margins is a necessary strategy for effective teaching and learning, one that enhances the likelihood that all children will feel like they belong and feel successful. (p. 311)

The need for improvement lies not only in classroom practice, but also in the selection and preparation of teachers entering the profession. New teachers must be prepared to address ethnic diversity, disability, and regular classroom instruction simultaneously if they are to be effective. Zeichner (1996) notes several elements in preservice teacher education. These are:

• Admissions procedures screen students on the basis of cultural sensitivity and a commitment to the education of all students, especially poor students of color who frequently do not experience success in school.
• Students are helped to develop a clearer sense of their own ethnic and cultural identities.
Students are taught about the dynamics of prejudice and racism and about how to deal with them in the classroom.

Students are taught about the dynamics of privilege and economic oppression and about school practices that contribute to the reproduction of societal inequalities.

The teacher education curriculum gives much attention to sociocultural research knowledge about the relationships among language, culture, and learning. Students are taught various procedures by which they can gain information about the communities represented in their classrooms.

Students are taught how to assess the relationships between the methods they use in the classroom and the preferred learning and interaction styles in their students’ homes and communities.

Students are taught how to use various instructional strategies sensitive to cultural and linguistic variations and how to adapt classroom instruction and assessment to accommodate cultural resources that their students bring to school.

Students participate in community field experiences with adults and/or children of another ethnocultural group with guided reflections.

Students complete practicum experiences in schools serving ethnic and language minority students.

Benchmark results reported by ACT provide some sobering statistics regarding the preparation of high school students for college biology. One can assume the results will be even more limiting for students entering the physical sciences, when and if they are examined. The report from ACT indicates that in order to have a high probability of completing first year college science courses with a grade of C or higher a student should have a benchmark score on the ACT examination of 24 or higher. Results of 2003 seniors indicate that 26% of all high school students taking the test scored at that level. The percentages fell off significantly for minority students to 14% of Hispanic and American Indian students, 10% of Mexican American students, and 5% of African American test takers (Penick, 2003).

Effective classroom teachers provide opportunities for all students to participate in a wide variety of content-related lessons (Stellar, 1988). Penick (2003), in noting the lag between science testing as compared to reading and mathematics under the accountability measures of No Child Left Behind, is concerned that science instruction is not taking place. A question arises regarding how much science will be taught, and how it will be taught and assessed, when science assessment becomes required in 2007-2008 under NCLB.

Research on effective schools and effective classroom practices supports the integration of special education students into general education classes (National Council on Disability, 1989). Other research has indicated that providing adaptations within the general education classroom instead of pull-out programs may prove to be more effective (Baker & Zigmond, 1990). Research has generated questions about serving mildly disabled students and minority students via pull-out programs (Epps & Tindall, 1987; Idol-Maestas, 1983; Leinhardt, Bickle, & Pallay, 1982; Polloway, 1984). As special education students are more fully included in general education classes with high expectations and a challenging curriculum, teachers will be required to determine when adaptations are warranted to meet each individual student’s learning needs.

**Determining When to Make Adaptations**

Using individual assessment data is one way for teachers to determine when adaptations are needed. When diagnostic assessment occurs, research has shown the students learn significantly more (Fuchs, Fuchs, Hamlett, & Ferguson, 1992). When teachers make adaptations, the needs of the student should drive the process, not the student’s label or the specific curriculum standard (Cousin & Duncan, 1997). There is such a great difference in students’ learning styles and needs that teachers must carefully
examine the instructional requirements of individual students and the variety of instructional methodologies when designing lesson adaptations (Mercer, Lane, Jordan, Allsopp, & Eisele, 1996).

Special and general educators can work collaboratively on making adaptations, using the student’s Individual Education Plan (IEP) as a framework and reference (Golomb & Hammeken, 1996). Myles and Simpson (1989) found that adaptations are most successful when general education teachers are involved in making decisions about designing and implementing the adaptations for students with disabilities. General educators must teach students with a wide variety of abilities and background in inclusive settings. For the special education students often included in general education classrooms for content instruction, the teacher needs to adapt both instructional methods and curriculum (Schumm & Vaughn, 1991).

If teachers are given structures and supports for implementing adaptations, they will use them effectively in the general education classroom (Fuchs, Fuchs, Hamlett, Phillips, & Karns, 1995). Scott, Vitale, and Masten (1998) have reported that when these support systems are in place, teachers will make the necessary adaptations for students. Staff development courses can offer supports for teachers in their efforts to design effective adaptations for students. However, instructional leadership from administrators and special educators is needed to secure staff development opportunities for teachers to learn about effective teaching practices and how to make adaptations for students with special needs.

Udvari-Solner (1996) found that when teachers decide what adaptations need to be implemented, they engage in a personal, reflective dialog with self-questioning. This leads to these same questions being posed when they meet in a group setting with other educators and parents. Parents often desire the opportunity to work collaboratively with teachers when determining appropriate adaptations for their children (National Council on Disability, 1989). This collaboration can foster positive relations between home and school, one of the effective school correlates (Salvione & Rauhauser, 1988).

According to Udvari-Solner (1996), when teachers use a process of asking questions as a structure to determine when adaptations should be made, it produces the framework for best changing how lessons are developed, structured, and implemented. These questions are summarized below:

1. Can the student actively participate in the lesson without any adaptations and achieve the same outcome?
2. Will student-specific learning objectives need to be written?
3. Can the student’s participation level increase by altering the modality of instruction?
4. Can the student’s participation level be increased by altering the structure of the lesson?
5. Can the student’s participation and comprehension be increased by altering the instructional methods or teaching styles?
6. Can the physical environment be altered to help facilitate participation?
7. Will the student need individual help to ensure participation?
8. Will an alternative activity need to be implemented?

Teachers want all students to be successful in their science classroom. This success can also be achieved in an inclusive science classroom. When creating an inclusive science classroom, Patton (1995) suggests the following guiding principles:

- Science lessons should be hands-on.
- Teachers should be facilitators of knowledge, rather than dispensers of knowledge.
- Cooperative groups should be created.
- Teachers need to make curricular and instructional adaptations.
- Theme-based instruction should be utilized.
Teachers should capitalize on "teachable" moments.
Teachers need to encourage students to engage in problem-solving exercises.

Students with special needs can benefit when adaptations are made in the science classroom. Inclusive science classrooms provide rich learning environments for all students. Inclusive classrooms of all kinds provide teachers with the opportunity to design and implement both curricular and instructional adaptations. These adaptations can positively impact student learning. When teachers apply these principles to create an atmosphere in which all students are comfortable and are engaged in quality teaching techniques, students will be successful in inclusive science settings.

**Types of Adaptations Teachers Can Make**

Adaptations made in the general education setting often include four main categories: time, learning styles and instructional delivery, environment, and adjustments in content (Murphy, Meyers, Oelson, McKean, & Custer, 1998). In two effective schools in Pittsburgh, researchers Sizemore, Brossard, and Harrigan (1983) found that teachers actively made adaptations in printed materials such as basal readers and their corresponding assessments. Ysseldyke and Algozzine (1990) found that one way teachers adapt instruction is to use specific strategies such as peer tutoring, cooperative learning, behavior management systems, and technology. Class-wide peer tutoring provides each student with the chance to work at his or her own instructional level, work as a tutor and tutee, communicate with students with various skill and ability levels, and be engaged in arrangements that center around a collective performance (Delquadri, Greenwood, Stretton, & Hall, 1983).

Activity-oriented approaches to science that address fewer topics but in a more in-depth way can be especially beneficial for students with special needs (Patton, 1995). Both content and activity-oriented approaches can be adapted and modified to meet the diverse learning needs of students. On a regular basis, lesson plans can be modified to include methods, materials, motivational activities, study skills, and/or learning strategies that will provide more opportunities for learner success. Instructional methods should include a wide variety of activities – hands-on experiences as well as reading information from a textbook. Students should be actively engaged in activities that reinforce concepts presented in a number of ways. For instance, building models of plant cells using cell parts made of common materials hung in a shoebox could call students’ attention to sizes and numbers of cell parts and their functions.

Experiments can be "retooled" to include materials that students can more easily use. Students with visual or motor difficulties may need to use larger instruments or materials. Students with difficulty attending to task for long periods of time may benefit from structuring the timing and placement of materials used.

For students with learning difficulties, providing study guides, study sessions that emphasize the use of mnemonic devices, and other learning strategies should increase their likelihood of success. Formatting tests to meet the needs of students who are easily confused by information is generally a good idea as well. For those students who have difficulty remembering large quantities of information and distinguishing between individual bits of information, chunking tests into smaller sections usually helps. Providing these kinds of accommodations may take a great deal of time. Working as a collaborative team, a regular class science teacher can provide the expertise needed to develop content lesson plans and appropriate activities. A special educator can provide the expertise needed in modifying lesson plans to include learning strategies and needed materials/activities to better ensure the success of needy students.

Content-centered approaches can also be adapted to meet students’ individual learning needs. One instructional adaptation is the use of advanced organizers. The use of this specific adaptations can be especially beneficial for students with disabilities. In a study of teachers, King-Sears and Cummons...
(1996) found that when the teachers used advanced organizers at the beginning of the day and at the beginning of lessons to show the sequence and flow of content, students with learning disabilities had fewer questions than when the organizers were not used. The organizers were on the board and often had picture icons to correspond with the text.

Curricular adaptations are often varied according to the content and grade-level expectations. They can be designed for groups of students and for individual students. Booth and Ainscow (1998) have suggested that one type of curricular adaptation is allowing students to participate in setting their own learning and social objectives combined with the teachers’ objectives in the same areas. The students can then evaluate their progress on their goals as well as on the teacher’s goals. However, Stainback et al. (1996) have suggested that writing separate or varying learning outcomes for one student or small groups of students can foster a sense of isolation and separateness in the general education setting.

Adaptation suggestions from Scott, Vitale and Masten (1998), Mastropieri and Scruggs (1995), Deschenes, Ebeling, and Spragg (1994), and Scruggs and Mastropieri (1992) are:

1. **Modify instruction:** Provide classroom demonstrations, adjust the lesson pace, and employ multiple instructional modalities during instruction. Simplify language, pre-teach vocabulary, use mnemonics, use picture clues, implement peer tutoring, and evaluate which vocabulary is essential.

2. **Modify assignments:** Provide models, shorten assignments, and lower difficulty levels. Adapt the time allowed for learning, task completion, or assessment.

3. **Strategies:** Teach study skills, test-taking skills, and learning strategies. Modify rate and how material is presented, include visual organizers, present concrete examples, pre-teach prerequisite information, provide additional application activities, use a variety of instructional strategies, provide advanced organizers, integrate other content areas into science, shorten lessons, and provide structure.

4. **Alter instructional materials:** Provide alternate materials, taping books, and reformatting worksheets. Provide graphic organizers and framed outlines, highlight important vocabulary and key concepts, implement partner reading, provide tape-recorded readings of text selections, and use trade books at various reading levels.

5. **Vary instructional groups:** Use peer tutoring and cooperative learning groups.

6. **Facilitate progress monitoring:** Read tests orally, provide study guides, allow students to retake tests, and modify grading criteria. Provide authentic and performance-based assessment that can be easily linked to scientific processes, allow for multiple opportunities to demonstrate acquired knowledge and skills, implement portfolio assessment, teach test-taking skills and study techniques.

Teachers in effective inclusive classrooms may use one or a combination of several of these adaptation types to meet the needs of diverse learners in the content areas. Classroom teachers should choose adaptations that allow students to remain actively engaged and participating in the lesson and any corresponding activities whenever possible.

While general education teachers do implement a wide variety of adaptations to meet student needs, they do not always find that all types of adaptations are as readily implemented as others. Adaptations rated most feasible in a study by Johnson and Pugach (1990) centered around using positive methods and
multi-sensory techniques that were readily integrated into daily classroom routines. Adaptations less favorably rated involved dealing with students individually. Ysseldyke, Thurlow, Wotruba, and Nania (1990) found that when teachers were asked to rank desirable classroom adaptations, the following practices were noted as being most important: identifying alternate ways to manage student behavior, implementing alternative instructional methodologies, using a variety of instructional materials, and using alternative grouping practices.

Teachers use typical adaptations more frequently than substantial adaptations. Typical adaptations include altering the format of directions, assignments, or testing procedures. Substantial adaptations include changing the difficulty level for students, such as implementing altered objectives, assigning less complex work, and providing texts with lower readability levels (Munson, 1986). Other substantial accommodations include: 1) modifying the work space, equipment, and supplies to make the laboratory experience accessible, 2) allocating student time and support to allow pacing appropriate for the student, and 3) creating group work opportunities and other social experiences that produce a sense of belonging and social acceptance for each and every student. This research suggested that even though there are a wide variety of adaptation types, teachers will implement the types they are comfortable with and understand. Teachers in effective schools feel that they have the instructional freedom to alter instruction and assignments to meet the individual needs of their students (Jackson, Logsdon, & Taylor, 1983). When teachers understand typical and substantial adaptations and believe that they have the freedom to make such adaptations, students in inclusive settings benefit.

A Summary of Guidelines for Creating an Inclusive Science Classroom

General educators can successfully adapt curriculum and instruction in all subject areas, and science is no exception. Adapting science curriculum and instruction provides special needs students with rich experiences that they may not receive in self-contained settings. However, adapting curriculum in science can present special challenges. Without administrative support, support from special educators, a positive and cooperative school climate, and disability-specific teaching skills, the challenges can become overwhelming to a regular classroom teacher.

Science is conducive to inclusion, as it has a strong base of research supporting the value of hands-on multi-modality instruction as a superior form of instructional delivery. Teaching science in an inclusive setting is one way for students with special needs to receive quality science instruction. Special education students often miss science instruction when they are pulled out to receive special education services. Often when these students do receive science instruction, it is from special educators who have little, if any, training in science instruction (Gurganus, Janas, & Schmitt, 1995).

Adapting science instruction to meet the needs of special education students is not always an easy task. It does, however, provide students with the opportunity to experience science in a content-rich environment. When teachers make adaptations in curriculum, instruction, and materials in the inclusive science classroom, students with special needs can interact with their peers and receive quality science instruction.

Creating an inclusive science classroom is a balance of designing an accepting environment, implementing effective instruction techniques, and adapting curriculum, materials, and instruction. Inclusive science classrooms are important for students. Patton (1995) states:

As professionals interested in preparing students for the challenges of adulthood, we must ensure that all students--both with and without special needs--receive meaningful and relevant science education. If science is important in many aspects of our lives, then science education must cover the topics that have a significant impact on our personal, family, workplace and community needs. (p. 4)
In summary, teachers need to make adaptations when students are not successfully meeting the demands of the general education setting and when the learning style or skills of a student do not match the instructional delivery or content objectives (Stainback et al., 1996). Curricular and instructional adaptations in the science classroom are similar to those in other content areas. However, science adaptations can sometimes pose special challenges due to the nature of experiments and the materials used. Teachers must plan lesson adaptations in advance and anticipate difficulties that students may encounter with the materials needed or the science activity. In inclusive settings, where adaptations are made, all children can learn, feel a sense of belonging, and achieve their educational and social goals.
Chapter 4
Accommodations and Assistive Technologies

This chapter discusses assistive technologies and their importance, provides information on physical accommodations to allow classroom participation of individuals with significant physical impairments, and gives suggestions for assistive technology screening that involves the student and other participants in the Individual Educational Plan. It also addresses ways that recent and ongoing advances in technology have made science learning through direct engagement possible in many instances for persons with physical disabilities.

Universal Design Principles

It is important that science teachers become active participants in the planning and organization of space and materials to allow for maximum access and participation of all students. The principles of universal design challenge all responsible persons to design products, environments, services, and resources to be used by all people, to the greatest extent possible, without the need for adaptation or specialized design. Most persons with architectural or administrative backgrounds are not familiar with the daily operation of a science laboratory or science classroom. Typically their designs are made for the average able-bodied user. Inattentiveness to needed considerations at the outset often requires major accommodations when a student with a significant disability or health impairment is placed in science classes, particularly classes with a major laboratory component. On the other hand, when universal design principles are considered during new construction or remodeling, the necessary facility modifications can usually be minimal, even for persons with severe disabilities.

Among the things to consider for physical challenges are wheelchair access, walking/standing, pushing/pulling, lifting/carrying, balance, gross motor control, fine motor control (grasp/pinch/manipulate), mobility (bending, stooping, movement), and stamina/endurance. Sensory challenges include vision, hearing, touch, smell, taste, and expression. Cognitive impairments include writing, reading, number recognition and computation, learning disabilities, behavioral disabilities, attention deficit disorders, and unique circumstances related to medication or traumatic brain injury. Recognizing the range of individuals who might be students over the life of the instructional space can make the environment more accessible and enjoyable for everyone. In general, accommodations made with a specific group in mind (e.g., curb cuts, closed captioning) are found to help the general population as well.

When modifying a science classroom, often our inclination is to think about costly and major accommodations rather than simple accommodations that can provide equitable and flexible access. Talking about needs with the students, parents, and others can often address an inconvenience or accessibility issue with minimal cost.

When planning instruction, think about the students’ range of abilities, experiences, and language skills. In examining the learning environment, pay attention to equitable use – identical when possible equivalent when not. Consider persons with physical challenges, sensory impairments, and cognitive limitations. Whenever possible, the student should be able to gain independent access to the materials and work space.

The following seven principles should be applied to evaluate existing designs, guide the design process, and educate both designers and educators about the characteristics of more usable products and environments (Connell, B., et al., 2000).
1. Equitable use: The design is useful and marketable to people with diverse abilities.
   - Provide the same means of use for all users: identical whenever possible; equivalent when not.
   - Avoid segregating or stigmatizing any users.
   - Make provisions for privacy, security, and safety equally available to all users.
   - Make the design appealing to all users.

2. Flexibility in use: The design accommodates a wide range of individual preferences and abilities.
   - Provide choice in methods of use.
   - Accommodate right- or left-handed access and use.
   - Facilitate the user’s accuracy and precision.
   - Provide adaptability to the user’s pace.

3. Simple and intuitive: Use of the design is easy to understand, regardless of the user’s experience, knowledge, language skills, or current concentration level.
   - Eliminate unnecessary complexity.
   - Be consistent with user expectations and intuition.
   - Accommodate a wide range of literacy and language skills.
   - Arrange information consistent with its importance.
   - Provide effective prompting and feedback during and after task completion.

4. Perceptible information: The design communicates necessary information effectively to the user, regardless of ambient conditions or the user’s sensory abilities.
   - Use different modes (pictorial, verbal, tactile) for redundant presentation of essential information.
   - Provide adequate contrast between essential information and its surroundings.
   - Maximize "legibility" of essential information.
   - Differentiate elements in ways that can be described (e.g., make it easy to give instructions or directions).
   - Provide compatibility with a variety of techniques or devices used by people with sensory limitations.

5. Tolerance for error: The design minimizes hazards and the adverse consequences of accidental or unintended actions.
   - Arrange elements to minimize hazards and errors: The most used elements are most accessible; hazardous elements are eliminated, isolated, or shielded.
   - Provide warnings of hazards and errors.
   - Provide fail-safe features.
   - Discourage unconscious action in tasks that require vigilance.

6. Low physical effort: The design can be used efficiently, comfortably, and with a minimum of fatigue.
   - Allow user to maintain a neutral body position.
   - Use reasonable operating forces.
   - Minimize repetitive actions.
   - Minimize sustained physical effort.

7. Size and space for approach and use: Appropriate size and space are provided for approach, reach, manipulation, and use, regardless of user’s body size, posture, or mobility.
   - Provide a clear line of sight to important elements for any seated or standing user.
   - Make reach to all components comfortable for any seated or standing user.
   - Accommodate variations in hand and grip size.
   - Provide adequate space for the use of assistive devices or personal assistance.
Architectural accessibility is an important consideration in accommodating students with disabilities in your classroom. Although most school buildings have already been made accessible, science labs have seldom been made fully accessible. Immediate factors that need to be considered are whether visually impaired students can read exit signs, whether there is a visual warning sign for deaf students, and whether steps and floors have non-slip surfaces. It is important to capitalize on mobility specialists whenever a person with an impairment is a student in a science class.

**Universal Design of Instruction**

Application of the concept of universal design in construction and architecture has made a tremendous difference in the lives of all Americans. Dealing with the tangible world is one aspect of universal design. Application of the concept of universal design to the educational process provides an opportunity to move to the intangibles, those things that make resources accessible that might not be visible or even detectable with our senses. The application of the principles of universal design to instruction can provide a framework that eliminates potential barriers by placing alternatives into the design. It involves the flexible design of instruction that provides access for all potential students with a broad range of abilities, ages, disabilities, learning styles, languages, mathematical abilities and reading levels.

Care must be taken that when applying the principles of universal design of instruction that expectations are not lowered. Not every learning situation will include everyone in all applications. However it does involve the anticipation and elimination of potential barriers through the design of flexible materials and learning activities. It examines ways to engage diverse activities and allows learners to individualize their participation. One key is the consideration of multi-modality approaches to instruction, student engagement and demonstration of knowledge.

Moriarty and Conroy (2006) developed a series Principles of Universal Design for Instruction. These principles with examples are described in the following paragraphs:

1. **Equitable Use:** Instruction is designed to be useful to and accessible by people with diverse abilities. Use visual and tactile materials within the framework of instruction. Provide the same means of use for all students: identical whenever possible, equivalent when not.
   - **Example:** Provision of class notes and instructions online. Comprehensive notes can be accessed in the same manner by all students, regardless of hearing ability, English proficiency, learning or attention disorders, or note-taking skill level. In an electronic format, students can utilize whatever individual assistive technology is needed to read, hear, or study the class notes. The notes can be used by specialists and aids to become familiar with the materials covered in class. If instructions and materials are made available experiments may be done in advance or repeated in a small group or individual setting.

2. **Flexibility in Use:** Instruction is designed to accommodate a wide range of individual abilities. Provide multiple ways to gain knowledge. Select materials early. Provide choice in methods of use.
   - **Example:** Use of varied instructional methods. Select materials that accommodate a variety of reading levels and language skills. Prepare an outline to help students organize concepts covered in a lecture, share concept webs, structure class periods with interruptions for short discussions within student groups.

3. **Simple and Intuitive:** Instruction is designed in a straightforward and predictable manner, regardless of a student’s experience, knowledge, language skills, or current concentration level. Be familiar with your desired learning outcomes and communicate them to the students in
advance whenever possible. Eliminate unnecessary complexity.

- **Example:** Provision of a grading rubric that clearly lays out expectations for exam performance, papers, or projects; a syllabus with comprehensive and accurate information; provide opportunities for multiple submissions on difficult homework assignments.

4. Perceptible Information: Instruction is designed so that necessary information is communicated effectively to the student, regardless of ambient conditions or the student’s sensory abilities. Seek media materials that provide captioning. Search for tactile models, have thermoforms prepared in advance for drawings and illustrations used in the classroom.

  - **Example:** Work with an instructional technology specialist to seek out on-line support materials or print materials at varied reading levels so students with diverse needs (e.g. vision, learning, attention, English as a Second Language) can access materials through traditional hard copy or with the use of various technological supports (e.g., screen reader, text enlarger, online dictionary).

5. Tolerance for Error: Instruction anticipates variation in individual student learning pace and prerequisite skills. Identify essential learning components for students who may not be able to master all of the elements

  - **Example:** Break a major project into a series of component parts so that students have the option of turning in individual project components separately for constructive feedback and for integration into the final product. When appropriate provide examples that students can look to for guidance. Make time available for feedback and provide opportunities for resubmission.

6. Low Physical Effort: Instruction is designed to minimize nonessential physical effort in order to allow maximum attention to learning. *Note: This principle does not apply when physical effort is integral to essential requirements of a course.*

  - **Example:** Allowing students to use a word processor for doing assignments, for writing and editing papers, or in student assessments. This facilitates editing a document without the additional physical exertion of rewriting portions of text (helpful for students with fine motor or handwriting difficulties or extreme organization weaknesses, and provides options for those who are more adept and comfortable composing on the computer).

7. Size and Space for Approach and Use: Instruction is designed with consideration for appropriate size and space for approach, reach, manipulation, and use regardless of a student’s body size, posture, mobility, and communication needs. Instructional spaces are designed to maximize inclusion and comfort

  - **Example:** Arrange desks for work in cooperative groups to allow students to see and face speakers during discussion. Use a paper towel end roll as a dummy “microphone” required by any student who speaks in the classroom—important for students with attention deficit disorder or those who are deaf or hard of hearing.

8. A Community of Learners: The instructional environment is welcoming to all learners, teachers are approachable and available. The educational atmosphere is one that makes everyone feel important and appreciated.

  - **Example:** Individual needs are addressed in and out of class by modeling an environment where every individual is treated with dignity and respect. Individual examples of caring behavior are acknowledged and rewarded.

9. Instructional Climate: Instruction is designed to be welcoming and inclusive; high expectations are espoused for all students.

  - **Example:** The school is a place where topics such as bullying, individual differences and elements of good character are addressed and reinforced throughout the curriculum. Instructional time is set aside to establish the expectation of tolerance as well as encourage students to discuss any special learning needs. Efforts are made to provide
informational resources about minorities, females, and persons with disabilities who have made significant contributions to the field or topic of study

10. Equitable Assessments: assessments are designed that allow every student the opportunity to communicate what he/she has learned and is able to do. The assessments are examined for bias and experiential deficits that may be associated with gender or culture.

Example: Students are provided with multiple ways to demonstrate learning outcomes. There is a congruency between testing and teaching. Students are given opportunities to express what they have learned through multiple modalities such as drawings or projects. There are many formative assessments that are intertwined with instructional activities. There are opportunities to communicate science learning by students who have deficits in reading, mathematics and/or written expression.

Assistive Technologies

The two major components of assistive technology are assistive technology devices and assistive technology services. An assistive technology device is any item that is used to increase, improve, or maintain the functional capabilities of a person with disabilities (Hoban, 2006). They include devices that aid with mobility and positions; adapted utensils, tools, and probes to facilitate self-help, or fine motor skills; and alternative and augmentative communication devices from pictures to computerized communication devices. Some devices may be as simple as a pencil grip where others can cost thousands of dollars such as the AccessScope Workstation described later in this chapter. An assistive technology service is defined as any service that helps an individual with a disability to assess, choose, use, or acquire an assistive technology device. Awareness and knowledge about assistive technology devices and access to services are both sorely lacking in educational centers at all levels.

Fortunately, two major factors have the potential to significantly enhance educational opportunities for students with disabilities through the increased availability of assistive technologies -- legislation and cost. New and revised legislation under the Individuals with Disabilities Education Act (IDEA) and Americans with Disabilities Act (ADA) requires that reasonable accommodations, including assistive technologies, be provided in public schools (Ludlow, 2001). IDEA requires teachers to consider the support that students must have to access the general curriculum. A second factor is improved availability and lower costs associated with assistive technology devices (Lahm & Sizemore, 2002).

Research shows improved student outcomes when teachers integrate assistive technology into the classroom (Michaels & McDermott, 2003; Anderson & Petch-Hogan, 2001). Providing pre-service teachers with demonstrations and hands-on practice improved teachers’ knowledge and ability to use assistive technology in school settings (Anderson & Petch-Hogan, 2001). Once teachers and students become familiar with the hardware and/or software, if it is congruent the curriculum goals and is maintained, it is generally used well and results in improved student performance. However there appears to be a large gap between research outcomes and active use of assistive technologies in educational setting.

Connor and Snell (2006) indicate that although program directors believed in the importance of improving competency in student knowledge and awareness of assistive technologies they did not believe their programs were successfully integrating these skills into their graduates. They cite the need for professional development both in the pre-service and in-service areas. They also note the need for administrative support and greater involvement and participation by technical consultants who install and maintain software. Hoban (2006) reports that in addition to installation, teacher training is important.

A general area of concern in the classroom with great promise and potential through assistive technologies is augmentative communication. The communication device can contribute to what the
person can already do, in effect, augment their speech, or replace their speech. A vast number of different conditions affecting both expressive and receptive language. Spoken language is the most commonly used form of communication in the classroom and without well-established language skills the acquisition of other communication skills, such as written language, is also delayed (Graft-Hanson, 2006). Initiating efforts by working with educators and organizations who provide assistance and support can help get these aids into a science classroom.

Science is more vulnerable to getting these aids than many other areas because effective selection of available assistive technology devices requires knowledge of the assistive technology, the content, and the curriculum. This frequently provides a gap where resources that would be extremely valuable to the student (adaptive work stations, probe ware, and software) are overlooked. In-service training and ongoing collaboration is essential between science teachers, special education teachers, occupational therapists, physical therapists, and speech-language pathologists.

The DO-IT Program has demonstrated considerable success in helping students with disabilities transition from high school to post-secondary academic and employment settings. A major focus of the program is self-advocacy and self-determination. Burgstahler (2006) describes self determination as the skills, knowledge, and beliefs that enable a person to participate in goal-directed, self-regulated, autonomous behavior. Being self-determined involves understanding one’s own strengths and limitations, believing in oneself, taking risks, and making informed choices. Self-advocacy requires self-knowledge and the abilities and skills necessary to articulate and successfully meet one’s personal and educational employment needs. A major opportunity exists, particularly in secondary schools and post-secondary settings, for a science teacher/professor to work in collaboration to acquire appropriate assistive technologies to help in the learning process.

Assistive Technology Resources

With advances in the internet it is virtually impossible to stay on top of the new assistive technology resources and the improvements in existing resources. It is important for science teachers to initiate communication with the student and/or resource specialist to discuss accessibility and assistive technology needs. A number of databases are available on the internet that provide information about assistive technologies. A brief outline of resources from one of these databases, Closing The Gap, is presented to familiarize the readers with the many resources that are available to assist in the teaching/learning process for students with disabilities. If students with disabilities are to reach their maximum potential it is important to search out avenues for improved expressive/receptive communication and opportunities for hands-on participation in all aspects of science instruction. Following is a short list of Assistive Technology Product Databases accessible on the internet.

Assistive Technology Product Databases

Closing The Gap is an organization that focuses on computer technology for people with special needs through its bi-monthly newspaper, annual international conference, and extensive web site.

The Trace Research & Development Center is part of the College of Engineering, University of Wisconsin-Madison. The Trace Center is currently working on ways to make standard information technologies and telecommunications systems more accessible and usable by people with disabilities. This work is primarily funded by the National Institute on Disability and Rehabilitation Research (NIDRR) (U.S. Department of Education). http://trace.wisc.edu/

ABLEDATA is a database of information on assistive technology and rehabilitation equipment available in the United States. It is primarily funded by the National Institute on Disability and Rehabilitation Research. The data base contains over 29,000 product listings. http://www.abledata.com/

Assistivetech.net is an online information resource created by Georgia Tech's Center for Assistive Technology and Environmental Access. It is primarily funded by the National Institute on Disability and Rehabilitation Research. It provides information on assistive technologies and related resources. http://www.assistivetech.net/

EnableMart is a commercial site whose mission is to assist individuals in the search for computer access solutions by locating, supporting, and selling computer hardware, software and related technologies designed for specific needs. It offers adaptable computer interfaces, ergonomic keyboards, portable devices, voice recognition and artificial speech. http://www.enablemart.com

Legal Guidelines

Scientists and engineers with physical disabilities invariably talk about advisement, counseling, and administrative efforts to steer them away from the laboratory sciences and toward vocational choices involving human services or trade professions. Although no evidence supports an increased rate of injury in students with disabilities, advisers and science teachers have concerns about safety and reservations about students with disabilities participating in the laboratory sciences. The skepticism becomes more pronounced as students progress through the grades into secondary schools. Staff in disability services from higher education can often provide guidance concerning available assistive technologies for general classes, but usually are not familiar with laboratory accommodations, particularly specialized science laboratories.

How can students with disabilities have science classes and laboratory experiences that meet their needs? The Department of Justice enforces the Americans for Disabilities Act Accessibility Guidelines for Building and Facilities (ADAAG). However, some interpretation is needed because the guidelines are not specific to science. The ADA requires that existing deficiencies be corrected as each area of the building is renovated. Every area of the school used by any student must have access for physically disabled persons. ADA requires that one sink in each laboratory be in compliance with its guidelines.

In addition, computer-based technology has done much to improve information access for persons with disabilities. Experiment simulation programs and laboratory systems in which measurements are made through a computer are becoming more commonplace. Other devices and instruments are emerging to help students communicate and use a computer, such as dictation programs, alternative keyboards, voice output, infrared sensitive receptors. While these are tremendous aids, they are not sufficient alone to meet the needs of students with disabilities.

Assistance for adapting science classes and lab space can also be found in the 1988 Technology-Related Assistance Act and its 1993 amendments. These provide federal funding to help states establish programs to promote the provision of technology-related assistance. For more information, visit Web sites for RESNA, DO-IT (Disabilities Opportunities, Interworking and Technology), EASI (Equal Access to Software and Information), and Closing the Gap.
A standing committee of the American Chemical Society, active since the mid-1970s, has also endeavored to provide assistance to make laboratories and work spaces for scientists with disabilities more accessible. The following information has been extracted with minor modifications from a modern graph titled *Teaching Chemistry to Students With Disabilities* (Kucera, 1993):

Laboratory experience is essential for students of an experimental science, and the student with a disability is no exception. Some disabilities may restrict the student's laboratory activities more than others, and the level of involvement desirable and necessary must be determined through discussion with the student on an individual basis. However, students whose efforts in the laboratory are sharply restricted by a disability are not necessarily barred from careers involving laboratory work. Many successful scientists with disabilities direct experimental programs without the need to perform laboratory manipulations themselves. Many persons in science and engineering with disabilities work in the lab in the same manner as scientists who do not have a disability, with few or no special accommodations. With technology advances there are devices such as probes or robotics that can manipulate materials to allow active participation even for individuals with limited motor capabilities.

**Information sources**

Title II of the ADA requires public schools to comply with either the ADAAG or the Uniform Federal Accessibility Guidelines (UFAS). Independent schools must follow ADAAG requirements. For help in applying ADAAG regulations to specific design issues, contact the Justice Department’s technical assistance hot line at 1-800-514-0301. The Web site is [http://www.usdoj.gov/crt/ada/adahom1.htm](http://www.usdoj.gov/crt/ada/adahom1.htm). Also consult the state ADA accessibility office to determine state requirements. Information is also available from the Office of Technical and Information Services, Architectural and Transportation Barriers Compliance Board (also known as the Access Board), 1331 F Street, NW, Suite 1000, Washington, DC 20004-1111; 1-800-872-2253 or 202-272-5434. Documents can be accessed at [www.access-board.gov/](http://www.access-board.gov/).

Publications are available, including the following:

- A publications checklist (Document G-08)
- The *Uniform Federal Accessibility Standards* (UFAS) (Document S-04)
- Title III of the ADA, with the latest requirements from the Justice Department on the ADAAG (28 CFR 36, Appendix A; Document S-14)

**Laboratory Modifications for Students with Mobility Impairments**

The student with impaired mobility needs easy access to equipment, including computers, materials, safety devices and other services (restrooms, ramps, elevators, and telephones) and accessible doors and exits. The student also needs enough aisle space to permit lateral movement and maneuverability. Positioning a wheelchair parallel to the lab bench and fume hood is generally restrictive, although some students prefer it. Ideally, a workbench should have an opening underneath that allows a student using a wheelchair to be closer to the work surface.

Every teaching laboratory should have at least one adapted workstation. The basic requirements for a laboratory workstation for a student in a wheelchair are:

- Work surface 30 inches from floor.
- 29-inch clearance beneath the top to a depth of at least 20 inches and a minimum width of 36 inches to allow leg space for the seated individual.
- Utility and equipment controls within easy reach.
- Clear aisle width sufficient to maneuver a wheelchair; recommended aisle width is 42 to 48 inches.

If the aisles in the lab/classroom are too narrow, portable workstations are available with lowered decks and modified control access (i.e., push button or electronic) to accommodate students with limited mobility. These stations may be equipped with water, gas, electrical power, and sockets for apparatus rods.

Laboratory sinks. ADAAG Guidelines specify a sink depth of no more than 6 inches with a rim height maximum of 34 inches, vertical knee space of 27 inches, and knee width of 30 inches. There must be lever-controlled faucets or a similar alternative. Controls should not require tight grasping, pinching, twisting of the wrist, or exerting more than five pounds of force to operate.

Fume hoods. Maximum height and knee space requirements for fume hoods are the same as for sinks. In most cases, this will require the purchase of portable fume hoods that meet ADA Guidelines. These are available with ducts or ductless. (i.e., www.aircleansystems.com)

Safety showers and eyewashes. Standard eyewash systems are generally mounted too high for access by students in wheelchairs. The stations must be modified, generally to 32-34 inches to accommodate a student in a wheelchair. If there is a second eyewash in the room, it may be at standard height.

Other adaptations. Wall cabinets, table tops, and shelving should be examined for sharp corners. Supplies students use should be accessible to the student with disabilities at a suitable height and easy access without stretching. Federal guidelines have been forwarded for students ages 12 and under, but these are not yet enforceable. The key factor to remember is that accessibility for students with disabilities is mandatory.

Another alternative for setting up a lab station, if the student can transfer from the wheelchair, is to design a more maneuverable chair for use in the lab only. A modified chair can often permit good mobility around the lab, increased mobility at the bench, and increased accessibility to the bench top. Supplies and equipment can be moved around the lab on the chair-and-platform device, which provides a flat, steady surface. The adjustable-height wheelchair may include a tray that can be snapped onto the chair's arms to carry equipment such as flasks and crucibles, leaving both hands free to operate the chair. Mobility and accessibility at the bench can also be enhanced by constructing a platform to raise the student to a height more compatible with the height of the bench top and by modifications to the bench itself, such as pull-out shelves.

One chemist who uses a wheelchair performs most experiments on a standard vacuum rack. This 22-inch high, 12-inch deep workspace provides the vertical access required by a seated individual for doing titrations, distillations, and column chromatography. The adjustable serving tables used in hospitals can provide another alternative. They can easily be rolled out of the way when not needed for instructional use and can be prepared in advance to reduce set-up time for the student with a disability.

The laboratory as a whole can be made more accessible to students with impaired mobility by making various modifications:

- Adjustable-height storage units and special-equipment work space.
- Pull-out or drop-leaf shelves or countertops for auxiliary use; for example, shelves at lap-board
height to hold instruments for students in wheelchairs.

- Single-action lever controls or blade-type handles rather than knobs for students with impaired manual dexterity.
- Flexible connections to electrical, water, and gas lines for students with limited reach (e.g., in a wheelchair).
- Alternative means of storage, such as a portable lazy Susan or a storage cabinet on casters.
- Use of low-tech occupational therapy equipment and devices fashioned for ADL (Activities for Daily Living) and independent activity in the home.

Students whose disabilities affect the use of both upper and lower limbs may need an assistant to perform experiments under the student's direction. The student should be able to observe the data acquisition as well as direct the experiment. This approach for the quadriplegic student is much the same as that described for the student who is visually impaired.

Various disabled scientists have successfully used the previous provisions for making a laboratory more accessible to students with impaired mobility. Again, however, students' needs tend to be individualized, so accommodations are best considered on a student-by-student basis.

The following section (p. 54-59) has been extracted from publications by Brad Duerstock with permission to use in this book. It provides an illustration of how, with modern technology, active participation by students with severe motor/orthopedic or sensory impairments is possible in laboratory investigations at the most sophisticated ends.
Development of Accessible Laboratory Equipment for Laboratory-Based Science Courses

By Brad Duerstock

ACCESSIBLE MICROSCOPY

Background

Light microscopy is one of the most basic laboratory skills a student or scientist uses in the life and physical sciences. Independent microscope operation encourages students with disabilities to take an active part in laboratory experiments, acquire active learning experiences (Scruggs & Mastropieri, 1994), and perform individual graduate-level research. Without access to a microscope, many students with disabilities are forced to read histology atlases, observe stock micrographs of histological images, or rely on another to operate the microscope for them. Often during science classes, students form groups to perform laboratory activities. Able-bodied students are typically teamed with disabled students to assist in physically performing the experiments. During biology labs the able-bodied group members get to mount specimens to slides, load the slides onto the microscope stage, and manipulate the microscope while the disabled student observes. However, this delegation of duties, though common, limits the amount of active participation of the disabled student (Dudgeon et al., 1997; Norman et al., 1998; Pence et al., 2003).

We developed an integrated accessible microscopy workstation, called AccessScope, for students and scientists with profound upper limb mobility impairments to perform light microscopy without requiring assistance. Unlike other minor accessible adaptations to conventional light microscopes (Scruggs & Mastropieri, 1994), AccessScope permits students with disabilities to independently perform all aspects of brightfield and fluorescence microscopy, image acquisition, and image analysis including loading slides onto the stage. We believe AccessScope is the first microscope system to allow persons with mobility impairments to fully participate in laboratory coursework. AccessScope is portable for classroom use, flexible for different laboratory-based curricula in the SET fields, and sophisticated enough to meet light microscopy for undergraduate use to independent research.

Results

A Windows® personal computer (PC) was the user interface for controlling the AccessScope workstation. The PC could be adapted for different preferences and a wide variety of motor impairments, including those with either fine or gross upper limb movements (Lau & O’Leary, 1993). During AccessScope evaluation, participants with different types of mobility impairments could choose from an array of input devices, such as a mouse, trackball, voice recognition, and keyboard. In addition, the AccessScope PC could incorporate assistive technology (AT) software to further assist students with mobility impairments.

The AccessScope control software application used a graphical user interface (GUI) to operate every feature of the accessible microscopy workstation, except for stage movement (Fig. 3A). A separate joystick controls stage movement (Fig. 3E). Through the control software, keystrokes or clicking on an interactive map of the microscope with a pointing device controlled different microscope functions. Focusing is accomplished using a slider bar or by directly entering distance values. We also included automatic functions, like autofocus and autoexposure, to alleviate the need of performing them manually.
Programmed ‘hotkeys’ are employed to automatically change the condenser, light settings, and filter wheel whenever the objective is changed.

One crucial problem when working with microscopy is loading slides onto the microscope stage. An additional software module controls the bulk slide autoloader to mechanically place slides onto the microscope stage (Fig. 3F). Once the automatic slide autoloader is loaded with up to 50 microscope slides, the user with a disability does not require further assistance. If each slide contains 10 histological sections, then AccessScope users would have access to 500 tissue specimens that they could observe microscopically without ever needing human assistance.

Figure 3. Fundamental components of the AccessScope workstation

A. A PC operates all microscopy functions and peripheral components of the system. Users can employ a variety of input devices to control the PC. B. A motorized light microscope is the core of the system to automate microscopy features, such as changing objectives and condenser. C. The microscope can also be partly controlled through a separate button pad. D. A motorized stage positions slides under the microscope lens. E. A joystick commands the movement of the stage in the X and Y directions. F. A bulk slide loader remotely loads slides stored in two cassettes holding up to 50 slides total. G. Tissue sections are displayed on the computer monitor via a digital camera mounted on the microscope. This eliminates the need to view through the inaccessible microscope eyepieces. Section images can be stored and managed on the computer for further anatomical study. H. An enlarged view of the external focus knob constructed to make manual focusing possible without the need for finger dexterity. Using a belt system, the original focus knob was attached to a large three-spoked knob that was positioned further in front of the microscope within reach of disabled users. This provides an additional means of focusing besides using the software.
A digital camera projects a real-time image of slide specimens in a viewport window (Figs. 3A and G). Therefore, looking through eyepieces is not necessary and image capturing was possible. Peering through the eyepieces of a conventional light microscope is difficult for wheelchair users due to their sitting position and height. Participants stated that one of the greatest obstacles when using a microscope was an inability to peer through microscope eyepieces. All wheelchair and scooter users responded that viewing the slides on the monitor in lieu of using eyepieces was a major improvement. Able-bodied microscope users sit on a stool leaning over the eyepieces.

Participants (n=8) with a range of upper limb mobility impairments from rheumatoid arthritis to spinal cord injury to polio evaluated AccessScope during its development and testing. The subjects had different motor impairments, consisted of both sexes, and ranged in ages from 22 to 59. All participants had limited motor ability in both upper and lower limbs. While most participants relied on scooters or wheelchairs to ambulate, two participants were able to walk on their own. The majority of participants lacked mobility in the most distal of their upper limb extremities, including the fingers and hands, resulting in lack of fine motor movement. Half of the participants stated that they required assistance in at least one daily living activity, such as bathing, dressing, eating, toiletry, or transferring.

Figure 4. Participants using the AccessScope workstation

A. A participant with juvenile rheumatoid arthritis. Though he has fine motor skills to turn knobs and push small buttons, common on the microscope, his reach and strength are limited. The close proximity of the joystick, mouse, and keyboard allow him to control all aspects of the microscope. B. A quadriplegic participant from a spinal cord injury has gross motor skills but lacks fine dexterity. He was proficient at using the joystick and a mouse and keyboard to control the AccessScope software. He also used AT
software for one-handed typing. C. An individual with digital amputations, contractures, and dermal scarring preferred to reposition the input devices to better accommodate her abilities. The upward projection of the microscope eyepieces in addition to the distance between the eyepieces and tabletop made ocular viewing difficult from a wheelchair or scooter.

Each participant was evaluated at two different time periods using AccessScope. The first session involved instructing the participant how to use AccessScope and determining each individual’s accessibility needs for operating the system independently. Each user’s needs were accommodated by adapting the PC user interface either by repositioning the input devices, buying a different pointing device, or having the participant bring in their own custom input device that they had adapted themselves. The height of the AccessScope table could also be mechanically adjusted with a toggle switch. The adjustable table could accommodate someone in a manual wheelchair, electric wheelchair, or sitting in a chair. Some participants were dependent on StickyKeys™ for typing and one participant with a spinal cord injury used MouseKeys™ for fine movements of the pointer. Only one of the participants regularly used speech recognition software but did not need it to operate AccessScope.

The second session involved evaluating each subject’s ability to perform general microscopy functions with AccessScope, including turning on the microscope and lamp, loading slides, changing objectives and illumination, focusing, stage movement, and acquiring digital images of histological sections. All subjects were able to successfully operate AccessScope without human assistance. Participants’ ability to operate AccessScope was qualitatively assessed through observation and questionnaires.

Persons with profound upper limb mobility impairments have no other means of performing light microscopy except with human assistance. Relying on a microscope assistant is expensive and often impractical. In addition, the ability to independently control a microscope is necessary for persons with mobility impairments to take practical exams by themselves, conduct undergraduate and graduate level research, and ultimately pursue many kinds of scientific, medical, or engineering occupations. AccessScope’s flexibility can accommodate different curricular and occupational requirements and sophisticated enough to perform any microscopy techniques necessary for undergraduate biology majors to medical pathologists. AccessScope can be used for brightfield and fluorescence microscopy, image acquisition and analysis, cell and tissue morphometry, and three-dimensional reconstruction of serial histological sections.

The participants in this study were also asked, because of “potential obstacles confronting your disability have you made an effort to stay away from laboratory-intensive classes.” All participants who were disabled during their college education responded that they made an effort to stay away from laboratory-intensive courses because of their disability. Likewise, participants were queried if the prospect of being required to use certain job-specific equipment or tasks ever dissuaded them from pursuing a particular course of study or occupational choice. Every participant answered affirmatively to this question. Some occupations that participants stated that they were interested in but decided not to pursue because of their disabilities were pharmacist, physician, radio disc jockey, and engineering technician. Instead, they choose careers or fields of interest that they thought were accessible to them, such as organizational management, disability academic affairs counseling, psychology, and computer programming.

**Summary and Future Goals**

Though the AccessScope project provides a singular scientific technique for a relatively small population of students, developing more accessible scientific equipment to perform other hands-on tasks
is possible. In addition, accessible scientific equipment helps persons with disabilities, but it can also benefit other segments of society. Most of the participants who evaluated our system became disabled in childhood or prior to college, however we did investigate age-related mobility disorders, specifically adult rheumatoid arthritis. We found that AccessScope can assist microscopists in the work force who become incapacitated later in life due to arthritis, carpal tunnel syndrome, or chronic fatigue.

We are also planning to investigate whether a computer-controlled microscope could also benefit to individuals with low vision. A combination of screen magnification software and a specialized GUI for AccessScope may permit users with low vision to control and view slides more clearly than from a conventional light microscope.

We acknowledge that certain realities must be considered in order to develop accessible laboratory devices and implement them in postsecondary educational institutions for future students with disabilities. Assistive technology equipment must be practical for use by both students and teachers and be cost-effective. Many pieces of AT educational equipment become underutilized because the onus is on the teacher to integrate this equipment into their curriculum (Carey and Sale, 1994). We wanted AccessScope to be intuitive to use by persons with disabilities and able-bodied users. Likewise, if an AT device allows persons with disabilities to perform a task but at a much slower pace than an able-bodied person or causes fatigue or stress, then the overall usefulness of that device compared to hiring an assistant would need to be evaluated.

Accessible laboratory equipment must be affordable. We performed preliminary testing to remotely control AccessScope over a computer network. Using client-server software, a remote PC in another room or building could operate and display slides from a school AccessScope workstation. Students with disabilities would be able to use AccessScope outside class on their own time or from their home. Using scheduling software, a single AccessScope system could be shared by multiple users (Robinson & Turek, 1999; Duerstock & Robinson, 2004). Thus, remote network sharing could help keep costs down by allowing students with disabilities from a particular region or even from a long distance away to have access to the laboratory device.

Lastly, accessible laboratory equipment may have other applications besides assisting persons with disabilities. For instance, a remote-controlled microscope would allow a pathologist to view histological slides in real-time from great distances away through the Internet. Another application of the accessible microscopy workstation could be performing automated, high-throughput microscopical routines. The motorized features of AccessScope could be programmed through the PC to run automatically overnight, such as loading a series of slides, acquiring views of samples at specific magnifications, applying filters to the images, and making morphometric measurements. Such cross-disciplinary use may make accessible laboratory devices more affordable and useful to large academic institutions with both teaching and research functions.

Laboratory Modifications for Students who are Deaf and Hard of Hearing

Unlike visual and orthopedic disabilities, impaired hearing is not a visible disability unless one sees the student wearing a hearing aid or using sign language. Some deaf students do not speak at all. In general, impaired hearing has little effect on the ability to work in a laboratory setting. Except for the installation of visual warnings in addition to normal audible warnings, and emphasis on good communications, students who are deaf or hard of hearing have few special needs in a science laboratory.

Students who are deaf sometimes face a social barrier in that deafness impedes communication with other students. Eye contact with a speaker is essential for many deaf students. A simple adaptation
requiring that every student hold an object before speaking in group work often works well. The teacher
can assist in finding a sensitive lab partner or assistant when a partner is needed. Accommodations may
be required regarding the positioning of an interpreter to allow concurrent communication. These can
usually be worked out through individual consultation.

Assistive Technology Screening

The following list of challenges, interventions, and modifications can serve as a beginning point in
assistive instructional screening. Use the information in Table 4 in conjunction with the Accommodation
Model found in Appendix A included with permission from Dr. Sheryl Burgstahler, the Director of DO-
IT. The Accommodation Model was extracted from http://www.washington.edu/doit/Brochures/PDF/
accommodation.pdf. Always remember the best alternative is often to go through and review with the
student or, if necessary, an appropriate mentor to determine which modifications might best fit the
learning needs of the individual.
Implementing Assistive Technologies and Accommodations

Assistive Technology Screening

Table 2

Challenges, Interventions, and Modifications Relating to Assistive Technology Screening

<table>
<thead>
<tr>
<th>Access to Materials &amp; Equipment</th>
<th>Environmental Adjustments</th>
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<tbody>
<tr>
<td>• alarm system that responds to those with place keepers, tracker, pointers</td>
<td>• proximity seating</td>
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<tr>
<td>• manipulatives (blocks, counters, magnetic letter, etc.)</td>
<td>• small-group instruction</td>
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<tr>
<td>• pencil grips</td>
<td>• study carrel available</td>
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<tr>
<td>• highlighters for underlining</td>
<td>• interpreter</td>
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<tr>
<td>• templates and/or graph paper</td>
<td>• instructional assistant</td>
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<tr>
<td>• rubber or latex gloves (be aware of allergies)</td>
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<tr>
<td>• nonslip floor surfaces, nonslip mats</td>
<td></td>
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<tr>
<td>• computer/word processor (in classroom or lab)</td>
<td></td>
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<tr>
<td>• plastic labware</td>
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<tr>
<td>• safety goggles</td>
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<tr>
<td>• hearing aid</td>
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<tr>
<td>• Braille writer</td>
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<td>• auditory trainer</td>
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<td>• augmentative communication device</td>
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<td>• electronic switch access</td>
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<td>• tape recorder</td>
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<tr>
<td>• personal alarm</td>
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<tr>
<td>• sensory deficits</td>
<td></td>
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<td>• sensors and accessories</td>
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<table>
<thead>
<tr>
<th>Instructional Interventions</th>
<th>Scheduling Modification</th>
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</thead>
<tbody>
<tr>
<td>• untimed assignments</td>
<td>• academics scheduled at appropriate times for student</td>
</tr>
<tr>
<td>• oral administration of tests</td>
<td>• scheduled breaks</td>
</tr>
<tr>
<td>• use of large print</td>
<td>• testing done at the time of day beneficial to the student</td>
</tr>
<tr>
<td>• use of a word bank</td>
<td>• accessibility to laboratories after school hours</td>
</tr>
<tr>
<td>• short answers accepted for lengthy essay</td>
<td></td>
</tr>
<tr>
<td>• project accepted for major written assignments</td>
<td></td>
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<tr>
<td>• teacher or assistant records answers when given orally</td>
<td></td>
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<tr>
<td>• copies of notes supplied</td>
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<tr>
<td>• instructions given in Braille direct instruction</td>
<td></td>
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<tr>
<td>• generalization instruction</td>
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<td>• maintenance instruction</td>
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<table>
<thead>
<tr>
<th>Curricular Modification</th>
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<tbody>
<tr>
<td>• textbooks on tape</td>
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<tr>
<td>• textbooks in Braille</td>
<td></td>
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<tr>
<td>• adjustment in performance criteria</td>
<td></td>
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<tr>
<td>• use of a competency checklist</td>
<td></td>
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<tr>
<td>• modified text</td>
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</table>
Assistive Technology Resources


Table 3

Assistive Devices Accessible from the Internet

<table>
<thead>
<tr>
<th>Device Type</th>
<th>Hardware</th>
<th>Software</th>
<th>Hardware</th>
<th>Software</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternative keyboard</td>
<td>136</td>
<td>324</td>
<td>Braille output</td>
<td>125</td>
</tr>
<tr>
<td>Braille input</td>
<td>24</td>
<td>63</td>
<td>Dedicated communicator</td>
<td>126</td>
</tr>
<tr>
<td>Keyboard emulator</td>
<td>56</td>
<td></td>
<td>Environmental control</td>
<td>68</td>
</tr>
<tr>
<td>Keyguard</td>
<td>41</td>
<td></td>
<td>Large print display</td>
<td>74</td>
</tr>
<tr>
<td>Optical character recognition</td>
<td>11</td>
<td>23</td>
<td>Printer</td>
<td>40</td>
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<tr>
<td>Switch</td>
<td>151</td>
<td>148</td>
<td>Speech output</td>
<td>193</td>
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<tr>
<td>Voice recognition</td>
<td>9</td>
<td>48</td>
<td>Modem</td>
<td>28</td>
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<tr>
<td>Mouse emulator</td>
<td>93</td>
<td></td>
<td>Speech trainer</td>
<td>1</td>
</tr>
<tr>
<td>Telecommunications</td>
<td></td>
<td>30</td>
<td>Switch interface</td>
<td>79</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Disability</th>
<th>Hardware</th>
<th>Software</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hearing – 244 options</td>
<td>43</td>
<td>201</td>
</tr>
<tr>
<td>Learning – 1015 options</td>
<td>157</td>
<td>858</td>
</tr>
<tr>
<td>Cognitive – 889 options</td>
<td>172</td>
<td>717</td>
</tr>
<tr>
<td>Physical – 737 options</td>
<td>291</td>
<td>446</td>
</tr>
<tr>
<td>Speech – 655 options</td>
<td>180</td>
<td>475</td>
</tr>
<tr>
<td>Vision – 483 options</td>
<td>207</td>
<td>276</td>
</tr>
</tbody>
</table>

Each option is followed with a short description of the device and its use. The description includes technical information, address of vendor, and approximate costs. Additional lists provide information about the manufacturers and their products.

Most individuals with disabilities can engage in two-way communication if sufficient effort is made to obtain an appropriate assistive technology. A few categories and short descriptions are listed, taken from the Web site of the University of Washington Adaptive Technology Laboratory (University Adaptive Technology Lab, 2000), to provide you with an awareness of some common assistive devices.

**Alternative Input**

HeadMaster (Prentke Romich Company) and HeadMouse (Origin Instruments) allow hands-free operation of a Macintosh or PC (HeadMouse only). A lightweight headset (HeadMaster) or a reflective dot worn on the forehead (HeadMouse) translates head movement to the mouse pointer.

The DARCI TOO (WestTest Engineering) and Adap2U (AdapTek Interface) for PC and Kenx (Don Johnston) for Macintosh are alternative input devices that allow switch input control of a computer (via sip and puff, paddle, or jellybean switches). The user can use regular, step, inverse scanning, or Morse code input methods with a variety of switches.
Word Prediction

Co:Writer 2 (Don Johnston), Screen Doors II (Madenta Communications), and Telepathic (Madenta Communications) are word prediction software packages that operate on a Macintosh. They simplify the text entry process, especially when used in conjunction with an alternative input device.

Alternative Keyboards

Intellikeys (IntelliTools) is a large programmable keyboard with a variety of overlays designed for individuals with limited fine motor control. Only light pressure is required to activate the keys. Both Macintosh and PC versions are available.

Keyboard Aids

Accessibility Options Control panels (Microsoft), and Easy Access (Apple) are features that assist individuals who, due to mobility impairments, can press only one key at a time. They allow two- and three-key functions to be accessed by pressing single keys sequentially on the keyboard of a PC. They make it possible to perform mouse functions by pressing single keys on the keyboard.

Mouse Alternatives

A Track Ball (Kensington) and GlidePoint Trackpad (Cirque) are pointer alternatives that replace the mouse on a Macintosh or PC.

Comfort Aids

A CarpalRest hand rest (Fox Bay Industries), marvel Wrist Support (Office Emporium), and WristAir 2000 (Wristair) provide support in front of the keyboard for those who require extra wrist support while typing. A document holder (Fellowes) helps people with disabilities position documentation so that it is easy to read.

Optical Character Recognition Scanning Package

The Open Book Unbound (Arkenstone) package, installed on a PC, offers powerful document scanning and voice output. Components include a Scanjet IIc Scanner (Hewlett Packard) and a DECTalk (Digital Equipment Corporation) voice synthesizer card. The system uses optical character recognition (OCR) technology to convert scanned documents to text that may be saved in a variety of formats.

Screen Readers

OutSPOKEN Screen Reader (ALVA Access Group) for Macintosh, and JAWS for Windows 3.0 (Henter-Joyce) allow a visually impaired user to navigate a graphical interface using voice output and sound cues.

Braille Output

Index Braille Embosser (Access Systems International) prints PC output in Braille. Duxbury (Duxbury Systems) allows the computer to translate text into Braille format and send it to the Braille embosser.
Navigator Refreshable Braille Display (Telesensory Systems) provides a tactile Braille display of a PC screen, allowing the user to read what is on the screen 40 characters at a time.

**Braille Notetaker**

The Braille’n Speak 640 (Blazie Engineering) is a portable Braille note-taking device with speech output. This small unit contains 640K of active memory and has a built-in spell-checking utility. It can connect to a PC via a serial port for file transfer.

**Word Prediction**

Inspiration (Inspiration Software) is a brainstorming and writing tool that allows ideas to be represented graphically and converted to outline format. IntelliTalk (Intellitools) is a simple talking word processor that can speak letters, words, or sentences through a variety of sound cards. It is available for PC and Macintosh platforms. Mathcad (MathSoft) is a program that uses standard math notation to represent problems and graphs, allowing a person who can’t use pen and paper to show his or her work.

**Hearing Protectors**

Hearing Protectors (American Optical Corporation) can be helpful to individuals who are distracted by noise in the facility.

**Visual Cues for Computer Sounds**

When the sound level is set to zero on a Macintosh, a visual cue is provided as an alternative to sound for the individual with a hearing impairment. Accessibility Options Control Panels for Windows 95 and 98 (Microsoft) include a "Show Sounds" option that blinks the screen or puts a small musical note in the upper left-hand corner of the display whenever the computer makes a sound.

**Software**

Software products are an emerging, rapidly changing, and advancing field of assistive technology. The TRACE center at the University of Wisconsin and the Center for Assistive Technology and Environmental Access at the Georgia Institute of Technology, funded by the National Institute on Disability and Rehabilitation Research, are constantly producing new assistive technology products and are assisting with dissemination. The centers provide information about product databases, assistive technology related organizations, training and professional development opportunities, and upcoming professional conferences. Although there are many software products, three products important to science teaching are noted below.

**Kurzweil 1000 and 3000.** Kurzweil 1000 and 3000 is the most widely used program for students with literacy and language problems. Kurzweil Educational Systems has a text-to-speech software program, to assist students in reading, writing, and study skills. The program is content independent and offers multiple means of representation, expression, and engagement for both students and teachers. It is suitable for students of different ages and abilities.

In the area of representation, Kurzweil 1000 and 3000 can change reading speed or voice, magnify texts, change color for improved visibility, customize toolbars, and create portable audio files for text. It can provide language support for English Language Learners via different language voices and foreign
dictionary support. The software has easily accessible audible reference tools such as dictionary, thesaurus, and encyclopedia. It also demonstrates study strategies and provides opportunities for skills practice.

Kurzweil 1000 and 3000 offers opportunities for expression in a digital environment. It allows students to answer text-based questions in a variety of ways. It can easily reread blocks of text, proofread work, do editing using audible spell check and facilitate writing using word prediction. It can be used to add auditory text support for e-mail and instant messaging. The developers are engaging in collaborative efforts with many other software companies to improve engagement opportunities. Although the program does not have voice recognition it can work with speech-to-text software. They have collaborated with Mayer Johnson to provide picture symbol dictionary, Vcom 3D for American Sign Language Accommodations, and Intelliswitch or Discover USB Software concerning switch accommodations enabling individuals with motor impairments to perform all keyboard and mouse functions.

The next two products relate to mathematics which is often the gatekeeper to students that SMET Careers. Mathematical expressions have unique notations which provide substantive and complex information to those who can see them. It is an ongoing challenge to replicate the efficiency of mathematical expression for print-disabled students. Two efforts, Math Speak and MathML, are among the leading initiatives in this area.

Math Speak. The Math Speak project is centered at Purdue University to develop a new technology that allows mathematics and science to be conveyed verbally as well as visually, thereby enabling print-disabled students improved opportunities to learn. Math Speak is a high-tech solution involving the use of a computer to read SMET materials using a special language just for the aural rendering of mathematics. The goal is to retain semantic meaning successfully decoupled from the visual presentation. This will provide access for persons with visual impairments, learning disabilities, and other disabling conditions to higher level mathematics.

Mathematical Markup Language (MathML). MathML is intended to facilitate the use and re-use of mathematical and scientific content on the Web, and for other applications. MathML can be used to encode both the presentation of mathematical notation for high-quality visual display and of mathematical content for applications where the semantics plays more of a key role such as scientific software or voice synthesis. Although the mark-up language HTML has a large repertoire of tags, it does not function well for mathematical operations. MathML attempts to capture something of the meaning behind equations rather than concentrating entirely on how they are going to be formatted on the screen. It uses XML which is closely related to HTML and assumes a very similar, but not identical syntax. MathML is intended to facilitate the use and re-use of mathematical and scientific content on the Web.
Science teachers have widespread concern for safety when working with students with disabilities. In an April 2000 survey of grade 7-12 science teachers, 59% of the respondents believed that students with disabilities presented an increased safety risk in a laboratory setting (Stefanich, 2000). However, no research evidence has indicated that students with disabilities are at greater risk than other students. Yet, classroom safety is always a concern, and it is true that the accident rate of students in school chemistry laboratories is considerably higher than that of the chemical industry. Research into the factors that accompany school accidents indicate accidents happened because of:

- Inadequate or poorly designed working space, overcrowding, and too few workstations
- Teachers with poor course work preparation
- Teachers who are teaching more than two preparations at the same time
- Poor school discipline
- Inadequate safety training

Some teachers fear that students with disabilities may be uncontrollable in the lab, creating a safety hazard for themselves and others. Again, no evidence has indicated that students with disabilities in the regular classroom are more disruptive on the average than other students. In fact, one advantage of working with students with disabilities is the extra assistance available. If a behavior problem arises, the special education teacher or aide can help find a solution. Of course, continuous disruptive behavior by any student cannot be allowed in the laboratory. For a special education student, a re-evaluation of placement can be requested if necessary. In some cases, it may not be in the student’s best interest to be in a regular laboratory environment with other students. However, this should be a rare exception, not a common practice.

Fortunately, the most important strategy for ensuring the safety of students is simply a good safety program! For example, elements concerning safety should be highlighted in instructional materials and reinforced both verbally and in print materials the students use. Adaptive strategies may be necessary for some student disabilities. This simply means modifying instructions, like giving the safety test orally. The special education teacher can provide other ideas and can often help with adaptations, for example, helping a student in the resource room. For liability purposes, keep all safety tests or checklists on file.

A good safety program requires constant teacher awareness. All students need reminders, especially if they have not recently used a particular piece of equipment. Also, it is imperative to require the use of safety devices, like safety glasses. Discuss emergency communication procedures with the students, outlining the steps in case of an accident. This chapter includes a list of suggested elements for a good safety program.

With a comprehensive safety program, additional safety adaptations for students with disabilities will be minimal. When a special student is placed in a regular classroom, one needed alteration may be more emphasis on safety. When a group of special students has a maturity level significantly below their age, a separate or organizational laboratory experience outside of regular laboratory times may be needed. In this case, an adjusted safety program can be developed based on student needs. The Science Safety Inspection Checklist in Appendix B can serve as a beginning point (Morley, Johnson, & Callahan, n.d., p. 223, Adapted with permission).
Duties of Laboratory Assistants

Lab assistants can play a vital role in helping students with disabilities get the most out of their laboratory experience.

Matthews (2000a) lists the following recommendations for laboratory assistants. The amount of assistance may vary from experiment to experiment. The instructor and the student should assess each experiment to determine appropriate assistance.

When assisting a student who cannot physically do the experiment, the assistant will

1. Follow the directions given by the laboratory instructor and student being assisted.
2. Physically manipulate the lab experiment as needed.
3. Discuss the procedure with the student before proceeding, whenever possible.
4. Not solve problems for the student.
5. Permit the student to participate as much as possible in the process.
6. Not discuss the student’s experiment or progress with the instructor or anyone else without the student’s presence and permission.
7. Follow all of the lab safety rules and adhere to all lab policies as outlined in the syllabus, lab manuals, and other pertinent written materials.

When assisting a student who cannot write lab notes, the assistant will:

1. Follow the directions given by the laboratory instructor and student being assisted.
2. Write only when the student directs.
3. Not solve problems for the student.
4. Be prepared to assist if the student does not know how to write a symbol, draw a picture, or write a formula.
5. Not discuss the student’s experiment or progress with the instructor or anyone else without the student’s presence and permission.
6. Follow the lab safety rules and adhere to all lab policies as outlined in the syllabus, lab manuals, and other pertinent written materials.

When assisting a student who cannot see, the assistant will:

1. Describe the components of the experiment.
2. Read all printed materials such as directions, labels, charts, etc.
3. Follow the directions given by the lab instructor and student being assisted.
4. Physically manipulate the lab experiment as needed.
5. Wait for the student’s instructions before proceeding whenever possible.
6. Not solve problems for the student.
7. Permit the student to participate as much as possible in the process.
8. Not discuss the student’s experiment or progress with the instructor or anyone else without the student’s presence and permission.
9. Follow all of the lab safety rules and adhere to all lab policies as outlined in the syllabus, lab manuals, and other pertinent written materials.

Legal Considerations

The primary function of a school safety program is to prevent accidents. If an accident does occur, it is normally one of the following:
1. Pure accident: An unavoidable accident that could not be foreseen by the student or instructor
2. Intentional act: An accident intentionally caused
3. Negligence: An accident resulting from the instructor, students, or a combination acting in a careless manner

Negligence is a major concern for instructors. To be held liable for negligence, it must be shown that an instructor failed to exercise the care expected of a reasonable and prudent person. Determination of a reasonable and prudent person includes (a) acting in a manner consistent with how a person of ordinary intelligence and foresight would act under similar circumstances, and (b) providing care consistent with the danger involved and age and maturity level of the student.

School boards and school districts held liable for allowing a lack of proper facilities and mandating curricula for which facilities were inadequate. The best protection for science teachers is to inform their superiors about facilities that do not provide a safe working environment. Any of the following factors might result in litigation:

- Inadequate space
- Poor ventilation
- Conditions that lead to poor supervision of students
- Lack of safety eyewashes, safety showers, or alarm systems
- Lack of adequate lighting
- Lack of equipment or chemical storage
- Unsafe electrical outlets (Biehle, Motz, & West, 1999)

The best defense against a charge of negligence is having a good safety plan and adhering to it. The courts expect a reasonable and prudent person to account for four areas if an accident occurs: having a plan; following the plan; providing for health and safety; and giving proper instruction. For example, if you are lax about safety glasses and an accident occurs, this would be considered negligence in following the safety plan. More teachers are found negligent for failing to follow a plan to prevent injuries than for failing to plan and foresee dangers.

Another important consideration in negligence is foreseeability. A reasonable and prudent instructor is expected to foresee potential dangers and take necessary precautions to avoid accidents. For example, if a student is injured while using improperly working equipment (i.e. glassware that is not checked for cracks), the instructor may be held liable. Another example is making objects in class that can be potentially dangerous outside class. An instructor may be held liable if a student is not warned of this potential danger. An example might be an electrical tester. If electrical safety is taught and documented, then the instructor has fulfilled his or her obligation.

Many states have a "save-harmless" law that protects employees from financial loss that results from assigned duties. If an instructor is found negligent in a school accident, the school district will usually pay the damages. However, this does not protect the instructor and administrator from being charged with the accident and defending the instructional plan in court. This law also does not protect the instructor from damage to personal reputation (Morley, Johnson, & Callahan, n.d., p. 223-224. Adapted with permission).

**Suggested Safety Program Components**

The following components are suggested for a comprehensive safety program:
1. Policy and objectives
   a. School system policy
   b. Lab use policy
   c. Program safety objectives
2. Safety inspections
   a. Annual lab safety inspection and recommendations
   b. Annual architectural accessibility inspection and recommendations
3. Instruction
   a. General lab safety rules
   b. Specific equipment safety rules
4. Evaluation and documentation
   a. Cognitive tests
   b. Performance tests
   c. Record-keeping form for documentation
5. Emergency action
   a. Emergency action procedures (primary and secondary)
   b. Parent/guardian communication
   c. Accident report form
   d. Hazardous conditions report form
   e. Tags for nonworking equipment
6. Maintenance
   a. Maintenance cards for equipment

**Suggested Teaching Procedures**

1. Be sure that eye protection is worn. Have the students remind each other that safety glasses must be worn.

2. Check out all students on the laboratory apparatuses that they are about to use. Review the safety rules from time to time with each student, especially after a student’s vacation or prolonged absence. Be sure to document this instruction review.

3. Check medical records to determine if any special students are subject to seizures, fainting spells, etc. If the teacher finds someone with one of these conditions, that person should be given extra attention while using all equipment.

4. Make students aware of the potential dangers of chemical supplies, glassware, etc.

5. Remind students periodically of the importance of keeping work areas clean and free of hazardous objects.

6. Supervise all students and keep them busy to limit horseplay. The amount of horseplay from special students will depend on the professional personnel and the rules established for the laboratory.

7. Isolate special students when they violate laboratory rules. However, a primary instructional goal must be to keep the students separated from the rest of the group no longer than one class period.

8. When appropriate, assign special students to a certain lab area and be sure they understand they must stay there.
9. Test a special student’s abilities using continual teacher observation and student demonstration.

10. Evaluation should include feedback to insure student comprehension.

11. Make modifications in operations and supplies to promote a higher level of student success while doing laboratory experiments.

12. Enhance communication between teacher and student by using devices that improve reception and expression of information. Amplifying and magnifying stimuli, whether coming in or going out, are important considerations.

13. Individualize the program of instruction as much as possible to modify the instructional method to meet the needs of the student.

14. Plan to reserve a portion of your facility that can be made free from noise, physical stimuli, and visual stimuli. This may help students who are easily distracted.

15. Maximize access barriers to sinks, doorways, laboratory solutions, tools, etc.

16. Accept students as they come to you. Keep in mind that their success depends not only on their own characteristics and abilities, but also on the teacher’s attitude and the quality of the learning environment.

17. Employ the aid of special education resource people on your school staff. These specialists can provide you with valuable information in dealing with the problems of the special needs students in your program.

18. Keep in mind that many special needs students respond very favorably to frequent acknowledgment and positive reinforcement.

19. Encourage heterogeneous grouping in the classroom. Placing the special student in a small group of students with various abilities will provide a model for behavior in a laboratory (Morley, Johnson, & Callahan, n.d., p. 224-225. Adapted with permission).

**Emergency Action**

Emergency situations can arise anywhere in a school. The procedures for dealing with these events should be developed and approved by each district or building before the school year starts. Review and revise these procedures periodically to determine their effectiveness, and review appropriate accommodations for moving special needs students.

Two areas of concern arise in emergency situations: (a) activities that must be done immediately following an injury, and (b) actions to be taken after the confusion has subsided and the injured party is treated.

**Primary Concerns**

Your first concern relates directly to the injured party and reducing the hazard to that person. The degree of emergency care depends on the injury and the qualifications of the person administering the care. If you are not qualified in first aid, do only the things that will ensure no further damage to the injured student and immediately seek trained help. Your role might be limited to stopping the bleeding or
covering a person in shock with a blanket. Although every teacher should be trained in basic emergency first aid, many are not. Serious damage to the injured can sometimes result when they are treated by a nervous, untrained, panic-stricken teacher. Here are some basic first steps to follow when an injury occurs:

1. Determine the extent and type of injury. If this is not possible, immediately obtain professional help.

2. Restore breathing, restore heartbeat, and stop bleeding if you are trained in these areas; if not, send for help.

3. Apply only the first aid that is necessary to preserve life. Do no more until trained help arrives.

4. Disperse the crowd and keep the injured and the surrounding area as quiet as possible.

5. Ask students to notify the school nurse, principal, and immediate supervisor. Do not leave the injured alone.

6. If the injury is minor (splinter, slight cut), send the student to the school nurse accompanied by another student. Do not send the injured student alone.

7. If a foreign particle has entered the eye, seek professional help. A teacher should never try to remove something from a student’s eye. If a liquid has entered the eye (acid, etc.), immediately wash the eye in an eyewash and contact the nurse.

8. Notify parents and school officials.

It is your responsibility to know what to do in case of an accident and also what not to do. This kind of information is best obtained through a variety of first aid courses offered by the Red Cross and other agencies. The first few seconds or minutes of a pupil’s injury are sometimes the most critical. The action or inaction of the science teacher could be crucial to the student’s life.

**Secondary Concerns**

When the injured student has been treated by a medical professional (nurse, ambulance crew, or doctor), the teacher’s concerns focus on the remaining students and the follow-up procedures regarding the injury.

1. Calm the other members of the class. Restore the situation to a safe environment. If the accident was serious, discontinue instruction for the period. The students will be too upset to perform effectively and may in fact be "accident prone" due to the accident.

2. Complete an accident report in triplicate: one for the school nurse, one for the principal and immediate supervisor, and one for your permanent file (to be retained until the injured pupil reaches age 21; if the pupil is a special education student, retain permanently).

3. Analyze the cause and effect of the accident and make written recommendations to the principal for corrective measures to be taken. Retain a copy of this communication and subsequent action.

4. Review and record safety practices, procedures, instruction, and student evaluation concerning the cognitive, psychomotor, and affective instruction that was delivered and was intended to
prevent this type of accident.

5. Check on the treatment results of the injured pupil.

6. Follow up in your classes with a discussion and instruction regarding the safe practices that were violated and contributed to the accident.

These procedures should also be followed for "almost accidents" to ensure that the conditions that almost caused an accident are treated and eliminated from the class or lab.

**Emergency Communications**

Procedures established for emergency situations and accidents must contain the approved method of "who tells what to whom and when." To facilitate this communication, have a plan for contacting the nurse, building administrator, ambulance, fire and police departments. In addition:

1. All students should be familiar with the emergency procedures and telephone numbers.

2. If there is an accessible outside line, post the emergency procedures and police, ambulance, and fire department numbers and instructions for dialing an "outside" line.

**Communicating Safety to Parents**

For years, science teachers have sent home permission slips for parents to sign permitting their child to participate in field trips. Many teachers believed that this permission slip relieved them of some or all of their responsibility and liability should an accident occur. It does neither of these. The purposes of this type of communication are listed below. An example of this type of communication to the parents is included in Figure 5.

1. Inform the parent of his or her child’s participation in out-of-school activities.

2. Outline the safety instructions and procedures that are followed by the teacher and the district.

3. Obtain from the parent relevant information about health problems that may have a bearing on their child’s performance.

4. List the parents’ names and telephone number(s) where they can be reached during school hours and list the name of their family doctor.

**Hazardous conditions report.** Figure 6 presents an example of a form for reporting the hazard and directing action to see that the hazard is corrected or removed. If a hazard exists, the operation should be "red tagged" and shut down until corrected. (Note: This form can be used to report a student who is a hazard as well as a hazardous condition in the laboratory.)

**Accident reporting.** Any accident that occurs during a science class and in the science laboratory must be reported because this indicates corrective action needs to be taken by the teacher, administrator, or both. This applies to after-school accidents and those during the school day.

A form for reporting these accidents can be adapted from the one presented in Figure 7. This report should be completed in triplicate: one for the principal, one for the school nurse, and one for your permanent file. The following guidelines for reporting and analyzing accidents should be useful.
1. Require students to report all accidents to the teacher, regardless of nature or severity.
2. Keep a record of all accidents resulting in injury to students, regardless of nature or severity.
3. Analyze all accident reports to help prevent other accidents.
4. Use your school district’s printed or duplicated form to record the details of accidents and forward to the appropriate personnel (Morley, Johnson, & Callahan, n.d., p. 225-226. Adapted with permission).
School District
Science Department
School: 
Teacher: 
To: Parent or Guardian
(Name of Student) is enrolled in our science (specific science) program and will have the opportunity to use various equipment and laboratory apparatus and chemical supplies. Appropriate instruction in the safe operation of the laboratory is given, and close supervision is maintained at all times. Although every precaution is taken to prevent accidents, a certain risk is involved due to the nature of the experience, the age of the student, and the learning environment. We are asking your cooperation in impressing your child with the importance of being careful. We believe this will back up the instruction given in school. We welcome your visit to our school and the science department to see our program. These visits can be arranged by calling _________. Thank you very much for your help and assistance in providing your child with the “real world” experience of science in a safe working environment.

-----------------------------------------------------
I have read the attached communication and I understand the type of program that (student name) is enrolled in. I will stress the safety aspects of this program to my child. I encourage my child to participate fully in this laboratory program.

(Signature of parent or guardian)_______________________________ Date______________

Phone_______________(Home) _______________(Work)

Please identify any health problems that may have a bearing on your child’s participation in this class.

I agree to observe all safety rules and procedures for safe operation and conduct in the school science laboratory and will wear approved eye protection at all times in the laboratory in accordance with state law.

(Signature of student)________________________________________ Date______________

Figure 5. Communication to parent on laboratory safety.
Date ______________

To ______________________________
(Building administrator, position, school)

Description and location of health or safety hazard:

Suggested solution:

Teacher signature___________________________

Distribution:
Original – Building administrator
1st Copy – Department chairperson
2nd Copy – Teacher reporting hazard
3rd Copy – District safety officer

Action taken:

By whom:_______________________________________________________
(Signature)

Figure 6. Hazardous conditions report.
Student name___________________________________________________ Grade________

Location of accident______________________________________________ Time ______a.m./p.m.

Date of accident _________________________________________________

Description of injury
_____________________________________________________________________________________
_____________________________________________________________________________________
_____________________________________________________________________________________

Location of instructor when accident occurred __________________________

Description of how accident happened
_____________________________________________________________________________________
_____________________________________________________________________________________
_____________________________________________________________________________________

Indicate experiment, apparatus, chemicals involved_______________________

Describe unsafe practices, if any, contributing to accident________________________

Suggestions for prevention of similar accident____________________________
_____________________________________________________________________________________

Witness to accident 1.______________________________________________
2._________________________________________________________________________

Instructor’s signature_______________________________________________ Date______________

Student’s signature___________________________________________________ Date______________

Note: One copy to be filed with department chairman

Figure 7. Student accident report to be compiled by instructor.
Safety Practices for All Areas

Safety rules vary from one school to another. However, most school laboratories have definite rules and regulations to follow, and the teacher has the responsibility to enforce them. A successful safety program results from an understanding by the students of the reasons and the advantages for each rule. Listed below are eight basic safety rules for students (Matthews, 2000).

Rule 1 Have the teacher approve all work that you plan to do and all equipment that you plan to use.
   a. Protect all class members from accidents caused by careless or incompetent use of equipment and chemicals.
   b. Ensure that laboratory equipment and supplies are not abused or misused.

Rule 2 Have the teacher’s permission before using any laboratory apparatus. Reasons:
   a. Ensure that you understand the proper laboratory procedures and can perform them safely.
   b. Allow the teacher the opportunity to check the condition of the apparatus.

Rule 3 Always wear approved eye protection whenever anyone is working in the laboratory or wherever eye hazards exist.

Rule 4 Wear clothing suitable for the laboratory, and always wear your laboratory apron when appropriate.

Rule 5 Make sure that no other student is in your laboratory area.
   a. Prevent crowding and bumping.
   b. Give the student conducting the experiment complete responsibility in the use of the apparatus.

Rule 6 Cooperate with your classmates in the student management of the laboratory.
   a. Make sharing in the responsibilities of laboratory management a satisfying experience.
   b. Do your share of tasks to maintain a desirable place to work.

Rule 7 Do not work in the laboratory unless a qualified science teacher is present.
   a. The science teacher is responsible for the personal safety of each student in his or her classroom or laboratory.
   b. The safety of the students working would be jeopardized without proper supervision.
   c. The professional status and reputation of the teacher would be jeopardized if an accident occurred.

Rule 8 Report all injuries, even though slight, to the teacher immediately.
   a. The teacher will determine if treatment is required for the injury. Immediate attention may be given by the teacher.
   b. First aid treatment helps prevent minor cuts, abrasions, bruises, or burns from becoming infected.
   c. Assist the teacher in correcting situations to prevent further injuries.

Figure 8 provides an example of a student safety guide.
This section of the guide should be readily accessible to all students as active participants in the school safety program. Teachers should encourage suggestions and contributions to this guide as an ongoing activity to keep abreast of changing trends in the school.

A Message to Students

You should learn about the procedures, equipment, and chemicals so that you can use them with confidence instead of being afraid. Don’t fake it…learn it! Horseplay in the laboratory is unacceptable and dangerous for both the perpetrator and others. We talk a lot about common sense and why the other person doesn’t use it, but in the school laboratory the whole safety program depends on it, and that means everyone in the course—no exceptions. It does require involvement by you, the individual student. Do your thing for safety because other students are depending on you.

Student Responsibility

As a student in science, you have a responsibility not only to yourself but to the group for safety in the classroom and the laboratory. Teamwork is required for the safety of all members who participate. Don’t wait for the next person to correct an unsafe condition; just correct it or call it to the attention of your teacher.

General Safety Rules for all Students

1. Review your experimental procedures and all apparatus you plan to use.
2. Wear appropriate clothing. Always wear an apron when appropriate.
3. Long hair should be confined.
4. Wear shoes at all times to prevent foot injuries.
5. Always wear approved eye protection.
6. Caution any student you see violating any safety rule.
7. Report to the teacher any equipment that does not seem to work properly.
8. Keep equipment and materials from extending over the edge of benches whenever possible.
10. Cooperate with your classmates in the management of your laboratory.
11. Keep floor clean.
12. Wipe up immediately any liquids spilled on floor.
13. Report all injuries to your teacher immediately.
14. Know and practice procedure to follow in case of fire or other disasters.
15. Keep hands and floor area completely dry.
16. Keep talking to a minimum and keep your mind on your work.

Figure 8. Example of a student safety guide.

Note. From Industrial and Vocational Education Safety Guide and Safety in the Science Laboratory, by S. Matthews, 2000b, St. Louis: St. Louis Community College ACCESS. Adapted with permission.

There is certainly a need to follow and enforce good laboratory practices and sensible safety measures for students. Those that follow are a few that are particularly oriented toward students with disabilities. This is not an attempt to provide a comprehensive discussion on lab safety.
Give the student with impaired vision an opportunity to become familiar with the lab before the first session. The student can then participate in the safety-orientation program with little trouble and will already know the location of exits, showers, and extinguishers.

Discuss and resolve individual limitations with the student with impaired vision. Can the student read labels? Are the labels big enough? Consult with the student as to whether there are any operations too risky for the student to handle alone.

Ensure that reagent containers are labeled clearly and returned to their shelves after each use. These shelves or the materials used for each lab assignment should be readily accessible to the student with a disability.

Assign the student with impaired mobility to a lab station on an outside aisle and close to an accessible exit, if possible.

Students, including those with impaired vision or poor manual coordination, are strongly urged to wear rubber gloves when working with harsh chemicals or those readily absorbed by the skin. Disposable, lightweight gloves are available, which will allow the student to manipulate equipment.

All students should wear plastic or rubber aprons when working with chemicals in order to protect their clothing. Students in wheelchairs or those who have no sensory perception in the lower half of the body should be advised of protecting their laps with a heavy rubber apron while working with chemicals.

Accessible and usable eyewashes should be located near the disabled student’s workstation.

When a deaf student is working in a lab, it is helpful to have available equipment with lights or other visual means of indicating on/off status, although most equipment can be monitored easily by touch. Alarm systems also should be visual, with flashing lights. Expensive changes to equipment are seldom needed for deaf students. For example, they can feel when a timer sounds if they are holding it or touching it. They can observe if an exhaust hood is working by observing a piece of tissue taped inside the hood.

Ideally, combustible gas supplies from gas jets on the benches should contain odorants. Students with hearing impairments may not hear the sound of an open gas jet.

Lightweight fire extinguishers should be provided for mobility-impaired students, but all students should be instructed in the use and limitations of fire extinguishers and in fire drill procedures. Lightweight dry chemical fire extinguishers are often the only kind a mobility-impaired student can handle.
Chapter 6
Assessment and Evaluation

Assessment is a major and necessary component of education. After all, it is beneficial to receive an appraisal of your work. But assessment in the world of education typically leads to controversy. Some believe assessment can serve as a stimulus for education reform while others think it’s a deterrent to educational programs sensitive to individual differences. This chapter discusses the implications of assessment and evaluation when students with disabilities are included in the classroom. The problems of using test results, the purposes of tests, the advantages and disadvantages of several kinds of assessments, and recommendations for the future use of assessment and evaluation are among the issues explored.

The Issues

Much of the controversy swirling around educational assessment exists because groups involved have different
a) agendas,
b) widely different views on the validity and reliability of standardized assessments,
c) concerns about how the results of assessment will impact the students being tested,
d) concerns about how the results of assessment will be used to evaluate those giving instruction or delivering programs,
e) concerns about how legislative bodies will use the information from assessments in funding and evaluating schools,
f) concerns about the use of assessment in labeling and categorizing students, and
g) concerns about whether or not the test(s) accurately assess the knowledge of the individuals and their ability to perform in tasks relating to qualifications.

How Test Results are Used

While the question of how test results are used is the newest controversy in assessment, questions concerning assessment go back a long way. In fact, many perceive that American schools were becoming increasingly less accountable, allowing casual students to receive diplomas and casual teachers to sustain employment. As one result, high-stakes testing has emerged in the last decade. For instance, some state agencies and/or independent school districts require certain performance levels on standardized or criterion-referenced tests before students receive a grade advancement or diploma. Many in education see such high-stakes testing as a positive, necessary means to hold professional educators and students accountable for responsible and attentive actions to their duties. High school teachers in states with student competency exams perceive that a larger percentage of students demonstrate a more serious approach to their studies when performance-level assessment is involved. Increased legislative pressure stimulated largely by No Child Left Behind has also required that school districts establish outcomes and construct assessment tools that evaluate student learning.

However, there’s a flip side to such potential benefits of testing. High-stakes testing initiatives have not been in place a long enough time to bring to light their political, financial, and social consequences to students who are unsuccessful, or to determine how those students’ subsequent choices may affect society in general. For example, we know that where there is high-stakes testing, educational agencies and families have incurred increased costs for remediation and supplemental instruction. The negative consequences to students who do not pass these tests and are retained are consistently noted in the educational literature. The social costs to students who choose to drop out and not continue school will need to be evaluated. The greatest threat to arbitrary enforcement of standards may be the ability to withstand political challenges. The rhetoric of "leave no child behind" is especially formidable.
Ongoing discrepancies exist between results of testing shared with the public and the professional interpretations of the data. For example, for dropouts there are no data, and scores for students with a special education label are often not included in group reports. Students with disabilities are over represented in schools with lower expectations and content deficits. If this results in diminished funding and/or increasing threats, the school climate is destined to become more punitive and demanding, putting more pressure on those least able to handle intimidation.

Along with the well-intentioned rush toward accountability has come a tendency to characterize the performance of a child by a single number or series of numbers. Empirical investigations of standardized tests consistently find that socioeconomic status, broadly defined, accounts for 85-90% of the variance in test scores (Kohn, 2001). Upon closer scrutiny, the validity of the screening tests to identify students with disabilities is suspect. These same numbers are often used further to interpret the quality of teaching and the performance of the school. But, the meaning of education for teachers and students cannot be reduced to one single number for any purpose. It is important to look at the broader implications regarding the purpose of schools and the impact of schooling on each individual student.

As parents and community members become more familiar with high-stakes testing and standardized tests, they become more critical and more disenfranchised. However, school testing is currently being driven by a top-down, heavy-handed, corporate style version of school reform that threatens the basic premises of school improvement (Kohn, 2001). It suits the political appetite for rapid quantifiable results (Thompson, 2001). Innovations supported by best-practice research are overlooked, particularly in communities where the need for developmentally appropriate practice is most critical.

**Effects on the Curriculum**

Perhaps the greatest danger of high stakes testing is the tendency to narrow the curriculum for those who most need a variety of educational experiences. Sometimes the tests themselves are used to define the boundaries of the curriculum. In such cases, teachers spend excessive time preparing students and modifying their curricula to conform to test items that appear on the mandated achievement tests. The result can be a substantial long-term cost for minimal short-term gain. Students in low-performing schools often face an increased focus on basic skills with less attention to the broad fields of science, social studies, humanities, and the arts. Yet, an exposure to these content areas is critical in developing higher order thinking skills, which become ever more important as students progress through the educational spectrum. Eisner (2001) has expressed concern that when there is only a limited array of areas in which assessment occurs, students whose aptitude and interests lie in other areas become marginalized. The importance of having informed educators who actively participate in establishing appropriate parameters cannot be overemphasized.

Science is particularly vulnerable to assessment effects on the curriculum because one of the best ways to raise test scores may well be to teach badly—to fill students full of dates and definitions and cover a huge amount of material in a superficial fashion (Kohn, 2001). Yet research shows that well-prepared teachers and in-depth teaching make a difference. National Science Teachers Association Reports (2000-2001) notes that in a comparison of the results of the Third International Mathematics and Science Study conducted in 1995, Minnesota eighth grade students scored significantly higher than other eighth graders in the United States and were second only to students from Singapore. Internal investigations show Minnesota teachers introduce fewer topics and devote more time to developing them in depth. They embrace hands-on teaching and are better prepared in science. While 74% of science teachers as a whole hold a major in science or science education, the figure in Minnesota is 97%.
Identification of Students with Disabilities

Students with disabilities present a particular challenge concerning assessment and evaluation. Under the requirements of IDEA, students with disabilities are eligible to have testing modifications to enable them to demonstrate their learning. This has been done successfully for students with visible disabilities (physical, visual). But students with invisible disabilities present a problem. Specialists in identifying disabilities often disagree with classroom teachers about whether a student’s poor performance is due to a cognitive processing impairment or student apathy and defiance of the learning opportunities. In some disability categories, the primary criterion is performance at a certain level below average classmates. Therefore, if perfectly normal learners elect not to study and learn, they may get a disability label. This mix of students with bona fide learning disabilities with those who choose to ignore or disrupt the educational process presents a formidable challenge for valid assessment.

Effects of Testing Modifications

The increase in using minimum competency testing to determine whether a student has attained mastery of skills and competencies implied by the certificate (i.e., diploma, degree, and licensure) becomes a complex, controversial topic when students with disabilities are considered. When minimum competency tests or testing procedures are modified, questions arise about the coherence, quality, and accuracy of the modified test. Does the test adequately determine whether the individual has the needed skills and knowledge implied by the score or certificate? If there is not a uniform standard of proficiency, the certificate loses its significance as a representation of competence. On the other hand, if students with disabilities are not given a certificate, they face social stigma, embarrassment, increased likelihood of dropping out of school, and reduced job opportunities (Wolman, Bruininks, & Thurlow, 1989).

Guidelines about testing accommodations for students with disabilities are usually developed in conjunction with standardized tests or minimum competency tests in order to award high school diplomas. A partial summary of state written guidelines on testing accommodations is presented in Table 4 (adapted from Thurlow, Ysseldyke, & Silverstein, 1993, B1-B18). Often policies that states adopt for their assessment programs are insufficient and end up embroiled in controversy. The available literature reveals little consistency in assessment policy and little empirical research on how assessment practices have impacted students with disabilities.
### Table 4

**Written Guidelines on Testing Accommodations**

<table>
<thead>
<tr>
<th>Alternate Presentation</th>
<th>Alternate Setting</th>
<th>Student Response</th>
<th>Alternate Timing/Scheduling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large print</td>
<td>Administered in small group</td>
<td>With computer</td>
<td>Extra time</td>
</tr>
<tr>
<td>Braille Magnification</td>
<td>Administered in a carrel</td>
<td>Language board</td>
<td>Administered with breaks</td>
</tr>
<tr>
<td>Amplification</td>
<td>Administered in a special classroom</td>
<td>Writing template</td>
<td>At the time most beneficial for the student</td>
</tr>
<tr>
<td>Noise buffers</td>
<td>Administered at the student’s home</td>
<td>Speech synthesizer</td>
<td>At time most beneficial for the student</td>
</tr>
<tr>
<td>Templates</td>
<td>Administered individually</td>
<td>Exemption from written portion of examination</td>
<td>Testing over several days</td>
</tr>
<tr>
<td>Administration by a person familiar to the child</td>
<td>Administered with teacher facing student</td>
<td>Oral response</td>
<td>Administered with breaks</td>
</tr>
<tr>
<td>Computer interface options</td>
<td>Administered by special education teacher or other approved personnel</td>
<td>Exclusions included in the IEP, and indicated on the “Roster of Exclusions and Modifications”</td>
<td>Intermittent administration based on physical ability or attention span</td>
</tr>
<tr>
<td>Thermoforms</td>
<td>Adapted or special furniture</td>
<td>Voice input</td>
<td>Extra time</td>
</tr>
<tr>
<td>Oral presentation</td>
<td>Special lighting</td>
<td>Sign language</td>
<td></td>
</tr>
<tr>
<td>Tape presentation</td>
<td>Special acoustics</td>
<td>Marked response in test booklet</td>
<td></td>
</tr>
<tr>
<td>Sign language</td>
<td>Color transparencies</td>
<td>Mechanical aids</td>
<td></td>
</tr>
<tr>
<td>Avoided interruption</td>
<td></td>
<td>Calculator</td>
<td></td>
</tr>
<tr>
<td>Tactiles</td>
<td></td>
<td>Word processor</td>
<td></td>
</tr>
<tr>
<td>Use of place markers</td>
<td></td>
<td>Augmented communication</td>
<td></td>
</tr>
<tr>
<td>Use of interpreter</td>
<td></td>
<td>Dictated answers</td>
<td></td>
</tr>
<tr>
<td>Modality modifications</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Content modification to student’s IEP</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Simplify language of directions</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Revision of test format, rereading &amp; review of directions</td>
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<td></td>
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<tr>
<td>Provide additional examples</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Highlight verbs in instructions</td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

This issue of who takes minimum competency tests and when can be somewhat simplified if students with disabilities are placed into two groups: (a) those who require modifications in the instructional goals and curriculum, and (b) those who have the knowledge and can demonstrate adequate understanding with appropriate modification of the learning/testing environment. For students with disabilities in the first
group, there could be (a) a test exemption; (b) use of a different proficiency standard depending upon the instructional goals in the student’s IEP; or (c) a different level of acceptable test performance. However, there are implications about how such competency certificates (e.g. diploma, licensure) are interpreted when the data are used to make life decisions (e.g. admissions, employment.)

An exceedingly complicated and more fundamental equity issue concerns students with disabilities in the second group. Is it possible to make testing accommodations that remove irrelevant sources of difficulty but still measure the same construct? When the test form, mode of administration, language, extended time, and omission of certain types of items are applied, is the technical adequacy of the test (predictive, content and construct validity, reliability, coherence, comprehensiveness) compromised? Do the scores have the same meaning as those from standard administrations? If there are differences in the constructs being measured, can admissions officers or employers make decisions expecting equivalent performance?

In some states that use high-stakes testing, students with a disability label are eligible for graduation, whereas non-labeled students with the same performance scores are not. As a result, rather than holding students accountable as the tests were intended, the ploy becomes one of maneuvering to get a disability label for certain students to forego their personal accountability. It becomes a game of seeking an advantage for those with resources and/or influence to challenge the decisions implied by the test scores.

Testing accommodations for students with disabilities is not a new issue. Empirical studies, policy reports, and legal judgments are shaping decisions regarding the application and use of assessment tools for students with disabilities. Unfortunately, individuals far removed from educational practice are making many of the most influential decisions. In many states, professional education communities (administrators, teachers, and professors) are deeply involved. In others, mandates emerge from a state department of education containing requirements for compliance that are frequently compromised. Still in other cases, groups of educators representing as much diversity as possible are brought together for a short period, but are not given time to develop group consensus or a common platform. In the vast majority of instances the testing agenda is implemented, and the resulting problems that inevitably emerge become engulfed in controversy.

**Purpose and Use of Assessments**

Assessment and evaluation serve many purposes, and these frequently become confused in implementation. Internally, many states are working for an alignment of education standards and assessment. The standards are intended to convey expectations about what is important to learn, and the assessment is designed to determine the degree to which the students have acquired the learning expectations. Policymakers and administrators see the scores being used internally to help guide and improve instruction. The scores can also be used to differentiate between students and certify those who have met a standard. There are also external purposes. One may be to provide information for teacher accountability and administrators’ performance. If schools are viewed in light of a business model, productivity is reflected in the amount of student learning that has taken place as a result of the professional educator’s interventions. Assessment then can be used to guide school policy decisions and to gain information for program review and for effective resource allocations.

These distinctions between internal and external assessment purposes are not precise, and it is important to clearly communicate the format and purpose of assessment. Good assessments in school settings should not only measure student progress; they should also provide opportunities for student learning. Tests can increase student responsibility, motivation for learning, and provide feedback on what students know and are able to do.
Educational testing is a big business in the United States. The average student spends between 10% and 20% of his or her time at school taking tests. According to a study reported by Stiggins and Conklin (1992), about one-fifth of the testing time in elementary school mathematics involves standardized or commercially published tests. In most cases, students are in a passive role of answering questions rather than thinking about ideas and posing problems. The tests exclude many types of knowledge and performance contained in most schools’ mission statements and goals. The simple recall of facts and information is emphasized rather than higher order thinking skills (Madaus et al., 1992). Standardized and commercially published tests are often used for inappropriate purposes—to track students and allocate awards and sanctions (Darling-Hammond, 1999).

Types of Assessments

It is important to align assessment tools with their intended purpose and use only the information that is congruent with that purpose. The selection and use of assessments have special significance for students with disabilities and schools with a large percentage of students from segments of the disenfranchised population. Five types of assessments are described, four of which are commonly used—criterion-referenced, standards-based, management-oriented, and program-oriented—and one, responsive evaluation, which has shown great potential for providing a more comprehensive and insightful picture.

Criterion-Referenced Assessment

The primary purpose of a criterion-referenced assessment is to support instruction and facilitate learning. This type of assessment plan should be coherent, comprehensive, equitable, and engage all students. It should also be integrated with instructional strategies and curriculum materials to promote effective student learning and provide information that will yield valid information about student learning. One advantage of criterion-referenced assessment is that it does not have the threatening implications of some other types of assessments. The criterion-referenced assessment strives to help teachers determine desirable outcomes for every student who demonstrates effort and initiative. Some other forms of assessment (standardized tests, for example) tend to pit students against each other, using rewards and consequences. However, criterion-referenced assessment uses several methods of gathering accurate student data without putting students against one another. Conversations, questioning, signaled responses, discussions, hands-on assessment, and portfolios are all tools that work effectively. Brief overviews of each of them follow.

Conversation is an important informal way to gain information about what students have learned. Just asking students to describe what they did and what they have learned can give valuable information. If students respond with some misconceptions, they can be clarified or the student can be redirected. The conversation itself requires that the students reflect on what they have done and thereby serves as a learning tool. Enlisting value judgments, such as what they have confidence about and questions that they still have, can be used to guide their learning.

Through questioning, a teacher can often determine if a student’s understanding is secure or vague. When teachers inquire, students are more likely to be motivated to find solutions and answers. Through guidance and facilitation, students can be encouraged to apply their prior knowledge or research to solve a problem. The well-developed art of questioning, as illustrated by Socrates, may be one of the most valuable instructional aids any teacher has in his/her repertoire of teaching strategies.

A group or signaled response can give teachers a lot of information about instructional effectiveness, without singling out an individual student. Working with instructional techniques that allow students to display what they have learned in non-threatening situations can go a long way in improving instructional effectiveness. Students with disabilities are often aware of the social implications associated with
responses to teachers’ questions. Individual questions force students to respond in a situation where peers are making value judgments about the quality and depth of their understanding. It is not surprising that some students choose inappropriate actions rather than embarrassing themselves in front of their peers.

Discussions enable students to model democratic processes in the classroom. Through discussions students become familiar with the ideas of others and develop skills to clarify positions that reflect their own ideas. Van Zee (2000) has reported that a teacher’s role should be to guide discussions, to help students organize and facilitate knowledge, and to encourage students to stimulate the thinking of others rather than give information to transmit knowledge. To facilitate learning, teachers can increase their skills by listening more carefully, waiting longer for an answer, and using questioning to draw out the concepts from the students.

Hands-on assessments allow teachers to observe the quality of students’ performance in using science tools and science thinking. During inquiry-based investigations, students have higher satisfaction and less conflict with other classmates. In addition, they feel more familiar with the science education principles and are more able to share results of their work with audiences (Canton, Brewer, & Brown, 2000). Hands-on assessment activities engage students in actively doing science: They are encouraged to design investigations, collect their own data, gather information, and demonstrate outcomes of their investigations.

A portfolio allows students to tell a story about what they have done and what they have learned. The concept of portfolios was borrowed from the disciplines of art and architecture. The portfolio is an ongoing assessment strategy; teachers and students add and delete items all year long to reflect the student’s progress throughout the year. They provide opportunities for students to assess and reflect on their own work. Because students help develop their own portfolios, they are able to represent their own efforts and accomplishments in a concrete form. Another important element of a portfolio is the student-written proposal. It should provide a depiction of a student’s instructional goals, learning interests, and performance on a variety of learning tasks.

Standards-Based Assessment

A standards-oriented approach to evaluation involves all affected constituents agreeing on the purposes and uses of established goals, standards, benchmarks and/or objectives that can be measured and assessed. All fifty states have adopted state standards in some form, all based on the assumption that the educational context is the same for each child (Pilotin, 2001). The evaluation becomes a closed system, a way of thinking which defines the outcomes of instruction as immediately observable and ideally the same for everyone.

Maeroff (1998) has stated that high-stakes testing ignores what is known about the 20% of students who live in poverty and the majority of students with disabilities. Many of these students do not have an understanding of the academic system and cannot imagine how it connects with their lives. Enrichment is perceived as a better alternative. Furthermore, objectives relating to values, such as helping individuals gain perceptions and sensitivities to human diversity, are not articulated in standard-based assessment, simply because they are not easily measurable. Qualitative objectives so important to the success of disenfranchised populations (e.g., creating a sense of belonging, developing a sense of academic initiative, giving the child a sense of success and of knowing) are generally given little attention.

One strength of the standards-based minimum competency test is its simplicity. All parties involved in the process can understand expectations and monitor their progress. Parents and community constituents are clear about the common expectations for all students and are more likely to become involved in helping students meet the standards of performance. In practice, the assessment tools focus
largely on student understanding and application of the basic skill areas of reading, mathematics, and
writing. At higher grade levels, reading tests and application questions in mathematics depend heavily
upon student exposure to experiences in a variety of contexts or settings. Increased potential can be
developed through interactive hands-on experiences in the sciences, multi-modality experiences in social
studies, and in-depth experiences in the arts and humanities. In each of these fields, children of poverty
and students with disabilities are likely to receive fewer opportunities than those from advantaged
settings.

Low-performing schools often have a high turnover of both students and teachers. What is most
important is how the same individual students are doing as we follow them over time. However, this
becomes an almost impossible task in many of our schools with a large percentage of poor and
disenfranchised families where there is high student mobility. It is not fair to assess teachers and
administrators on their effectiveness with a revolving-door student population.

Standards-oriented approaches to evaluation can and should have a place in education. If tests are
reliable and valid, the data can be useful to decision makers. The information is generally less susceptible
to biases than that derived from more qualitative approaches. Some information can be used for increased
accountability. That is, the public appears to have more confidence in measurement results when test
scores that are convertible to standard scores.

Standards-based reform aims to hold high expectations for all students and provide high levels of
support. It is fundamentally concerned with equity and improving student learning across the board. It
shifts from a focus on inputs to a focus on improving the quality, content, and delivery of instruction
using a variety of assessments. According to Thompson (2001), under a system of authentic standards,
stakeholders are participants in the process of determining the standards for their school. For example,
professional development opportunities are available for teachers and administrators to support their work
to teach to the standards, student assessments are aligned with the standards, students have numerous
opportunities to demonstrate that they have met the standards; and high-quality individualized support is
there to help and guide students in their learning.

A concern is that test-based reform, as it is currently being implemented, is effectively sabotaging the
authentic standards movement. In too many cases the goal is to raise test scores with little consideration
of the learner’s needs. In authentic standards-based reform, the purpose is to enable all students to achieve
their creative, intellectual, and social potential as much as possible (Thompson, 2001).

When using standards-oriented tests to make decisions for students with disabilities, care must be
taken. Educators need to first understand that policy and legal considerations relevant to assessment and
the use of assessment data have been shaped by both constitutional and statutory law as next described.

The due process and equal protection clauses in the 14th amendment set forth two constitutional
rights: (a) a guarantee of equal protection under the law (in education, this translates into a guarantee of
equal educational opportunity, not equal outcomes); and (b) due process when state action may adversely
affect an individual.

Section 504 of the Rehabilitation Act of 1973 mandates that admissions tests for persons with
disabilities must be validated and reflect the applicants’ aptitude and achievement rather than any
disabilities extraneous to what is being measured. The Education for All Handicapped Children Act (PL
94-142) mandates that all children with disabilities receive a free, appropriate public education. It also
mandates due process rights, responsibilities of the Federal Government in providing some financial
assistance, and the requirement that special education services be monitored. In testing, according to
Suran and Rizzo (1983):
The tests used to evaluate a child’s special needs must be racially and culturally nondiscriminatory in the way they are selected and the way they are administered, must be in the primary language or mode of communication of the child, and no one test procedure can be used as the sole determinant of a child’s educational program. (p. 175)

The passage of the Americans with Disabilities Act in 1990 (PL 101-336), although intended mainly for industry, has many implications for educators, specifically about the licensing/credentialing process. This act requires that the test application process and the test itself be accessible to individuals with disabilities. Although a person may not be able to meet other requirements of the credentialing process, he or she may not be barred from attempting to pass the credentialing exam. The agency or entity administering the test must provide auxiliary aids and/or modification and may not charge the individual with a disability for the accommodations made.

Testing accommodations that may be provided include an architecturally accessible testing site; a distraction-free space; an alternative location; test schedule variation; extended time; the use of a scribe, sign language interpreter, readers, and adaptive equipment, adaptive communication devices; and modifications of the test presentation and/or response format (Thurlow, Ysseldyke, & Silverstein, 1993).

Concerning performance examinations in science, the facilities must be accessible and usable for individuals. Other requirements include the acquisition or modification of equipment or devices, appropriate adjustment or modifications of examinations, qualified readers or interpreters, appropriate modification in training materials and/or policies, and other similar modifications (42 USC 12/11, Section 101(9)). A person with a disability must provide documentation of the disability.

If standardized tests are to be of any value to teachers, information must not only be identified but also quickly retrievable. Use of a multivariate design with disaggregated data analysis is critical. With advances in technology comes the promise of developing a computer-based system in which data elements can be retrieved and matched with other data and used in multi-varied ways.

Under the reauthorized statute of IDEA in 2004, reporting of all children with disabilities must be included in all state and district wide assessment programs, with appropriate accommodations and alternative assessments where necessary and as indicated in the students’ respective IEPs. These assessments must be aligned with the state’s challenging content standards and challenging student achievement standards. Reporting requirements must include the number of students participating in regular assessments and the number of students provided accommodations.

Management-Oriented Evaluation

Many educators consider accountability one of the elements most lacking under the current model of American public education. While the increased use of high-stakes testing may hold students accountable, there is also public concern about accountability for administrators and teachers. All too often mediocre performance is common practice, and the protections offered through tenure, teacher unions, and vague accountability standards sustain that model.

Yet, any teaching/evaluation approach will come under question for several reasons. From a management point of view, it’s not possible to have consistency in the raw materials (students), there are insufficient controls to relate the treatment (teaching) to the students’ learning, and there is no agreement on the desired educational accomplishments of schooling. Still, teachers and administrators can find help from the research on effective schools and best practices to formulate a plan for administrator and teacher accountability using a management-oriented evaluation.
The importance and value of the effective administrator (manager) is strongly supported in the literature. Research originating in the late 1970s described characteristics or practices used in highly effective schools. Descriptions of practices found in schools that demonstrated higher levels of student performance were disseminated widely in educational journals. But since the 1970s, we’ve seen that when administrators have arbitrarily implemented these practices to improve their schools, the desired improved performance outcomes were seldom realized. The research findings on effective schools may be a delineation of the artifacts of effectiveness rather than the conditions that produce effectiveness.

What administrators/managers need to see is that effective schools have a positive culture that is facilitated and nurtured rather than imposed. Effective leaders generally find the best practice research to be a valuable guide to gaining a positive school culture, but they do not manage or impose elements found in the literature onto teachers or students like a medical prescription. The desired culture must be nurtured through a consistent and supportive transition period.

Healthy and sound school cultures correlate strongly with increased student achievement and motivation and with higher teacher job satisfaction and productivity (Stolp & Smith, 1994). Fullan (1992) wrote that administrators are often blinded by their own vision and are inclined to manipulate the teachers and school culture to conform to it. Cheng (1993) reported that strong school cultures have shared participation, charismatic leadership, intimacy, shared vision, and school-wide goals. Fyans and Maehr (1990) presented five dimensions that must be considered as influences on school culture: academic challenges, comparative achievement with similar students in similar settings, school-community commitment and participation, shared commitment to school goals, and recognition. All of these dimensions should be part of an evaluation if there is to be a level playing field when high-stakes judgments are made relating to administrator, teacher, and student performance.

A first step in any accountability plan must include an accurate evaluation of the school administrators’ credibility. Without this, all other evaluations are suspect. Such a plan needs to determine the following:

- Do the administrators know and understand the context of the setting they are evaluating?
- Are they trusted by their constituency?
- Are they consistent in implementing policies?
- Do the individuals in the organization perceive the administrative structure as one that encourages success and accomplishment for all participants?

Effective schools have administrators who display strong professional behavior, reflect the mission and renew and revise goals annually, regularly observe the classroom setting, make suggestions to improve instruction and teaching, and involve staff in the planning and decision-making process. Managers are generally in control of structure and resource allocation decisions within any organization. In such a critical role, evaluative information is an essential part of any good professional practice. The information collected, what it tells about the audience it is directed to, and the way the information is applied are all critical elements in evaluation.

School administrators/managers also need to serve as the instructional leader. Their duties must include personnel and process decisions involving program planning, program implementation, and both formative and summative program evaluations. The manager’s decisions affect both internal (students, faculty and staff) and external (community, state, and national) consumers.

Yet, little information is typically available on administrative evaluation. When conducted, the evaluation often consists mainly of survey data followed by a conference with an administrative superior,
a committee, or a school board. It is rare to have a credible, objective, professional evaluator who spends sufficient time in the educational context to gain a thorough understanding of the principalship. It is only through a deep and rich familiarity with the school context that credible recommendations can be forwarded to improve the administrators’ skills and the quality of the school.

Management-oriented evaluation models do exist (e.g. Stufflebeam, 1983). These models present a process to provide information about how a program is functioning and to make a value judgment on the worth of the program and its potential use in other contexts. The following are noted as strengths and weaknesses of the management-oriented evaluation model.

Perhaps the greatest threat of management-oriented evaluation is that the power resides in the decision makers. Those in power can manipulate resources, legislate policies, manage structure, and make personnel decisions without the accountability found in the free enterprise system. Raw materials (students) and social structures (family and community) are highly varied and multi-faceted. A behavioral approach of rewards and consequences based on achievement will likely have a negative impact on those students who most need support and cooperation. The utility or failure of assessment processes rests largely upon decisions made by management. They alone possess the power, the capacity to structure programs, and the ability to allocate resources in efforts to maximize school effectiveness.

However, management-oriented evaluation is often not favorable in schools with great challenges. Administrators and teachers providing admirable service in the most difficult conditions are likely to be victimized, as are students with disabilities and students of color. High student mobility, community support, and high staff turnover all make it difficult to establish a positive culture that has a powerful influence on school effectiveness. Management-oriented evaluation, then, heavily favors schools that can be selective in their student population. This idea runs counter to the foundation of public education in this country, where managers and decision makers must respect the special challenges of marginalized groups if any form of educational equity is to evolve.

The charter schools movement is one illustration of the power of management in such a challenged school system and its potential to victimize teachers and students. Almost without exception, charter schools require some type of contract of commitment from both the child and guardians. Then, if the child (and often the family) does not live up to the contractual commitments and responsibilities, the school retains the power of removal. Any school that possesses such power by administrative dictate cannot be compared with a public school that must work to educate all students regardless of their dispositions and unique learning needs.

Management surveys indicate that over 80% of our nation’s students are inclined to be compliant when instruction is appropriate for their needs. On the other hand, 2-5% of students come to school with devious intent. These students are a formidable challenge. And, any evaluation or educational model that increases the concentration of non-compliant students in one setting, where administrators are powerless to remove them, is bound to be inequitable. Jonathan Kozol’s (1991) book, Savage Inequalities, spells out the inequities and challenges faced by schools not within the mainstream culture and schools located in settings with a limited tax base.

It is important that administrative decisions be fair and equitable. Administrators must be informed about assessment results, including: the context from which the data were derived; the objectivity, reliability, and validity of the data; and the utility of the information relative to the decisions that are being made. They have a responsibility to communicate to all affected parties an awareness about the evaluation information and hold themselves accountable for inappropriate application and misuse of assessment data.
Along with power comes accountability. Administrators must be accountable to those affected and to the public they serve for decisions they make. The right of individuals to appeal decisions they feel are unfair needs to be protected, and due process procedures need to be developed.

**Program-Oriented Assessment**

The most common form of program evaluation throughout the United States is conducted through national or regional accrediting agencies that grant approval of educational institutions based on quantitative and/or qualitative standards. In most states, organization accreditation is supplemented or duplicated by state department of education accreditation.

The accreditation process includes three major facets. A reporting process with some minimal standards ensures that the facilities and educational materials are adequate, that there is sufficient breadth in the curriculum, and that the educators’ qualifications will lead to students receiving education that meets certain quality standards. This report is usually an annual, but sometimes more frequent, requirement. A second facet, usually required on a five-to-seven year cycle involves a self-study component in which the institution is required to define the mission and goals, explain how the institution is meeting the students’ needs, delineate strengths and aspirations (both short-term and long-term) and denote the tools of data collection and how the information will be used to guide school improvement. A third accreditation aspect, also on a five-to-seven year cycle, involves an external review, usually done by a team of peers who evaluate the alignment between the information reported in the self-study and the operational effectiveness of the program. It is critical to select evaluators who are credible, objective, reliable, and committed to help the organization improve. Site visitation is an important part of the evaluation process. Without an understanding of the context of the environment, it is unlikely that the evaluation will provide the depth necessary to improve the institution(s).

Many educational critics, however, view this oversight as being weak and ineffective. Some cite it as inherently incestuous. The standards and criteria are developed primarily by members of the educational community, and the visiting team members are drawn from the professional ranks whose work they will judge. Other criticisms come from the selection process itself. Usually the institution being accredited helps select and determine members of the visiting team. Programs with weaknesses can "color" criticism by selecting reviewers who are "team players" and will forward only "soft" criticism.

Another criticism is that the public education monopoly makes closing a school almost impossible. Therefore, even when weaknesses are noted, the corrective steps to regain accreditation are minimal rather than systemic.

When it comes to program review for students with disabilities, the degree of oversight in the program quality of regular education is generally minimal. It is not cost-effective to bring in reviewers with expertise in all disability areas represented in the student population. Low-incidence disability categories are slighted, including all areas of physical disability. Special education reviewers’ expertise is more likely to be in areas such as learning disabilities or mild developmental delays.

There is very limited awareness of discipline-specific assistive technology or learning aids. Therefore, shortcomings in the regular educational program concerning included special education students are rarely brought to light through a broad formal review system.

This presents a special challenge for those committed to educational equity and the conceptual framework of leaving no child behind. The public, for good reason, is questioning the credibility of accountability in education and perceives it as an incestuous system that generally fails to police itself adequately. Without substantive oversight by objective credible reviewers, mediocrity sustains itself.
The system is immune to critics’ isolated challenges. Passive compliance is seen as the best way to protect one’s status within the educational arena. This is true for parents, teachers, and the students themselves.

The U.S. Department of Education has established a huge bureaucracy to monitor compliance of services to students identified with special needs. This compliance system and its policies have come under severe criticism after nearly three decades of implementation.

As one example, the system of Individualized Educational Plans (IEPs) with requirements for careful delineation of measurable student outcomes has resulted in teaching practices that more closely approximate “training” rather than “educating” students with disabilities. Such a demand to communicate quality or progress in the form of number(s) often inhibits, rather than advances, educational quality for students.

Complying with IEP requirements means that there must be regularly scheduled staffings and that the proceedings are monitored. Student performance on the IEP objectives must be presented, along with the interventions and indicators of progress in meeting the objectives. Part of the difficulty is the time it takes to meet all of the compliance requirements. Every minute spent on compliance recording and in staffings is a minute taken away from instructional services for the child. Plus, this complicated accountability process inherently focuses on a student’s lower order skills rather than helping the student acquire higher order conceptual reasoning.

Another example is the use of basic skills testing that has become the primary tool for measuring student performance and accountability for schools because of our culture’s inherent trust in this type of testing. Therefore, the special education teacher becomes another teacher of basic skills, focusing instruction on reading, writing, and arithmetic. The broad fields of science and social studies, which are critical for the development of higher order thinking abilities, are largely ignored. If special education teachers do help with these classes, often their role is to assist in reading, assignment modification and completion, and test taking. With time taken up in these tasks, the more substantive accommodations are largely ignored, such as alternative instructional delivery, modifying laboratory apparatus, discipline-compatible assistive technologies, and assistance in learning general principles and their application. Modifications for science class when the child is included are often left to the regular classroom teacher, who has little training in disability accommodations.

Responsive Evaluation

Responsive evaluation has emerged during the last decade as a means to gain greater insight into investigating concerns, issues, and consequences integral to the educational enterprise. In this type of evaluation, the researcher/evaluator is a highly knowledgeable observer or someone with astute skills in collaboration, or both. The approach, although subject to criticism as being costly, time-consuming, and lacking in explicit data, holds great promise for improving educational services for students with disabilities.

An important concern in responsive evaluation is working to understand the issue from the participants’ perspective. This involves fieldwork. The researcher must physically go to the people, setting, and institution to observe behavior in its natural setting. The research strategies used are inductive. The researcher must build concepts, theories, hypotheses, and abstractions relating to the elements being studied. The researcher becomes the primary instrument for data collection, often using multiple data sources.
The researcher provides a descriptive account or portrayal of the situation being studied. This includes rich observations, coupled with the researcher’s understanding of the complex relationships observed and their significance. Data collected may include field notes from observations; interviews; documents; records; interactions between students, teachers, administrators, and parents; anecdotal accounts; and verbal and non-verbal cues.

To be effective, responsive evaluation requires a staff commitment to participate in all phases of the study, participation by school leaders, and sufficient organizational stability to provide a support structure for the evaluation process. Technical assistance and staff support are needed to help in data entry, developing and refining questions and data-collection instruments, summarizing data, and assisting with documentation.

Responsive evaluation is beneficial as a formative evaluation when program staff need help monitoring a program and improving its effectiveness. It is valuable as a summative evaluation to help audiences comprehend all program activities, their value, and the pursuit of improvement. The very lack of structure is what makes responsive evaluation appealing, as it allows the researcher to adapt to unforeseen events and change direction in the pursuit of meaning (Merriam, 1998).

Addressing the needs of all students in a common educational setting is an emerging enterprise. Studies indicate that segregated learning settings limit opportunities for students with disabilities, regardless of the nature and severity of the disability. Because of its on-site observational basis, responsive evaluation can help generate the deep insights for improved practice in this important initiative.

Recommendations

While no one assessment tool is perfect, assessments that make connections between school tasks and tasks with skill applications for the real world can help students with disabilities. Educators must always keep the optimal goal in mind – to upgrade the learning of all students, to leave no child behind.

Educational evaluation may offer both great promises and great challenges if we are to make adjustments in the educational system to meet the learning needs of all students. The evaluation technique of ranking schools based on student performance gains is short sighted and punitive toward many of the most hard-working professional educators. However, an emerging science in education evaluation has evolved that presents correlates of best practice for educational administrators and teachers. Implementing the knowledge base from this emerging field is critical if we are to improve schools. It has the potential to move education from a field that is largely intuitive and artistic to one that applies a scientific foundation.

Accountability through accreditation and state department review is minimally effective with a high likelihood that the review of program quality for students with disabilities will be minimal for students mainstreamed in science classes. Current cumbersome practices of reporting requirements for special education compliance are inhibiting the quality and amount of educational services for students with disabilities.

Accurate Evaluation Data

Several measures must be implemented to provide accurate evaluation data relating to the effectiveness of instruction on student learning:

1. The academic gains must be tied to each individual student. Group data do not tell the story.
Many of the schools marked by the lowest performance scores have highly mobile student populations. Often, over half of the students in a class at the end of the year were not there at the beginning of the year.

2. The evaluation data must be disaggregated for the variables that affect student performance. Comparisons must be made on like students. For example, one of the most significant correlates on student performance is parental and community support. Because of this, it is inappropriate to compare charter schools that require a contract of parent and student commitment with public schools with an established attendance area. One example of the inequity in doing this is the KIPP Academy, a charter school in Houston, TX, highlighted during the 2000 Republican convention. Fifty students are selected for the school from a waiting list of 300. Students, their parents, and teachers at the middle school (grades 5-8) must sign a contract pledging total commitment. Several hours of homework are assigned each night, school days start at 7:25 a.m., and students stay until 5:00 p.m. every day but Friday. Saturday and summer sessions are mandatory. Teachers are on-call 24 hours a day. KIPP pays a college student and school alumni to stay late at night so students can work at the school. KIPP may be the best little school in Texas, but it does not reflect the conditions offered to the students attending other Houston schools (Manno, Finn, Bierlein, & Vanourek, 1998; McCafferty, 1999).

3. A level playing field is needed: Students with disabilities must be proportionally distributed among all educational institutions. It is unacceptable for private or voucher schools to reject students because they cannot address their special physical accommodations or learning needs. As well, it is inequitable for a private school official to tell a student, "For some reason there is not a compatibility between your educational needs and the educational services we offer; therefore, we are sending you to another school that may be more effective." Public school administrators should have equal opportunities to seek out the best school to serve the needs of a challenged student.

4. All aspects of educational performance must be presented. Evaluations tend to purport that educational quality can be reflected through a number. This places an overemphasis on basic skills, slighting science, social studies, and the expressive and practical arts.

5. Very serious attention should be given to equity of outcomes. If there is to be educational fairness across the United States, perhaps there should be a public commitment to equalize the level of funding across schools. This will require a greater financial commitment to those schools in which student performance is substandard. More educational resources (e.g., smaller class sizes, stronger support services, extra hours for science and computer laboratory accessibility, extra hours for libraries and media services, extended student services, family and parental support, extended school years, summer programs, enrichment opportunities) would go a long way to support educators working in the most challenging conditions. This appears to be one area where No Child Left Behind is having a somewhat positive impact. It has provided increased resources and services to communities and students where individuals are not reaching the benchmarks established by educators in the community.

6. Measures of school climate should be reported with a vigor equal to that of academic outcomes. Diversity should be valued as the essence of equity. The values of respect, understanding, acceptance, appreciation, equal worth, mutual benefit, and belonging need to be made our most important educational priorities. All students should gain an understanding that disability is not a deficiency but a vital part of the diversity of the human community (Kunc, 2000).

7. The effectiveness of the educational program should be evaluated for the full spectrum of student
diversity, with an equal commitment to fully developing the learning potential for each student. The public needs to understand that tracking in any form detracts from educational opportunity; the victims are often marginalized groups such as minorities and students with disabilities. The public also needs to understand that many urban districts have abandoned the average student and students with disabilities through the creation of "academy high schools" for the academically talented and a marginalized substandard curriculum for all other students.

**Administrator and Teacher Accountability**

If school reform is to occur in the 21st century, the focus must be on administrator and teacher accountability. Recent efforts at educational reform have targeted students as the primary victims of accountability. The imposition of performance criteria for grade-level advancement and graduation has increased the power of educators to make students responsible for learning. When learning does not occur at the desired level, it is unfair to assume that the student is solely to blame. Learning is a shared responsibility; the instruction must be appropriate for the learner, and the learner must assume responsibility for learning. Improved student learning outcomes should be an artifact of accountability rather than the imposition of accountability. Good teachers accommodate instruction so that all students can have a successful learning experience if they use responsible learning behaviors. It is unfair to expect all students to perform equally or to meet a predetermined standard. Each student’s potential will vary greatly.

When using assessments, educators must be careful in interpreting student scores. Poor instruction can occur in instances when all the students pass the competency examinations. This can result because of the innate abilities of the student, the capacity of students to accommodate their learning to the material being taught, or community and parental support that overcomes ineffective teaching practices. On the other hand, teachers may be working incredibly hard in conditions where there are few supports for student learning outside of the school, where students have significant experiential deficits, where there are limited supplies and resources, where the instructional materials contained in the curriculum are developmentally inappropriate for the learning level of the majority of students, and where there are community elements that interfere with the students’ educational experiences.

The educational arena is rampant with excuses for poor evaluations. Teaching has always been a very independent profession, with little monitoring and oversight outside of the purview of management and control of the students. It is commonplace for teachers to assume a teaching style, to prepare instructional materials for convenient delivery, and to retain the same teaching posture for many years. Assumptions are made that their teaching is appropriate, and when a student doesn’t learn, it is because of apathy, lack of initiative, or something wrong with the student. Students with disabilities are perceived as having a defect. Helping them has previously come under the responsibility of special education personnel or other clinical staff. It is not uncommon for secondary teachers in advanced science courses to perceive that they have a sorting responsibility. Statements such as, "Not everyone can be an engineer; we can’t have bridges falling down" or "If I teach to the slow students my better students will not be prepared for their college or university classes" are commonplace. These attitudes violate the basic premise of inclusive education for all students.

Saxton (1985) summarized the human degradation so many students with disabilities face, particularly those with physical impairments. She states:

All of those people trying so hard to help me. All of them hoping for me to do well, all wanting to be kind and useful, all feeling how important helping me was. Yet, they never asked me what I wanted for myself. They never asked me if I wanted their help….I do not feel entirely grateful. I feel, instead, a remote anger stored beneath my coping pattern of complacent understanding. People do the
best when they can help in meaningful ways, I know. I just wish all students with disabilities would say to their helpers: "Before you do anything else, just listen to me."

Instructional leadership must encompass a strong commitment to instructional improvement. It cannot be piecemeal, consisting of two or three observations that go into an evaluation file or a board report. Areas of improvement need to be identified, and then supports are needed to help teachers develop the skills. Surveys conducted in 1995 and 2000 indicate that few regular classroom teachers feel adequate in their knowledge about teaching science to students with disabilities and that they have little understanding of resources, adapted instructional materials, alternative laboratory tools, or alternative instructional strategies for meeting student needs. An attempt to survey special education teachers about instruction in science yielded a very low response rate (under 20%). Their knowledge of and familiarity with resources was as lacking as those of the regular classroom teachers. In interviews, it was found that few special education teachers taught science and they seldom interacted with science teachers during instruction. They perceived their primary role as helping students with reading, assisting with assignments, and modifying and administering tests (Stefanich et al., 2000).

A multitude of inventories for observing and evaluating teacher performance exists. However, all have their limitations and should be used several times with many interactions to accurately reflect a teacher’s abilities. The evaluation must be context driven; the evaluator must be familiar with the students and the setting. Plus, the actions suggested from the evaluation should be supportive and include professional development opportunities to help teachers gain the competencies necessary to meet the needs of all of their students.

Evaluation is not a one-time process of collecting and assessing data. Rather, it is a continuing process that provides the foundation for all teaching and learning. Evaluation of teacher performance is very difficult because the public believes you are evaluating skills, competence, and function. Instead, it is an appraisal process focusing on counsel, advice, suggestions, and help with classroom demands. Information collected in a teacher evaluation must not only be identified, but should also be quickly retrievable. Data must be collected so it provides longitudinal information that can be matched with other data and compared in multi-varied ways. The data must be accurate, credible, and have high utility. Equally important is the propriety of the teacher evaluation process: It must be done legally, ethically, and protect the rights of those involved.

Assessments of school administrators are also needed. Clear and abundant evidence shows that the principal has a great influence on the climate and culture of a school. Yet, as with teachers, there is little oversight of administrators’ performance after their initial employment. Instead, the primary evaluative criteria for adequate performance often relate to the political and technical functions of the principalship rather than to a principal’s critical leadership role in the school improvement process and instructional leadership.

Too often, we neglect to look at an administrator’s leadership skills. Instead, the school becomes a political structure with an emphasis on maintaining convenience and comfort for the adults. The principal becomes more concerned with giving the party line, serving as a buffer to appease external challenges, and supporting those perceived as loyal to the organization. The political functions and role become administrative: focusing on communication of school policies, supporting teachers, managing discipline, and maintaining fiscal accountability. Thus, the principal’s critical role in the area of instructional leadership becomes secondary.

But if schools are to undergo substantive improvement, leadership must come from the principal. The effective schools correlates identify instructional leadership as one of the most important qualities of the principalship. Administrative guidance is needed to focus the mission and goals toward meeting the
educational needs of all students. Decisions regarding program structure and allocation of resources must be accountable and relate to improving student outcomes. These are the kinds of qualities and skills of a principal that need to be assessed on an ongoing basis, not just when the principal is first hired. However, few principals have an understanding of their role as an instructional leader and receive little training in the skills needed for effective instructional leadership. Much of their education focuses on a managerial role whereas the skills required for effective instructional leadership are facilitative in nature.

Effective principals possess the knowledge and ability to describe and analyze instruction and learning outcomes. They can assess teacher performance and relate the assessment to the instructional context. They can relate teaching to the diversity of learning needs of the students and seek out opportunities for professional development that are compatible with the school improvement process. They must be knowledgeable and current about research in teaching and learning.

Principals must be able to interact using a supportive approach to human resources. Their evaluation feedback to teachers should accomplish two major purposes: a) provide reinforcement for practices that are working well, and b) offer suggestions for remediation that will improve teacher performance. The arena of administrative and teacher accountability and evaluation brings forward one of the greatest challenges in school improvement: the ability to identify situations, conduct evaluations, and make judgments to improve the quality of the learning experiences students receive.

**Public Oversight**

Another area of evaluation requiring attention is public oversight – both accreditation and compliance. Current accreditation procedures are criticized as being soft-headed and communicating a false sense of excellence in the midst of mediocrity. Institutional accreditation tends to be broad and communicates little, except that the educational institution meets acceptable standards of quality. Few institutions are willing to put forth the expense for more rigorous introspection by credible outside reviewers.

In fact, very often there is an inverse relationship between education quality and the depth and review undertaken by the school staff. High-quality programs engage in a self-study process with considerable vigor. Site visitors are selected based on academic credibility, objectivity, and willingness to share deep insights. However, institutions with weaknesses are less likely to seek accreditation. If they do, site visitors might be selected who are not politically threatening (protectionist), and the self-study process may be shallow with limited outside participation in the number of reviewers and the amount of time devoted to the review.

Few outside reviewers possess the expertise to collect and summarize a substantial body of evaluative information in a short time span, and there is always a question of reliability, where the conclusions are colored by the individual biases of the reviewer. The result of such an accreditation review is that a school can sustain its existence for decades without addressing major educational shortcomings. However, even with such limitations as depth and reliability, the accountability of accreditation agencies offers great promise. Such agencies offer published standards, periodic self-study, external review by site visitors, and a review of the process by an accrediting body. When done well, such an accreditation can identify strengths and weaknesses, highlight what is good about a school, and enlighten the staff and consumers about future directions and needed resources.

On the other hand, program accountability for students with identified disabilities is generally monitored through detailed compliance policies from federal and state legislation. Some educators criticize this compliance because they say it involves too much paperwork requiring too much time, thereby depriving children of direct educational services to support their learning needs. Yet, some fear
that without such monitoring, special education resources would be dissipated and educators would not provide needed attention to students with special needs.

Some perceive that many of the best special education teachers leave the field not because they’re dissatisfied with their work with students, but because they have to divert so much of their attention to administrative tasks. Others perceive that less committed special education teachers can use administrative tasks as a means to spend less time with students, thereby diluting the educational services to the clients. With advances in technology, there may be opportunities to establish a better balance between instructional services to students while providing sufficient records to demonstrate compliance with regulations and policies.

**Conclusion**

Evaluation can be used to enlighten consumers and expose shortcomings. However, it will not correct problems. For instance, there is considerable evidence that many students with disabilities are not afforded equitable access to high-quality science education. Equitable access is commensurate with seeking out and using available accommodative materials and supplies, using assistive technologies to enable greater participation, making laboratories accessible and modifying the environment to allow active student participation, employing multi-modality instructional techniques, and having a teacher willing to modify instruction to the unique learning needs of the student.

With all of the complexities regarding evaluation, it is important that advocates for equitable opportunities for students with disabilities lend their support to the process. Evaluation, when used appropriately, has great potential for improving educational practice. Since educational evaluation is a very immature science, the most effective and valuable applications are those specifically tailored to the needs of the client. Both the data and the context need to be considered. Either, in isolation, distorts the promise to provide educators with badly needed information that can be used to improve the process of education.

Evaluation data must be used with discretion. It must lead to improved services for all students, not as a toll to sort and marginalize students with disabilities. The evaluation process must be flexible and redirected to serve the needs of all students in our schools. Creating a culture that provides appropriate opportunity for each student and enlists responsibility from that student is the essence of education.
Chapter 7
A Collaborative View of the Science Classroom

Science teachers, like many other regular education teachers, have concerns regarding the wide range of student needs already in a classroom. An increasing number of students have behavioral concerns, including hyperactivity, and disrupt the learning process. Many students with high needs do not qualify for special education assistance and remain in the regular classroom where overburdened teachers struggle to accommodate for these difficulties. Yet, recent trends in education indicate that inclusion of special needs students into the regular classroom has become more of a priority. This expectation, coupled with the wide range of abilities existing in classrooms, overcrowding, and a general lack of time to develop or find materials well-suited for these students, presents a stressful situation in schools.

For many years, a segregated pull-out special education model was utilized for students with disabilities. In recent years, this practice has come into question, due to a number of problems associated with pull-out programs. Many educators express concerns that include the following: negative social effects of labeling; the difficulty special education students have when attempting to transfer skills learned in a pull-out setting to the regular class setting; the lack of time for regular education teachers to communicate effectively with special education teachers regarding provisions needed for special needs students in the regular classroom; the lack of curricular coordination between regular and special education programs; and the social difficulties students experience due to math or reading disabilities when integrated into subject areas such as science and social studies due (Johnston, 1994). Due to its activity-based nature, science classrooms can serve as a model for integration of students with disabilities.

The Collaborative Viewpoint

Since the Education for All Handicapped Children Act (EAHCA) was enacted in 1975, students receiving special education services have increasingly been served in the regular education setting. More school districts are initiating collaborative partnerships between regular and special education teachers as a method of reaching students with and without identified special needs in the regular classroom setting. Such collaboration can exist in several different forms and usually requires a different perspective for viewing the educational process.

Collaboration in and of itself is a practice recommended among school professionals as a whole (Pugach & Johnson, 1990) and is described as a supportive system in which teachers utilize the expertise of other educators to solve problems. While there is no one standard model of collaborative service, Bauwens (1991) described three common models: teacher assistance teams, collaborative consultation, and cooperative teaching.

Of the three basic models, cooperative teaching seems to be a more frequently implemented practice in many school districts (Reeve & Hallahan, 1994). Cooperative teaching, also generically referred to as “collaboration,” involves regular and special educators coordinating efforts to jointly teach heterogeneous groups of students in integrated settings to meet the needs of all students (Bauwens & Hourcade, 1997). Of course, the approach educators take in cooperative teaching may vary from classroom to classroom. In one approach, the regular class teacher may provide primary content instruction while the special education teacher provides survival skills instruction on such study skills as note taking, outlining, or finding the main idea. These survival skills might be taught to a small group or the entire class, but it is all done within the regular class setting.

In another approach, both regular and special educator share all the classroom planning, preparation, and instruction. Both teachers in team-teaching situations have equal responsibility and alternately
present content at various times. In yet a third approach, the regular class teacher provides all instruction essential to the content of the course, and the special educator provides enrichment activities that support the content instruction. For instance, the regular class teacher might present initial content and lead a discussion about this content while the special educator presents application activities such as experiments or hands-on activities.

While the variations can be numerous, cooperative teaching generally implies sharing responsibilities between both regular and special class teachers. These responsibilities include not only the instructional aspect of the arrangement, but the evaluation of students, parent contact, and instructional planning and design.

Benefits for students and staff in cooperative teaching partnership include:

- A shared ownership and responsibility for meeting student needs.
- More special educator involvement in day-to-day activities.
- More effective curriculum modification aligned with educational outcomes for all students.
- A greater willingness to share materials.
- Better monitoring of low-achieving students’ learning process.
- A reduction in suspensions.
- An increase in parent contacts.

But the view isn’t always rosy. Time management is most frequently indicated as an obstacle to effective collaboration. Since cooperative teaching requires coordinated planning and preparation, this often takes time outside the contract day (Braaten, et al., 1992). Not all regular and special educators are willing and/or prepared to be collaborators. Mandating this form of service delivery may result in strong objections from those involved. It is also difficult at times to describe a collaborative service delivery model in a student’s Individual Education Plan (IEP). This may require much discussion regarding how this will be presented accurately.

Conflicting viewpoints are likely to come forth in any discussion on implementing a collaborative model. Often, the concept and its development in a school setting come from the teachers involved. Special and regular education teachers talking informally may lead to a proposal for one or more collaborative partnerships within a building. However, such actions will enjoy little success if there is no administrative support.

Collaborative Practices

Collaboration is a supportive system in which teachers utilize the expertise of other educators to solve problems. The existing dual system of regular and special education has fostered definitive boundaries between these two areas with little sharing of expertise and support. Under the dual system, science teachers often find themselves basically alone in their efforts to serve students with special needs who are placed in their classrooms. This isolation makes teachers more resistant to the changes involved with including special needs students. Perceptions that may interfere with effective collaboration can become ingrained in professional practice. Unless they are brought to the surface, these perceptions serve as persistent bottlenecks to collegiality between professionals. A few are listed below:

Too often, science teachers:

- See their responsibility as setting high standards, and holding to these high standards for all students. Some may go a step further and perceive their responsibility as “culling” those who
would diminish the overall quality of the scientific community.

- Believe their primary responsibility is to disseminate content. They often practice methods of delivery (e.g., lecture-recitation and verification laboratory exercises) that focus on disseminating information rather than discussion of concepts with frequent feedback and idea sharing.
- Believe students are and should be held accountable for their own learning. They perceive evaluation as a process of reporting student progress toward established standards.
- Believe that when students don't learn something there is something wrong with the student.
- Believe that if there is something wrong with the student, a specialist is needed to correct the deficit.

Too often, special education teachers:

- Believe expectations should be modified to meet the abilities of the student. They are inclined to sacrifice high standards for student comfort.
- Want students to perceive success in the process of evaluation. They perceive that it is appropriate to provide both guidance and assistance when conducting assessments for classroom teachers.
- Believe their primary role is to help students with assignments and tests and provide support for the development of basic skills.
- Do not have a sound understanding of the science content being taught and do not perceive a need to have operational capabilities with the concepts in the science curriculum.
- Lack the use of information science tools to locate resources and conduct investigations with students. Therefore, students seldom receive enrichment in science learning through multi-modality, hands-on laboratory experiences under the direction of the resource specialist.
- Emphasize external reinforcement to enlist student cooperation. They believe that good strategies utilize high structure and constant monitoring. Effective instruction is following a structured IEP, with explicit objectives and formal assessment procedures clearly denoted.

Although collaboration is discussed more thoroughly in another chapter, a commitment to mutual support between regular education and special education teachers is critical if we are to achieve greater success in addressing the learning needs of students with disabilities. Villa and Thousand (1988) have suggested that if teachers knew support was available, they would show more willingness to meet the needs of integrated students. Three common teacher support models are presented in the literature:

1. Teacher Assistant Teams in which groups of people (teachers, counselors, administrators, parents) join together to provide support to the classroom teachers in their attempt to provide appropriate opportunities to all students (Stainback & Stainback, 1989).

2. Collaborative Consultation offers an arrangement between a special education teacher and regular education teacher in which both teachers share their expertise in an attempt to accurately describe problems and mutually develop solutions to the problems.

3. Cooperative Teaching in which regular and special educators coordinate their efforts to jointly teach heterogeneous groups of students in integrated settings to meet the needs of all students (Bauwens, Hourcade, & Friend, 1989)

The benefits to students include increased social status through integration, more science, better science expertise, reduced isolation, and increased assistance when needed. The benefits to teachers include increased instructional and management support, shared expertise, a greater number of creative problem-solving methods, a better understanding of themselves as they interact, increased feedback, and greater companionship and assurance.
However, barriers to using these support models do exist. Regular classroom teachers may see the intended collaboration as an intrusion. Special educators may challenge the capacity of the regular teacher to accommodate the classroom and anticipate and fear meetings with resistive partners. In addition, conflict may result relating to the domination of one partner, expectations that one partner will be responsible for getting the job done, and the overall availability of the special educator to be in the classroom when needed.

Collaborative approaches have great promise; however, agreements have to be reached between all parties for this approach to operate effectively. Takes (1993) has identified these factors for agreement: shared commitment among participants, issues of autonomy and isolation, assistance requested and provided, trust and balance of power in a relationship, development of the relationship, conflict resolution, and professional growth.

Collaboration may be one of few current viable alternatives for meeting the needs of students with disabilities in science. In light of current research findings, it appears that regular classroom teachers are ill-equipped to accommodate instruction to the student with disabilities in the regular science classroom and special education teachers have little science knowledge. Evidence also shows that special education teachers, if left alone, do not teach much science and are inclined to be textbook dependent. Following an extensive research study on collaboration, Takes (1993) provided the following policy recommendations:

1. Provide inservice regarding what such a collaboration program might look like and consist of. This would allow teachers to begin a thought process geared toward making a change in the near future.

2. Provide an opportunity for teachers to observe cooperative teaching in action and to discuss the model with those observed.

3. Provide an opportunity for staff to discuss the advantages and disadvantages of such a program and also to list possible barriers to instituting such a program.

4. Provide opportunities for teachers to reexamine traditional teaching practices and the degree to which cooperative teaching challenges those practices.

5. Provide a description of professional growth expectations and how teachers should meet these expectations.

6. Provide opportunities for teachers to collaborate and develop and work on developing curriculum (pp. 374-375).

**A View from the Top: Invested Administration**

A collaborative partnership is not simply an act of combining two certified people together in a classroom with needy students. Two heads are not always better than one. It takes a great deal of planning, preparation, and cooperation before the partnerships are formed, and then, more planning, preparation, and cooperation during the collaboration for its success. Many issues need to be considered that may have a major impact on the success of such a program.

The underlying belief system within a building must be examined thoroughly before embarking on a mission of collaborative change. The building administration must embrace the theory and concept behind collaboration, support the teachers initiating such a change, and also provide structural supports
that will allow the collaboration to occur. Walter-Thomas, Bryant, and Land (1996) have suggested that administrators provide administrative support and leadership, select capable and willing participants, provide ongoing staff development, establish balanced classroom rosters, provide weekly scheduled co-planning time, facilitate the development of appropriate IEPs, and pilot-test classroom and school collaborative efforts.

A belief system within a school that promotes open sharing among colleagues would be most beneficial to a collaborative model. Traditionally, educators have not always been prepared to share and work in a collaborative fashion with other teachers. They have been taught to be autonomous and self-sufficient, for the most part, within their classrooms (Leithwood & Jantzi, 1990). Due to the physical separation of individuals within a building, teachers historically have learned to accept this isolation as the norm, or the existing condition of work in the education field. Many teachers, however, see this condition as isolation from the peers who can provide badly needed professional support within schools filled with many high-need students. A collaborative environment may help provide the support teachers feel is needed under these conditions. Many schools are thus turning toward the establishment of collegial norms. Administrators interested in establishing these norms must also increase awareness of a need for change toward collegiality.

At the elementary level, it is extremely important to have scheduled chunks of uninterrupted time when a number of students with special needs can be served in a collaborative classroom and when teaching partners are free to work together in that classroom. For example, if a second grade teacher is interested in collaboratively teaching with a resource teacher, that second grade class must have a chunk of time when the students served in that class will have no specials scheduled to interrupt this instruction.

At the middle school or high school level, blocks of time for instruction are usually more evenly distributed and signaled by a bell system. With today’s technological advances in place, many schools have scheduling software packages that distribute students as evenly as possible within grade level, subject area, and teacher availability parameters. Under these conditions, for example, if an eighth grade science teacher wanted to work collaboratively with a resource teacher during a particular period of the day, the students designated as those whose needs would be met in a collaborative setting might be hand-scheduled into that period’s section prior to the electronic scheduling of students (Nowacek, 1992). In this fashion, after-the-fact rescheduling of students to make collaboration happen and the resulting hassles can be avoided. Of course, this means that the resource teacher must also be free during the scheduled collaborative time so that the partnership in teaching can occur. This is not always easy. One idea to accomplish this task is to determine the special education teacher’s schedule first. This should be based on student need and the resulting integration possibilities, which, in turn, may free the special educator from chunks of previous pull-out times that can now be utilized for collaborative classroom time.

Another hurdle in the approach toward collaboration is the availability of time to plan (Johnston, 1994; Walter-Thomas, et al., 1996). Teachers forming partnerships will need time, at first, to become more acquainted with each other’s teaching styles and vision for instruction. As the partnership progresses, time will be needed to develop joint instructional plans and to collaborate on direction, evaluation, and student issues. This time is not always readily available and often takes the form of brief conversations in the hallway between classes or late afternoon meetings well beyond the contract day. If carefully planned, some of this time can be planned around specials time and in conjunction with personnel resources existing in the building. This planning time, in whatever form it takes, needs to be arranged in advance—an administrative task that requires advance organization when scheduling. A significant concern when initiating any change in an educational setting is the effect of that change on student performance. Current issues of accountability in education have prompted the trend toward establishing standards and benchmarks for student achievement. As a part of the collaborative change
process, such issues may lead administrators to establish a way to provide evidence of student achievement in the collaborative setting.

Once the proper groundwork and structural support systems are in place, ideally removing immediate barriers, teaching partners will likely feel more comfortable in developing effective collegial partnerships that serve student needs. These partnerships require a different perspective than the autonomous view commonly experienced by non collaborating teachers.

A View from the Trenches: Invested Teachers

Marriage, it is said, should not be entered into lightly. So, too, collaborative partnerships. Effective partners will likely experience many of the trials and triumphs of relationships in general. It is important, as in marriage, to make sure that co-teaching partners have some things in common and communicate effectively. For this reason, it is suggested that collaborating partners take the time to establish ground rules (see Figure 9) by discussing the questions Blaisdell (1994) has suggested.

1. **SCHEDULING**  
   a. When will the special educator be scheduled in sections?  
   b. How many students with special needs will be placed in this section?

2. **CLASSROOM MANAGEMENT**  
   a. What system of rules/rewards/punishments will be used?  
   b. Who will be responsible for instituting/enforcing this system?

3. **PLANNING TIME**  
   a. When will teachers plan together?  
   b. What will this planning time consist of?  
   c. Who will be responsible for this planning?

4. **ASSESSMENT**  
   a. How will students be graded?  
   b. Will students with special needs be handled differently?  
   c. Who will be responsible for grading papers and report cards?

5. **CLASSROOM ENVIRONMENT**  
   a. Whose classroom will be used? One teacher’s or both?  
   b. How do the teachers feel about being able to have access to such things as supplies, filing cabinets, instructional materials, personal belongings in the classroom, gradebooks, pencils/pens, etc.?

6. **TEAMWORK**  
   a. How will the teachers communicate to the students that they are a team? (List as many ways as you can think of.)

7. **BELIEFS**  
   a. What does each believe to be true about all students?  
   b. What does each believe to be true about students with special needs?  
   c. What methods need to be in use to meet the needs of special students?  
   d. What methods need to be used to meet the needs of advanced students?  
   e. What does each believe to be true about collaborative teaching as a method for reaching students with special needs?

8. **PROBLEM SOLVING TOGETHER**  
   a. If a conflict arises between the teachers, how is this handled?  
   b. What kinds of input does each teacher expect from the other?  
   c. Pet peeves: How does each feel about the other . . .
1. being on time to class?
2. running errands (for other or self)?
3. taking restroom breaks during class?
4. contributing to class discussion (and how should it be done)
5. explaining to a student during teacher presentation?

9. ROLES AND RESPONSIBILITIES
   a. What roles will each teacher take in this partnership?
   b. What responsibilities will the special educator have?

10. PARTNERSHIP GOAL SETTING
    a. What goals do the teachers have as a partnership in terms of curriculum? student achievement? professional growth?

Figure 9. Setting ground rules.

Setting ground rules can encourage communication that helps teaching partners get off to a good start. Despite best efforts to communicate on these issues, however, there are a number of influential factors that can emerge in cooperative teaching partnerships. These include issues of philosophical differences, input and role flexibility, degree of trust and/or power, degree of conflict or relationship development, and overall commitment to professional growth (Takes, 1993).

**Philosophical differences.** Partners’ philosophical viewpoints may either present opportunities for effective collaboration or may represent immediate barriers (Reeve & Hallahan, 1994). Some partners may share a commitment to cooperative teaching as a method of meeting the needs of all students. In other partnerships, individuals may have a level of uncertainty regarding this issue. Some teachers may feel that collaboration is merely another one of the many educational initiatives that will pass in time, or they may have even felt coerced into participation (Walter-Thomas, et al., 1996).

**Input and role flexibility.** Some teachers may feel that their sense of autonomy is threatened by a collaborative teaching model. Others, who feel that teaching is often done in isolation, may welcome the opportunity to receive input from others and share the roles and responsibilities of a classroom with another teacher (Nowacek, 1992).

**Trust and power.** Issues of trust and power play an important role in the collaborative partnership. The degree to which each teacher trusts the other’s skills as a teacher and one’s ability to carry through a task to completion can greatly affect the cooperative relationship. Partners may also need assurance that integrity will prevail within the relationship and that neither partner would resort to gossip regarding the relationship. In addition, the degree to which power is shared between partners in the relationship may also play a critical role in the perceived success of the partnership. This includes the power to share in the decision-making process such as when determining grading standards, curriculum, disciplinary measures, or acceptable modifications.

**Conflict or relationship development.** Teachers may feel a strong need to develop the partnership relationship more fully, since they are working closely together. This may include establishing with students the idea of the partners as a “team” through their interactions with each other. Sooner or later, one or both partners will likely have a conflict of some degree with the other. The degree to which conflicts--both large and small--are addressed and resolved seems to be vitally important to the overall success of the relationship (Reeve & Hallahan, 1994).
Professional growth. A last factor that may emerge as influential in the partnership is how much partners agree on the importance and direction of professional growth as collaborating partners. Professional growth can be individual in nature, perhaps in the form of increasing awareness of a topic or advancing skills. Growth could also be demonstrated as partners, including attempts at new teaching strategies or techniques or planning for future curricular or methodology adjustments.

When examined as a whole within a collaborative partnership, these factors may help determine the type of partnership between two teachers. Takes (1993) developed a model for looking at such relationships. This model uses four basic levels of partnerships that take the previous factors into consideration. These levels include parallel, collateral, convergent, and transformative partnerships.
Table 5

*A Classification of Influential Factors in Cooperative Teaching*

<table>
<thead>
<tr>
<th>LEVEL OF COOPERATIVE TEACHING</th>
<th>Description</th>
<th>Philosophical viewpoint</th>
<th>Forms and acceptance of assistance</th>
<th>Issues of trust and power</th>
<th>Relationship development &amp; conflict resolution</th>
<th>Commitment to Professional Growth</th>
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<tbody>
<tr>
<td>TRANSFORMATIVE</td>
<td>Partners have similar philosophies, work together in a constructive fashion toward an agreed upon purpose that exceeds limits of existing classroom structures Both satisfied within the partnership.</td>
<td>• Very similar philosophies, Shared commitment to integration, Shared commitment to cooperative teaching, No strong beliefs in teacher autonomy.</td>
<td>• Planning time used well, Flexible roles for each, Input given and accepted.</td>
<td>• No turf problems; Decision making almost wholly shared or divided reasonably; Partners trust each other on personal and professional levels.</td>
<td>• Partners already know each other or spend time getting to know one another, Good preconceptions confirmed or negative ones voided, Partners present themselves as team, Conflict successfully addressed.</td>
<td>• New teaching strategies attempted (beyond what traditionally existed in classroom) New curricular and methodology goals set</td>
</tr>
<tr>
<td>CONVERGENT</td>
<td>Partners have similar philosophies, Work together in a constructive fashion toward an agreed upon purpose within existing classroom structures Both satisfied within the partnership.</td>
<td>• Basically similar philosophies, but some differences may exist, Shared commitment to integration, Shared commitment to cooperative teaching, No strong beliefs in teacher autonomy.</td>
<td>• Planning time used well, Flexible roles for each, Input given and accepted.</td>
<td>• May have some problems with turf, Decision making mostly shared, Partners trust each other on personal and professional levels for the most part.</td>
<td>• Partners already know each other or spend time getting to know one another; Good preconceptions confirmed or negative ones voided; Partners present themselves as team, Conflict left unaddressed.</td>
<td>• Some new, agreed upon strategies may have been tried, but mostly within limits of existing classroom practices, Few to no new curricular and methodology goals set</td>
</tr>
<tr>
<td>COLLABORAL</td>
<td>PARTNER WORK COMPATIBLY, AT LEAST ON THE SURFACE, AND WITH COMMON PURPOSE, BUT ONE PARTNER HOLDS A SUBORDINATE POSITION TO THE OTHER, ESPECIALLY WITH RESPECT TO DECISION-MAKING POWER, ONE OR BOTH PARTNERS ARE DISSATISFIED WITHIN THE PARTNERSHIP.</td>
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</table>
| PARTNERS WORK COMPATIBLY, AT LEAST ON THE SURFACE, AND WITH COMMON PURPOSE, BUT ONE PARTNER HOLDS A SUBORDINATE POSITION TO THE OTHER, ESPECIALLY WITH RESPECT TO DECISION-MAKING POWER, ONE OR BOTH PARTNERS ARE DISSATISFIED WITHIN THE PARTNERSHIP. | **Philosophies similar in some regards, not in others,**
*Commitment to cooperative teaching and/or integration may not exist for both teachers,*
*Strong beliefs in teacher autonomy.*

**Planning time not used well,**
*Roles not flexible or shared,*
*Input not always asked for or given.*

**Issues of turf and class ownership exist;**
*Decision making not shared much;*
*Partners lack a trust in each other on personal and professional levels.*

**Partners do not spend time getting to know one another,**
*Preconceptions likely negative and not voided,*
*Partners may falsely present themselves as a team,*
*Underlying conflict avoided or left unaddressed.*

**Few to no new, agreed upon strategies tried,**
*Some individual growth may be evident,*
*Little to no evidence of new curricular and methodology goals being set.*

<table>
<thead>
<tr>
<th>PARALLEL</th>
<th>PARTNERS WORK IN THE SAME ROOM—BUT ALMOST ALWAYS IN A SEPARATE FASHION; SEPARATE GOALS MAY HAVE BEEN ACHIEVED BY INDIVIDUALS DESPITE LITTLE COOPERATION OR COMMUNICATION BETWEEN PARTNERS, ONE/BOTH PARTNERS ARE DISSATISFIED.</th>
</tr>
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</table>
| **Philosophies likely different,**
*Shared commitment to cooperative teaching and/or integration likely nonexistent or to small degree,*
*Strong beliefs in teacher autonomy.*

**Planning time not used,**
*Roles not shared or flexible,*
*Little to no input asked or given.*

**Issues of turf and class ownership exist;**
*Decision making not shared at all;*
*Partners lack a trust in each other on personal and professional levels.*

**Partners do not spend time getting to know one another,**
*Preconceptions likely negative and not voided,*
*Partners do not present themselves as a team,*
*Underlying conflict avoided or left unaddressed.*

**Few to no new, agreed upon strategies tried,**
*Some individual growth may be evident,*
*No evidence of new curricular and methodology goals being set.*

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In a parallel partnership, partners may work in the same room, but typically have separate goals, which may have been achieved by individual teachers. This relationship is marked by the fact that cooperation and/or communication is minimal between teachers; either or both partners may have expressed dissatisfaction within the partnership. The teachers may have entirely different philosophies and likely do not share a commitment to cooperative teaching as a successful means for reaching needy students. Feelings of autonomy often interfere with the ability of the partners to share input and effectively communicate. Trust is often lacking in these partnerships, and little time is taken to develop a better relationship.

A collateral partnership is one in which both partners, on the surface, seem to work compatibly with one another. One person, however, is ultimately subordinate to the other, especially with respect to decision-making power. Often, one or both teachers are dissatisfied within the partnership. Roles are likely inflexible due to the autonomous nature of one or more of the partners. Issues of autonomy may also affect the degree to which supplies are shared, as well as the degree to which trust is exhibited between the partners. Conflicts that arise will often go unresolved, and not surprisingly, professional growth occurs to a small degree or not at all.

A convergent partnership is characterized by partners who have mostly similar philosophies, who work together in a constructive fashion toward an agreed-upon purpose within the existing classroom structures, and who are both satisfied within the partnership. Some degree of departure likely exists, however, with regard to one or more factors. For the most part, the teachers are able to work productively around the differences and probably share a commitment or even excitement about cooperative teaching as a viable alternative to educating students with special needs.

Transformative partnerships consist of partners who have mostly similar philosophies, work together in a constructive fashion toward an agreed-upon purpose that exceeds the limits of existing classroom structures, and are both satisfied within the partnership. Both are effective communicators who resolve conflicts and pursue common goals of professional growth.

Transformative partnerships, then, would seem to be the desired norm in a collaborative model. A successful relationship should consist of partners who share a commitment to meeting the needs of students through a collaborative effort; who prefer to give and receive input from others with regard to the teaching job; who can trust one another with regard to their teaching skills, efforts, and integrity; who can share decision-making power; who take the time to develop the relationship to the degree that each feels part of a "team" and can resolve conflicts with one another effectively; and who promote professional growth between partners.

Collaborative partnerships will likely not all fit neatly into one of the four levels of cooperative teaching described in this model. Often, relationships may be difficult to define or may evolve over time (Nowacek, 1992). Several of the critical factors for partnership success are often difficult to discern because they are beneath the surface within a collaborative relationship. Shared philosophy, issues of trust and power, conflict resolution, relationship development, and a commitment to professional growth may all be hidden from immediate view to the outsider. In any given classroom, however, closer inspection of a collaborative partnership should immediately reveal the roles of the teachers involved.

**Conclusion**

Science educators today face a number of challenges in the classroom. The range of student abilities found in the same class section makes it difficult to plan activities that will capture both the interest and the learning capacities of all students involved. While collaborative partnerships between regular and special educators can pose interesting questions regarding belief systems, and cause additional burdens in
scheduling and time constraints, the combined expertise in such a partnership has great potential for meeting the wide range of needs in any given classroom. Science tends to be, as it should, a more hands-on experience. It also tends to be a subject that presents great difficulties for students with disabilities due to the need for conceptual thinking and higher reading ability at times. Because of these issues, science also seems to lend itself well to the collaborative effort. While it cannot be touted as a panacea of any kind, a collaborative partnership between individuals who have similar belief systems and who are willing to communicate and work together as a team to solve problems, set goals, and share roles and responsibilities will likely see great gains in student achievement in the science classroom.
APPENDIX A

An Accommodation Model

The Americans with Disabilities Act of 1990 and other federal and state legislation require that schools make programs accessible to students with disabilities. Accommodations are unique to the individual.

A Process
It is helpful to have a process to follow when determining appropriate accommodations for students with disabilities. The DO-IT project at the University of Washington has developed a model process and a Student Activities Profile form for creating effective accommodations. It can be used by any instructor and is composed of the following four steps:

Step #1: What does the task or assignment require?
Break down all of the components of the experiment, assignment, or exercise. As an educator, you are usually focused on the overall outcome of the project. To accommodate a student with a disability it’s important to think about the specific settings, tools, skills, and tasks that are required at each step. By analyzing and evaluating the task thoroughly, you will be able to determine how best to fully and effectively include a student with a specific disability.

Step #2: What physical, sensory, and cognitive skills are needed?
Match the tasks required to the physical, sensory, and cognitive skills needed to successfully complete the project. It is easy to say “If I had a physical, sensory, or cognitive disability I would not be able to complete this assignment” without really determining what skills are needed for specific aspects of the project. We need to separate the real requirements of a specific task from the fictional or perceived requirements of the project in total. It is impossible to place yourself in the shoes of the student with a disability. The student may have learned many ways to solve a specific problem or task and work around the limitations imposed by the disability.

Step #3: What components of the task require accommodation?
Once the task has been analyzed and the skills needed are identified, then you determine what accommodations may be required or how the learning experience might be altered to make it more accessible. Determine the project’s level of difficulty and how best to make an accommodation to create an

Four-Step Accommodation Model

1. What does the task or assignment require?
2. What physical, sensory, and cognitive skills are needed?
3. What components require accommodation?
4. What accommodation options exist?
inclusive environment for a student with a
disability. It is very important to consult with the
student to determine what aspect of the project
they think will need an accommodation or
assistance.

**Step #4: What accommodation options exist?**
Now that the tasks that need accommodation
have been determined, identify what resources
exist for providing the needed
accommodation(s). The student may have some
good ideas, however, this is a time when other
staff and professionals may have expertise in
specific areas and be called on to provide input.
In some cases, having students work in groups
where each person is assigned a task that he/she
has the ability to complete provides a reasonable
alternative.

The following *Student Abilities Profile* form is
designed to guide you in determining a student’s
skills and abilities and assist you in breaking
down the individual components of a science or
mathematics assignment. The form asks you to
briefly describe the student, the classroom or
laboratory environment, equipment or supplies
needed, available professional and external
resources, possible effective accommodations,
and the physical, sensory, and cognitive skills
needed for the task.

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**University of Washington**
College of Engineering
Computing & Communications
College of Education
### STUDENT ABILITIES PROFILE

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**Narrative:**

**Task/Assignment:**

**Environmental Adjustments**

**Physical Challenges**

**Sensory Challenges**

**Cognitive Challenges**
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<td>Accommodations Needed</td>
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Environmental, Physical, Sensory, & Cognitive Issues and Challenges

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<th>Physical Issues</th>
<th>Sensory Issues</th>
<th>Cognitive Issues</th>
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<tbody>
<tr>
<td>These are the more general considerations that relate to the (ergonomics-wrong word) of the workplace and learning environment for both the student and aides.</td>
<td>Think of the required physical aspects of the task. What will make the environment accessible, keep the student safe, and allow him/her to be an active participant? What lab equipment must be manipulated?</td>
<td>Think of room temperature, noise, fumes, dust, odors, and allergies. Also consider the ability to speak and/or communicate, and the visual aspects of the task or assignment.</td>
<td>Is the assignment done with a group, partner, or individually? What memory and communication skills are needed? What is the level of complexity of the task?</td>
</tr>
</tbody>
</table>

### Environmental Adjustments
1. proximity seating
2. small-group instruction
3. study carrel available
4. interpreter
5. instructional assistant

### Physical Challenges
1. lift/carry
2. stamina/endurance
3. push/pull
4. knee/squat
5. reach
6. repetitive tasks
7. fine motor: pinch/grasp
8. fine motor: manipulate/maneuver
9. gross motor
10. sit in chair
11. walk/stand
12. balance
13. bend/twist
14. stoop/crouch
15. other

### Sensory Challenges
1. vision
2. hearing
3. touch
4. smell
5. taste
6. oral communication
7. temperature
8. fumes
9. external stimuli
10. lighting
11. other

### Cognitive Challenges
1. short-term memory
2. long-term memory
3. task complexity
4. reading
5. writing
6. spelling
7. string of numbers (math)
8. paying attention
9. visual, auditory, or kinesthetic learner
10. self-esteem/advocacy issues
11. behavior issues/acting out
12. other
### Student Abilities Profile (Modified)

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<th><strong>Curriculum Issues</strong></th>
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</thead>
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<tr>
<td>Think about what accommodations are needed to allow the student to work at a comfortable pace when he/she is alert. Consider assessment circumstances that allow the student to express what he/she knows and what he/she is able to do.</td>
<td>Consider the sensory mobility capabilities of the student and the tasks and manipulations that are needed to involve the student in the lesson activities to the maximum extent possible.</td>
<td>Think about the design of instruction to provide student access for all elements of instruction. Examine ways to offer diverse activities that will allow the learner to individualize his/her participation. Give consideration to multi-modality approaches, student engagement and demonstration of knowledge and understanding.</td>
</tr>
<tr>
<td><strong>Scheduling Modifications</strong></td>
<td><strong>Access to Materials and Equipment</strong></td>
<td><strong>Curricular &amp; Instructional Interventions</strong></td>
</tr>
<tr>
<td>1. academics scheduled at appropriate times for student</td>
<td>1. alarm system that responds to those with place keepers, tracker, pointers</td>
<td>1. untimed assignments</td>
</tr>
<tr>
<td>2. scheduled breaks</td>
<td>2. manipulatives (blocks, counters, magnetic letter, etc.)</td>
<td>2. oral administration of tests</td>
</tr>
<tr>
<td>3. testing done at the time of day beneficial to the student</td>
<td>3. pencil grips</td>
<td>3. use of large print</td>
</tr>
<tr>
<td>4. accessibility to laboratories after school hours</td>
<td>4. highlighters for underlining</td>
<td>4. use of a word bank</td>
</tr>
<tr>
<td></td>
<td>5. templates and/or graph paper</td>
<td>5. short answers accepted for lengthy essay</td>
</tr>
<tr>
<td></td>
<td>6. rubber or latex gloves (be aware of allergies)</td>
<td>6. project accepted for major written assignments</td>
</tr>
<tr>
<td></td>
<td>7. nonslip floor surfaces, nonslip mats</td>
<td>7. teacher or assistant records answers when given orally</td>
</tr>
<tr>
<td></td>
<td>8. computer/word processor (in classroom or lab)</td>
<td>8. copies of notes supplied</td>
</tr>
<tr>
<td></td>
<td>9. plastic labware</td>
<td>9. instructions given in Braille direct instruction</td>
</tr>
<tr>
<td></td>
<td>10. safety goggles</td>
<td>10. generalization instruction</td>
</tr>
<tr>
<td></td>
<td>11. hearing aid</td>
<td>11. maintenance instruction</td>
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<td></td>
<td>12. Braille writer</td>
<td>12. textbooks on tape</td>
</tr>
<tr>
<td></td>
<td>13. auditory trainer</td>
<td>13. textbooks in Braille</td>
</tr>
<tr>
<td></td>
<td>14. augmentative communication device</td>
<td>14. adjustment in performance criteria</td>
</tr>
<tr>
<td></td>
<td>15. electronic switch access</td>
<td>15. use of a competency checklist</td>
</tr>
<tr>
<td></td>
<td>16. tape recorder</td>
<td>16. modified text</td>
</tr>
<tr>
<td></td>
<td>17. personal alarm</td>
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</tr>
<tr>
<td></td>
<td>18. sensory deficits</td>
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APPENDIX B
Science Safety
Inspection Checklist

Modified from the Inspection Checklist prepared by the Joint Safety Committee of the American Vocational Association-National Safety Council.

Introduction

A safe environment is an essential part of a safe science education program. This safe environment will exist only if hazards are discovered and corrected through regular and frequent safety inspections by school personnel – administrators, teachers, and students to determine if everything is satisfactory.

Inspections may be made at the request of the board of education, the school administration, or the teacher. Some communities have drawn upon the cooperative service of professional safety engineers, inspectors of state labor departments, insurance companies, and local safety councils to supplement and confirm inspections by school personnel.

Directions

Who inspects?

This will depend upon local policies. It is recommended, however, that science teachers and students – the student safety engineer and/or student safety committee – participate in making regular inspections. This not only tends to share responsibility but stimulates a broader interest in the maintenance of a safe science laboratory.

When to Inspect?

At a minimum, a safety inspection should be made at the beginning of every school term or semester. More frequent inspections may be advisable.

How to Inspect?

Inspections should be well-planned in advance.
Inspections should be systematic and thorough. No location that may contain a hazard should be overlooked.
Inspection reports should be clear and concise, but with sufficient explanation to make each recommendation for improvement understandable.

Follow-up

The current report should be compared with previous records to determine progress. The report should be studied in terms of the accident situation so that special attention can be given to those conditions and locations which are accident producers.
Each unsafe condition should be corrected as soon as possible in accordance with accepted local procedures.
A definite policy should be established in regard to taking materials and equipment out of service because of unsafe conditions.
The inspection report can be used to advantage as the subject for staff and class discussion.
Checking Procedure

Draw a circle around the appropriate letter, using the following letter scheme:
S – Satisfactory (needs no attention)
A – Acceptable (needs some attention)
U – Unsatisfactory (needs immediate attention)

Recommendations should be made in all cases where a "U" is circled.
Space is provided at the end of the form for such comments. Designate the items covered by the recommendations, using the code number applicable (as B-2).
In most categories, space is provided for listing of standards, requirements, or regulations which have local application only.

A. General Physical Condition

1. Shelves, equipment & supplies arranged so as to conform to good safety practices
   S A U
2. Condition of stairways
   S A U
3. Condition of aisles
   S A U
4. Condition of floors
   S A U
5. Condition of walls, windows, and ceiling
   S A U
6. Illumination is safe, sufficient, and well-placed
   S A U
7. Ventilation is adequate and proper for conditions
   S A U
8. Temperature control
   S A U
9. Fire extinguishers are of proper type, adequately supplied, properly located and maintained
   S A U
10. Teacher and pupils know location of and how to use proper type of extinguisher for various fires
    S A U
11. Number and location of exits is adequate and properly identified
    S A U
12. Proper procedures have been formulated for emptying the room of pupils and taking adequate precautions in case of emergencies
    S A U
13. Walls are clear of objects that might fall
    S A U
14. Utility lines are properly identified
    S A U
15. Teachers know the procedure in the event of fire including notifying the fire department and evacuating the building
    S A U
16. Air in laboratory is free from excessive dust, smoke, etc.
    S A U
17. Evaluation for the total rating of A, General Physical Condition
    S A U
B. Housekeeping

1. General appearance as to orderliness  S A U
2. Adequate and proper storage space  S A U
3. Lab tables are kept orderly  S A U
4. Corners are clean and clear  S A U
5. Special equipment racks are in orderly condition and provided at laboratory sites  S A U
6. Supply and/or material locations are steady  S A U
7. Sufficient disposal instructions are provided  S A U
8. Waste material is put in disposal promptly  S A U
9. Materials are stored in an orderly and safe condition  S A U
10. A spring lid metal container is provided for waste  S A U
11. All waste materials are promptly placed in the containers  S A U
12. Containers for waste materials are frequently and regularly emptied  S A U
13. Dangerous materials are stored in metal cabinets  S A U
14. Safety cans are provided for flammable liquids  S A U
15. Flammable liquids are not used for cleaning purposes  S A U
16. Floors are free of oil, water, and foreign material  S A U
17. Floors, walls, windows, and ceilings are cleaned periodically  S A U
18. Evaluation for the total rating of B, Housekeeping  S A U

C. Equipment

1. Equipment is arranged so workers are protected from hazards of other apparatus, passing students, etc.  S A U
2. Danger zones are properly indicated and guarded  S A U
3. All laboratory equipment is in a safe working condition  S A U
4. Adequate supervision is maintained when students are using equipment and chemists’ tools  S A U
5. Equipment is clean and in safe working order  S A U
6. Adequate storage facilities are provided for equipment and materials not in
immediate use

7. Evaluation for the total rating of
   C, Equipment
   S A U

D. Electrical Installation

1. All switches are enclosed
   S A U
2. There is a master control switch for all of
   the electrical installations
   S A U
3. Electrical outlets and circuits are properly
   identified
   S A U
4. All electrical extension cords are in safe
   condition and are not carrying excessive
   loads
   S A U
5. Electrical motors and equipment are wired
   to comply with the National Electric Code
   S A U
6. No temporary wiring is in evidence
   S A U
7. Evaluation for the total rating of
   D, Electrical Installation
   S A U

E. Gas

1. Gas flow to appliances is regulated, so
   that when appliance valve is turned on
   full, the flames are not too high
   S A U
2. No gas hose is used where pipe
   connections could be made
   S A U
3. Gas appliances have been adjusted so
   that they may be lighted without undue
   hazard
   S A U
4. Students have been instructed when
   lighting gas burners to light the match
   first before turning on the gas
   S A U
5. There are no gas leaks, nor is any odor
   of gas detectable in any part of the
   laboratory
   S A U
6. Evaluation for the total rating of
   E, Gas
   S A U

F. Personal Protection

1. Goggles or protective shields are provided
   and required for all work where eye
   hazards exist
   S A U
2. If individual goggles are not provided,
   hoods and goggles are properly
   disinfected before use
   S A U
3. Proper kind of wearing apparel is worn
   and worn properly for the job being done
   S A U
4. Hoods and/or respirators are provided to
   avoid toxic atmospheric conditions
   S A U
5. Instructions for cleaning and sterilizing
   respirators are clear and posted.
   S A U
6. Students are examined for safety knowledge ability
   S   A   U
7. Students’ clothing is free from loose sleeves, flopping ties, loose coats, etc.
   S   A   U
8. Evaluation for the total rating of F, Personal Protection
   S   A   U

G. Instruction
1. Laboratory safety is taught as an integral part of each teaching unit
   S   A   U
2. Safety rules are posted particularly at each danger station
   S   A   U
3. Printed safety rules are given to each student
   S   A   U
4. Pupils take a safety pledge
   S   A   U
5. Use of a safety inspector
   S   A   U
6. Use of safety tests
   S   A   U
7. Talks on safety are given to the classes
   S   A   U
8. Periodic safety inspections of the laboratories made by a student committee
   S   A   U
9. All accidents are investigated
   S   A   U
10. A proper record is kept of safety instructions which are given preferably showing the signature of student on tests given in this area
    S   A   U
11. Evaluation for the total rating of G, Instruction
    S   A   U

H. Accident Records
7. A written statement outlines the proper procedure when and if a student is seriously hurt
   S   A   U
8. Adequate accident statistics are kept
   S   A   U
9. The instructor reports accidents to the proper administrative authority
   S   A   U
10. A copy of each accident report is filed with the State Department of Education
    S   A   U
11. Accident reports are analyzed for instructional purposes and to furnish the basis for elimination of hazards
    S   A   U
12. Evaluation for the total rating of H, Accident Records
    S   A   U

I. First Aid
1. An adequately stocked first aid cabinet is provided
   S   A   U
2. The first aid is administered by a qualified individual
   S   A   U
3. Evaluation for the total rating of I, First Aid
   S   A   U
Recommendations
References


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Matthews, S. (2000a). *Role of laboratory assistants for students with disabilities*. St. Louis, MO: St. Louis Community College ACCESS.


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