Journal of the Iowa Academy of Science: JIAS

Volume 105 | Number | Article 4

1998

Safety Issues and Iowa Science Teachers

Jack A. Gerlovich
Drake University

Ed Wilson
Jester Insurance Services

Rahul Parsa
Drake University

Jour. Iowa Acad. Sci. 105(4):152–157, 1998

Safety Issues and Iowa Science Teachers

JACK A. GERLOVICH,[1] ED WILSON[2] and RAHUL PARSA[3]

[1] Associate Professor Science Education, Drake University, Des Moines, Iowa. 50311
[2] Risk Management, Consultant, Jester Insurance Services, Inc., Des Moines, Iowa. 50311
[3] Associate Professor Statistics, Drake University

The *National Science Education Standards* are providing an excellent blue print for improving science teaching for all students. However, the Standards are placing serious demands on teachers attempts to make science activities inquiry-based, real-life, open-ended, and directly applicable to today's students. This situation is further aggravated when teachers do not know essential science safety information from both federal and state governing agencies, as well as professional organizations. With proper training and tools, however, this problem can be positively addressed.

INDEX DESCRIPTORS: science safety, school science safety, science teacher safety.

Safety is an essential ingredient in all facets of our lives. It is especially important when working in today's complex sociological and demanding educational settings. Morality and ethics demand that we provide the best protective measures known for children and adolescents to assure the best education possible for the next generation. Legislative mandates and legal precedent further pressure and guide science educators in the pursuit of safety excellence. Even science and education organizations are helping coerce professionals to assure safe teaching and learning environments.

The *National Science Education Standards*-NSES (National Research Council 1996) state that students at the K–4, 5–8, and 9–12 levels should know and be able to "utilize safety procedures during scientific investigations." Within Teaching Standard D of the NSES, it is stated:

> "Teachers of science design and manage learning environments that provide students with the time, space, and resources needed for learning science. In doing this, teachers ensure a safe working environment."
> "Safety is a fundamental concern in all experimental science. Teachers of science must know and apply the necessary safety regulations in the storage, use, and care of the materials used by students. They adhere to safety rules and guidelines that are established by national organizations such as the American Chemical Society and the Occupational Safety and Health Administration, as well as by local and state regulatory agencies. They work with the school and district to ensure implementation and use of safety guidelines for which they are responsible, such as the presence of safety equipment and appropriate class size. Teachers also teach students how to engage safely in investigations inside and outside the classroom."

Reasonable and prudent judgment would dictate that informed science education professionals would follow guidelines of their profession, especially those involving safety of minors in their charge. How many science educators, however, know the applicable OSHA regulations (U.S. Dept. of Labor 1990), what safety equipment is essential, or what is appropriate class size?

Co-author of this study, Dr. Jack A. Gerlovich had done representative research on the subject of science safety in numerous states throughout the U.S., which raised his suspicions of a growing safety problem in science classrooms and labs. In June, 1996, he contacted Employers Mutual Companies (EMC) and Jester Insurance Services, Inc. to report this suspicion and initiate study of the issue and potential training programs for Iowa science teachers Upon presenting the preliminary data (Gerlovich 1995), the administrators of these companies agreed that more study and training should be provided in Iowa. Ed. Wilson, Risk Management Consultant with Jester Insurance Services, Inc., of Des Moines, Iowa, and co-author of this study, conducted an internal study of bodily injury claims in Iowa schools for the years 1990–1996. The study revealed an increase in the number of bodily injury claims as well as an increase in the number of law suits against Iowa schools. There was a corresponding increase in the cost of claims for that same period (Table 1).

Mr. Wilson extracted those claims that appeared to have occurred during science-related activities. The determination of whether a claim was "science-related" was dependent on the one-line injury description, usually provided by the school nurse, which did not always allow determination if the injury occurred in a science-related setting. For instance, "student burned hand with hot liquid." Because it could not be determined that this injury happened in a science-related activity and could have happened in home economics, industrial arts, art or science, it was not listed as a science-related injury. If a similar injury were described as "student burned hand during science experiment," it was listed as science-related (Table 2).

While not a scientific study, a pattern emerged that suggested about half of all science-related injuries involved chemicals. This calls to mind the various legal standards regarding lab safety, chemicals in the workplace, and personal protective equipment requirements for which science teachers and their districts are liable.

The next category indicates that about 20% of the accidents involved "cuts." While most of the cuts are minor injuries, a greater concern is the legal standard that now defines blood as a "hazardous material," with specific procedures to be followed to avoid exposure to various bloodborne pathogens. Approximately equal percentages of the science-related accidents involve various types of burns and slips and falls, while only 5% involved eye injuries.

Table 1. Bodily injury claims/lawsuits, Iowa School Science settings, 1990–1996.

TIME FRAME	1990–93	1993–96
Bodily injury claims		
Number of claims	674	1,002
Cost	$1,678,075	$2,300,172
Lawsuits		
Number of suits	96	245
Cost	$566,305	$1,238,662

Table 2. Science injury types reported in Iowa schools: 1990–1996.

PERCENTAGE OF INJURIES	ASSOCIATED CAUSE	COMMENTS
55%	Chemicals	45% chemical burns 40% eye injuries (splash/explosion) 15% inhalation
20%	Cuts	Glassware, scalpels, needles, animal bites
10%	Burns (non chemical)	Bunsen burners, glassware
10%	Slips and falls	Running, horseplay, falls from chairs or stools
5%	Eye injuries	Observing eclipses

Upon closer review of select cases from the insurance study, it was agreed that the accidents were likely precipitated by a lack of safety information. The administrators of EMC and Jester Insurance agreed that we should try to assess teacher understanding of applicable safety information, issues and procedures, and, if possible, address the shortcomings identified. They also agreed to provide nominal support for the study. Based on earlier national studies (Gerlovich 1995), a basis for the study was already established.

METHODS

In 1996, the first two authors planned one day science safety workshops and sent communications out to potential participants through the Iowa Department of Education, Iowa Association of School Boards and the Iowa School Administrators. Mailings were also made to teachers through the Area Education Agencies (AEA) in late fall. An integral part of the programs would be to assess science teacher understanding of the safety components of *The National Science Education Standards* (NSES), teachers' legal obligations, safety management techniques, and chemical management necessities. The day long workshops began in December, 1997 and were scheduled to take place each Friday throughout spring, 1997. By the completion of the study a total of 189 participants, representing 14 AEA's had taken part in 15 inservice training programs.

The six-hour workshops focused on the safety components of the NSES, reviews of legal obligations and applicable case studies; safety management techniques including proper techniques, facilities design and management, equipment usage; and proper management of chemicals (labeling, storage, hazard assessment, disposal). Each workshop began with each participant completing a Pre-training assessment of their understanding of critical safety issues in each of the above categories. A total of 189 participants completed this assessment. Following each training session, each participant completed a Post-training assessment. Due to schedule conflicts, however, only 157 of these assessments were collected.

Table 3. Participant background.

K–6 TEACHER	7–12 TEACHER	SUPERVISORS	PROFESSOR	OTHER	TOTALS
4	142	35	4	4	189

Participants were provided with copies of various science safety tools, including: catalogues, copies of the NSES, and safety software (Gerlovich, et al. 1996) customized to the legal and educational needs of Iowa. The majority of participants were science teachers in grades 7–12 or supervisors (Table 3). In addition, the average teacher had 17 years of teaching experience.

Following the collection of all data, a statistical test for proportion was conducted on the pre and post-training assessment data. It was hypothesized that the post-training correct assessments would be better than the pre-training assessment percentages correct. For example, consider the question addressing the National Science Education Standards (NSES) question regarding environment. The pre-training assessment indicated 3% correct responses; the post-training assessment indicated 75% correct. The hypothesis of interest is that there was an increase in the percentage of participants aware of the NSES standards regarding environment.

$$H_0: p < 3\% \quad H_1: p > 3\%$$

Rejecting the null hypothesis then implies that there was an increase in the percentage of participants who were aware of the NSES environment standards after attending the training, and failing to reject the null hypothesis implies that there was no increase in the percentage. In other words, rejecting the null hypothesis implies that the training was useful, and failing to reject the null hypothesis implies the training was not correct.

RESULTS AND DISCUSSION

The tests of hypothesis were conducted for 25 questions in four broad categories (NSES, Legal Management, Safety Management, Chemical Management). The resulting Z scores and P-values are summarized in Table 4. Note that the P-values for all questions are close to zero and hence significant at the 0.01 level. Hence the null hypothesis is rejected in every case and it is concluded that the ttaining was useful for the participants. Although each question is discussed individually, the statistical significance of each will not be analyzed separately.

The National Science Education Standards (NSES)

Few of the participants knew much about the safety components of the NSES. Only 3% (5 of 189) of the pre-training participants knew that the science teaching environment must provide adequate space, time, and resources necessary for the safe and effective teaching of science. By training's end, however, 75% (117 of 157) of the participants knew these recommendations. Just over 48% (90 of 189) of the pre-training participants knew that the Occupational Safety and Health Association (OSHA) is the organization that sets the

Table 4. Statistical analysis of differences between pre and post training.

	QUESTION ITEM	PRE-TRAINING % CORRECT	POST-TRAINING % CORRECT	Z SCORE	P-VALUE APPROX.
NSES	Environment	3%	75%	52.89	0
	OSHA	48%	89%	10.28	0
	Class size	12%	55%	16.58	0
Legal management	Tort	43%	95%	13.16	0
	Sovereign immunity	13%	66%	19.75	0
	Save harmless provision	7%	71%	31.43	0
	Negligence	19%	78%	18.84	0
	Due care	6%	79%	38.52	0
Safety management	Lab size	7%	90%	40.76	0
	Class/lab size	5%	91%	49.44	0
	Counter space	18%	84%	21.53	0
	Exits	70%	96%	7.12	0
	Fume hood	30%	94%	17.50	0
	GFI	23%	90%	19.95	0
	Fire extinguisher	13%	90%	28.69	0
	Goggles	9%	90%	35.46	0
	Fire blanket	33%	86%	14.12	0
	Equipment placement	2%	66%	57.28	0
	Enrollment	28%	99%	19.81	0
	Eye rinse time	21%	92%	21.84	0
Chemical management	Storage	40%	93%	12.65	0
	RTK	9%	59%	19.70	0
	Lab standard	8%	48%	18.47	0
	NFPA	21%	75%	16.61	0
	MSDS	32%	77%	12.09	0

Because the P-value is close to 0 in every case, the null hypothesis is rejected in every case, and it is concluded that the training was useful

standards for lab safety, while at the end of the program 89% (140 of 157) of the participants knew about OSHA. Lastly, only 12% (23 of 189) of the pre-training participants knew that teachers should follow professional guidelines for class size enrollments. By the end of the workshops, however, 55% (86 of 157) of the participants knew these facts and could apply them to their teaching situation.

Legal Issues

It was discovered that just over 43% (82 of 189) of the participants knew that tort law focuses on personal injury cases, however, 95% (149 of 157) of participants knew the specifics of Iowa tort law in science teaching by the end of the training. The remainder of the legal issues addressed all focus on components of tort law in education (Gerlovich and Gerard 1989).

Only 13% (25 of 189) of the participants knew that "sovereign immunity doctrines" were once used effectively as legal defenses for teachers in tort negligence cases. Prior to 1967, under the Sovereign Immunity Doctrine, public school districts could not be sued for torts committed by the district or its agents or employees. The Doctrine stated that any governmental operation could do no wrong, and, therefore, could not be sued without its consent. This legislation has generally been superseded by the Save Harmless Provision as a more effective and fair assessment of negligence. By the end of the training 66% (104 of 157) participants could explain this legal situation in Iowa.

Only 7% (8 of 157) of the participants knew that the "save harmless provision" is currently used as a powerful defense for educators in tort negligence cases. The save harmless provision is nearly universally applied in all states. It generally states that accidents can happen, parties can be injured by educators, and law suits can be filed against the educator. However, unless it can be proven that the educator broke the law (goggle legislation, Right-to-know legislation, etc.), or was grossly negligent (violated well accepted professional organizational guidelines, established codes, Department of Education standards, etc.), government subdivisions would be required to protect the teacher and pay any damages incurred. By the end of the training program 71% (112 of 157) of participants understood this critical concept (State of Iowa 1988).

Slightly less than 19% (36 of 189) of participants could explain what constituted negligence in science education. Generally speaking, negligence is defined as conduct which falls below a standard set by the law or one's profession to protect others from injury. Lack of "due care" is another legal synonym. Educators must conform to the civil laws of society as well as applicable codes (fire, electrical, plumbing, etc.) and standards (professional standards of performance, state Right-to-Know, Chemical Hygiene, Bloodborne Pathogen legislation, etc.) in order to assure a safe teaching and learning environment. Participants experienced significant growth in their understanding of this legal concept increasing to 78% by training's end (123 of 157).

Only 6% (11 of 189) of participants knew that "due care" was a synonym for assuring that the educator was not negligent and that it consisted of satisfying three major duties. First, is instruction appropriate for all students in one's charge (inclusion or special education students, students with special medical needs, etc.)? Second, is supervision adequate for the situation, surroundings, student population being served, and activities being conducted? Third, is the environment (equipment, instructional surroundings) properly maintained? Satisfying these duties helps assure that the educators in charge are not negligent should an accident occur. Participants grew dramatically in their understanding 79%, (124 of 157 correct responses) by the end of the program.

Safety Management Issues

Only 7% (14 of 189) of participants knew the recommendation of the National Science Teachers Association (NSTA) for laboratory size limitations. "a minimum of 4.0 square meters floor space per student in a laboratory. Because of safety considerations and the individual attention needed by students in laboratories, science classes should be limited to 24 students in elementary, middle level, and high school science labs unless a team of teachers is available." A minimum of 4.2 square meters of floor space per student is recommended for a laboratory (Texley and Wild 1996). The National Science Education Leadership Association (NSELA) recommends that "the minimum required floor area in net square feet per occupant (excluding furniture) for a science lab/classroom must conform to the fire code and administrative code of the state. The number of students assigned to a science lab/classroom that is occupied with 24 'built-in' lab stations (and which has adhered to state administrative and fire codes for appropriate square footage per student) should not exceed 22 if at least two of these students are classified as having special needs. There should not be more than 20 students assigned if at least three of the students are so classified." (NSELA 1996a) By the end of the program, participant understanding had improved to 90% (142 of 157) correct responses.

Only 5% (9 of 189) of the participants knew that NSTA recommends 5.5 square meters of floor space per student in lab/classroom combination rooms; not to exceed 24 students per teacher for. By training's end participant understanding had improved to 91% (142 of 157) correct participant responses.

Just under 18% (33 of 189) of the participants knew the NSTA recommendation for student lab counter space of 2.0 linear meters (6 feet) which helps address the overcrowding issue when using equipment as well as for personnel mobility about the lab and/or lab/classroom. By the end of training, participant understanding had improved to 84% (132 of 157) correct.

Nearly 70% (133 of 189) of participants knew that science labs should have at least two entrances/exits and that these should accommodate various human handicaps (wheel chair, crutches, etc.). Doors to these entrances/exits should also open outward in order to facilitate rapid egress during emergencies (Ashbrook and Renfrew1991, DiBerardinis et al. 1993) . Such portals should also be kept clear of clutter. All laboratories should be designed with efficient, safe exodus as a priority. By the end of the program 96% (150 of 157) could address this concept correctly.

Just under 30% (56 of 189) of participants knew that, unless other circumstances dictate, chemical exhaust hoods should be placed as far away from primary lab entrances/exits as possible. Air would be drawn from the primary entrance across the room and exhausted through the hood. This placement also prevents explosions, or other complications in the hood, from blocking the primary exit to the lab (Saunders 1993). Participant understanding had improved to 94% (148 of 157) correct by conclusion of the training.

Only 23% (44 of 189) of participants assessed knew the function of ground fault interrupters (GFI's). This strategic piece of safety equipment helps prevent electrocution due primarily to faulty grounds in electrical wiring. They are typically placed on electrical outlets in close proximity to faucets, where the reliability of electrical grounds is uncertain, as in older buildings, or where other potential electrical problems exist. Again, participants experienced significant growth by the close of the training program, with 90% (142 of 157) correct responses.

Only 13% (25 of 189) of participants knew the best type of fire extinguisher to place in science labs. For most general labs, ABC triclass dry chemical extinguishers are generally recommended, unless there are other unusual circumstances which exist. Where computers, or other sensitive electronic equipment items are a regular part of the lab, halon extinguishers were generally recommended. The training program again proved effective with 90% (142 of 157) correct responses. Today, Halon has been succeeded by the water mist, etc.

Only 9% (17 of 189) of participants knew the American National Standards Institute (ANSI) symbol for compliance with breakage and burn standards for eye protective equipment items such as goggles. ANSI, an independent testing agency, tests many types of safety equipment and then certifies them for government regulations (Byrnes 1989). The Z87 symbol, reflecting compliance with this ANSI clause, is generally placed on the faceplate and/or molding of the goggle along with the manufacturer's trademark. Compliance with this standard guarantees that the goggles will not break or burn under normal conditions. By the end of the training 90% (142 of 157) of the participants could correctly address these facts.

Nearly 33% (60 of 189) of the participants knew that fire blankets should be made of fire retardant wool or fiberglass. Such equipment should be readily accessible throughout the lab or lab/classroom. Over 86% (135 of 157) could correctly address this fact by training's end.

Less than 2% (3 of 189) of the participants knew that essential, strategic safety equipment (fire extinguishers, fire blankets, eyewash) should be placed no greater than 30 feet or 15 seconds travel distance from any point in the lab or lab/classroom. Growth of participants was not quite as great by training's end, regarding this concept 66%, (104 of 157 correct responses).

Just under 28% (52 of 189) of the participants knew the NSTA recommendation for limitation of class size to 24 students per teacher (Texley and Wild 1996), an absolute ceiling per teacher. In addition to this number, teachers and administrators must review the floor space, counter space per student, safety equipment items available, number of exits, and special needs students in the class. In many instances, the room will not accommodate even 24. The Council of State Science Supervisors supported this limitation in its 1987 position paper (Council of State Science Supervisors 1987). The National Science Education Leadership Association (NSELA) further refines this statement by recommending that "the number of students assigned to a science lab/classroom should not exceed 24 if only one instructor is responsible for teaching these students in a lab setting (regardless of how large the classroom may be). It is important for instructor and students to have immediate access to each other in order for the conditions to be safe and acceptable for appropriate learning. In addition, science lab class size should also be determined by the type of course and the age and maturity level of students. It is important to note that for some classes of younger, more active students no more than 20 students should be assigned (even if there are 24 'built-in' lab stations)" (NSELA 1996b). By the close of the training program, 99% (155 of 157) responses were correct.

Just under 21% (39 of 189) of participants knew that, in the event of a chemical splash to the eye, that medical experts recommend flushing with temperate, aerated water for 15 minutes. This time frame helps assure dilution of the damaging chemical until the victim can reach medical help. Application of neutralizing chemicals is not generally recommended without specific directions from qualified medical personnel. By the end of the program 92% (144 of 157) could correctly relate to this.

Chemical Management Issues

Just Over 40% (75 of 189) of participants knew that chemicals are best stored by chemical family. This method helps eliminate unwanted chemical reactions in the event of container breakage, it facilitates chemical association to properties, and it helps assure compliance with "Right-to-Know" and "Chemical Hygiene Plan" requirements. By the close of the program 93% (146 of 157) of participants understood this the need for this storage scheme.

Nine percent (17 of 189) of participants could identify the major requirements of the OSHA Hazard Communication Standard or "Right-to Know" (RTK) Legislation, designed to help employees recognize and eliminate the dangers associated with pertaining to hazardous chemicals in the workplace, was originally drafted as Final Rule in 1983 and effective November 25, 1985. All privately financed educational institutions are covered by the federal standard as well as the Right-to-Know laws in force in their respective states, publicly funded schools must comply with their respective state government statutes

The RTK requires that a *written program* be developed and that all affected employees know it's contents. The details of such legislation varies by state, however, these components are common: 1. Written Hazard Assessment Procedures, 2. Material Safety Data Sheets (MSDS's) for all chemicals, including; designated person responsible for maintaining the sheets, procedures for apprising and allowing employees access to them, procedures to follow when MSDS's are not received, procedures for updating the sheets, and descriptions of alternatives to actual sheets in the work area 3. Labels and Warnings, including; designated person responsible for ensuring proper labeling of chemicals, description of labeling system, and procedure for updating the labeling information. 4. Employee Training, including; designation of person responsible for conducting training, format of the program, documentation of training, and procedures for training new employees. By the close of the program only 59% (84 of 157) of participants could explain the details of this legislation.

Only 8% (15 of 189) of participants could identify the major components of OSHA's Laboratory Standard, Chemical Hygiene Plan (U.S. Dept. of Labor 1990), which became effective January 31, 1991. The plan requires that employers, including schools, develop a comprehensive plan for identifying and dealing with chemical hazards which must include all employees who could be exposed to hazardous chemicals. It must be updated annually or whenever new hazardous chemicals are added to the inventory. The corresponding sections of the plan are outlined and explained below. Laboratories engaged in activities that are encompassed within the definition of "laboratory use" must have a written Chemical Hygiene Plan (CHP) outlining how the facility will comply (Fiske 1994) standard applies to all employers engaged in the laboratory use of chemicals.

By the end of the inservice, just over 48% (75 of 157) of the participants could explain this legislation correctly.

Just over 21% (40 of 189) of the participants could identify the four components of the National Fire Protection Association (NFPA) Hazard Warning Label components. This four color, four component hazard diamond includes hazard ratings for chemicals regarding Fire (red), Reactivity (yellow), Health Hazard (blue), and Other considerations (white). The hazard ratings range from 0–4, with a 0 indicating no hazard and a 4 indicating extreme hazard for the respective categories. Participants quickly grasped the details of this safety sign, with understanding improving to 75% (118 of 157) correct responses.

Only 32% (61 of 189) of participants knew the purpose of Material Safety Data Sheets. MSDS's are chemical fact sheets designed to protect chemical users and others from harm by providing readily accessible information on hazards as well as precautions. These vital documents must be kept close at hand and referred to before handling or disposing of any chemicals. They may be several pages in length and are generally composed of the following nine parts:

1. material identification (chemical name, common name, code numbers, supplier name/address/emergency telephone)
2. ingredients and hazards (often including Threshold Limit Value—TLV, Permissible Exposure Limit—PEL)
3. physical and chemical data (boiling point, solubility, density)
4. fire and explosion data (fire fighting procedures, equipment, flash point)
5. reactivity data (chemicals, conditions that should be avoided)
6. health or physiologic information (primary routes of entry into body, acute and chronic effects)
7. spill, leak disposal (environmental) information (emergency management)
8. special protection information (protective equipment, hygienic procedures, first-aid)
9. precautions (warnings, special hazards, handling)

Recent federal and state legislation requires that these sheets be made available to employers and employees whenever a hazardous material is introduced into the work environment. Obtaining MSDS's is the responsibility of the employer. Participants understood the need for, and details of, this legislation immediately, with understanding improving to 77% (121 of 157) correct by the program's end.

SUMMARY

Historically, assuring a safe science teaching and learning environment in Iowa schools was a moral obligation. Today, it is also a legal responsibility endorsed, and expanded, by the science teaching profession. Trends from previous national studies and a recent rise in the numbers of Iowa school science-related accidents, and lawsuits raised suspicions about a lack understanding of vital safety issues among these Iowa professionals. A summer, 1997 study of approximately 200 science teachers verified this suspicion. It also showed that, with proper training, and tools, these problems could be successfully addressed.

LITERATURE CITED

ASHBROOK, P. C. and M. M. RENFREW. 1991. Safe laboratories: Principles and practices for design and remodeling, Chelsea, MI: Lewis Publishers, Inc.

BYRNES, J. K. 1989. Eyewear Meets the Challenge, Safety and Health. Washington, D. C.: National Safety Council. 134, (3):64, 67–69.

COUNCIL OF STATE SCIENCE SUPERVISORS. 1987. Exeter III: Proceeding of the National conference of the Council of State Science Supervisors at the Phillips Exeter Academy.

DIBERARDINIS, L. J., J. S. BAUM, M. W. FIRST, G. T., GATWOOD, E. F. GRODEN, A. K SETH. 1993. Guidelines for Laboratory Design: Health and Safety Considerations, (2nd ed.). New York: Wiley Interscience.

FISKE, J. R. 1994. The Chemical Hygiene Officer: Piecing Together the Liability Puzzle, Chemical Health & Safety, 1. Washington, D. C. American Chemical Society, 12–16.

GERLOVICH, J. 1995. Was I Supposed to Know That: Teacher Understanding of Science Safety Issues. Science Education International, 6 (3): 33–38.

GERLOVICH, J. and T. GERARD. 1989. Reducing District Liability in Science Teaching: A Safety Solution. American School Board Journal: Washington, D.C.

GERLOVICH, J., K. HARTMAN, T. GERARD. 1996. The Total Science Safety Software System—Secondary, (8th ed.), Waukee, IA: JaKel, Inc.

NATIONAL RESEARCH COUNCIL 1996. National Science Education Standards, Washington, D.C., National Academy of Sciences.

NATIONAL SCIENCE EDUCATION LEADERSHIP ASSOCIATION. 1996a. Class Size In Science Laboratory Rooms. NSELA Board Position, March 26.

NATIONAL SCIENCE EDUCATION LEADERSHIP ASSOCIATION. 1996b. Science Teaching Conditions. NSELA Board Position, March 26.

SAUNDERS, T. G. 1993. Laboratory Fume Hoods: A User's Manual, New York: John Wiley & Sons.

STATE OF IOWA. 1988. School Laws of Iowa, 280.10, Des Moines, IA Iowa Legislature.

TEXLEY, J. and A. WILD. 1996. NSTA Pathways to the Science Standards: Guidelines for Moving the Vision into Practice. National Science Teachers Association: Arlington, VA.

U.S. DEPARTMENT OF LABOR. 1990. Federal Register, Department of Labor, Occupational Safety and Health Administration, 29, CFR, Part 1910, Occupational Exposures to Hazardous Chemicals in Laboratories, Final Rule, Wednesday, January 31, 1990. Washington, D.C.: U.S. Superintendent of Documents, Government Printing Office.