Journal of the South Carolina Academy of Science 1(1):19-27 Fall 2003

SOUTH CAROLINA STATEWIDE SCIENCE SAFETY PROJECT

Linda Sinclair*, Jack Gerlovich, Rahul A. Parsa,

*South Carolina Department of Education, 801H Rutledge Bldg. 1429 Senate St., Columbia, SC 29201
lsinclai@sde.state.sc.us

ABSTRACT

Between the years 2000 and 2002, South Carolina state agencies worked with a science safety team to create a customized training program and CD-ROM package designed to address all applicable state laws, codes and professional standards. As part of this two year project, surveys were conducted concerning the status of facilities, equipment, and teacher understanding of their professional obligations. The pre-training survey results revealed serious science safety issues. Post-training workshop surveys indicated that the training and customized CD-ROM's were valuable to the participating science educators.

INTRODUCTION

In recent years there has been a great deal of inquiry surrounding the conditions of safety in science settings throughout the United States. In the fall of 1999 and spring of 2000, a yearlong science safety project was completed in Wisconsin (Gerlovich et al., 2001). As part of that effort, teachers were required to complete a pre-training survey of their facilities, equipment, and understanding of their legal and professional obligations towards safety. The results were disturbing and confirmed earlier studies by Gerlovich (1997) indicating that few teachers were aware of their legal and professional obligations for safety within their science settings. The study also supported safety conclusions that emerged from a 1998 Iowa study (Gerlovich et al., 1998) which indicated that poor facilities and equipment combined with inadequate understanding of legal and professional obligations resulted in increased numbers of accidents and lawsuits. These studies raised concerns relative to the status of safety in South Carolina schools. In early 2000, the South Carolina Department of Education State Science Coordinator contacted Dr. Jack A. Gerlovich, Professor of Science Education/Safety at Drake University to collaborate on a study of the status of science safety in South Carolina schools. This report **is** the summary of that study.

MATERIALS AND METHODS

Throughout the summer and fall of 2000 Linda Sinclair, Science Supervisor, South Carolina Department of Education, worked cooperatively with Dr. Jack A. Gerlovich to convene a science safety advisory committee with representatives from the South Carolina Science Supervisors, Department of Education, Fire Marshall, Department of Environmental Health and Collaboration, Occupational Safety and Health, and the Department of Health. This advisory group reacted to survey tools, workshop agenda models, and science safety CD-ROM models from other states that could form the basis for a South Carolina model.

During the spring of 2001 each committee member individually researched the safety regulations required by their respective state agency and shared this with the committee. Following prioritization of issues, the committee then worked to develop a pre-training survey

instrument that reflected the information collected. The ultimate purpose of the survey was to have the invited science teachers use the instrument to assess the safety status of South Carolina secondary school science facilities, equipment, procedures, and their understanding of legal and ethical obligations prior to attending the training workshops.

In the summer of 2001, knowing the laws, codes, and professional standards with which science teachers must comply, a draft edition of a science safety CD-ROM was developed and then refined by the committee for use with teachers in the fall of 2001.

During the fall of 2001 and summer of 2002 a total of ten full-day training programs were conducted for approximately 280 secondary science educators from across the state. Pre-training surveys were completed by participants and delivered to the workshop coordinators as part of the registration requirements. As part of the workshops, post-training workshop evaluations were administered concerning teacher perceptions of the value of the workshops and the CD-Rom package.

RESULTS

A. Facilities

Table 1 provides a summary of the findings provided by participants from the pre-training survey at the training workshops. The survey focused on the following items: Lab Age, Lab Square Footage Area, Lab/Classroom Square Footage, Fume Hood, Room Air-Turnovers, Lab Exits, Master Shut-Off's.

Table 1. Responses to the Facilities Part of the Survey.

Summary of Q1 (Lab Age)			Summary of Q2 (Lab Sq. Ft.)			Summary of Q3 (Lab/Class Sq. Ft.)		
Response	**Count**	**%**	**Response**	**Count**	**%**	**Response**	**Count**	**%**
0-10 yrs	82	39.23	500-749	92	56.10	500-749	61	40.13
11-20 yrs	48	22.97	750-999	46	28.05	750-999	46	30.26
21-30 yrs	41	19.62	1000-1499	16	9.76	1000-1499	34	22.37
30+yrs	38	18.18	>1500	10	6.10	>1500	11	7.24
Total	209	100	Total	164	100	Total	152	100

Summary of Q4 (Fume Hood)			Summary of Q5 (Exits)		
Response	**Count**	**%**	**Response**	**Count**	**%**
Yes	113	53.81	1	78	40.00
No	95	45.24	2	96	49.23
Don't Know	0	0.00	3	14	7.18
No Functional Hood	2	0.95	4	7	3.59
Total	210	100	Total	195	100

It was found that approximately 40% of the labs of the participating teachers were less than ten years of age, while nearly 38% were 21 years or older in age. Lab Age can have serious implications when considering newly implemented codes.

Square footage of labs can be critical. The State of South Carolina School Facilities Planning Guide states that: "All science classes grades 7-12 shall be taught in or have access to classrooms designed specifically for student oriented laboratory experiences. It is recommended that class

load be limited to 24 students. ...[In addition] separate labs should have a minimum of 900-1000 $ft^{2.}$" The National Science Teachers Association (NSTA) recommends 45 ft^2/student in science labs, (1080ft^2) while not exceeding 24 students. (Biehl et al, 1999). The survey indicated that slightly more than 56% of the labs surveyed had less than 750 square feet, while just under 15% had over 1000 square feet.

When considering Lab/Classroom square footage in combination science settings, over 70% of the responding teachers indicated that their settings were less than 1000 square feet. The NSTA recommends 60ft^2 per student in such settings, while the South Carolina Facilities Planning Guide (State of South Carolina, 1995) states such settings should be:

> "Designed as a self-contained classroom, this style laboratory/classroom facility has an instructor's demonstration and flattop student desks in one-half of the classroom with student laboratory stations in the other half. It is recommended that 50 square feet/student be allowed for each science laboratory/classroom combination..."

The State of South Carolina School Facilities Planning Guide further states that such combination facilities should have between 1200 ft^2 and 1800 ft^2 of total floor space, depending on design style.

Nearly 54% of the participating teachers indicated that they had a functioning fume hood. By contrast, just over 45% did not have such equipment. This question may have been misleading to the participants, since the curriculums in some science programs may not require such equipment. The South Carolina Planning Guide requires an exhaust fan only.

Approximately 56% of the participating teachers' labs had two or more lab exits with outward opening doors. According to the South Carolina Planning Guide, two exits are required for science labs – clearly a critical problem that needs immediate attention. In some instances, windows can be used as an exit, as long as they meet certain size minimums

> "Size of egress openings: For a single- or double-hung, casement, or sliding window, there shall be a minimum of 6 sq. ft. opening in the clear, with a minimum clear dimension of 24" in either direction. If projected windows are used, they shall have a minimum clear sash opening of 32 wide and 40" high, and not less than 6 sq. ft. clear passage under the sash when the sash is at 45° open position."

The National Fire Protection Agency (NFPA, 1991) codes 45 and 10, adopted in many communities, spell out the exit requirements for lab facilities. NFPA 45, for instance, requires that labs have two exits, not greater than 50 feet distance from any point in the lab, if they:

1. contain explosion hazards that could block them,
2. are Class A Labs (hazardous materials that present significant fire hazards) that are larger than 500 ft2,
3. are Class B labs (moderate fire hazard),
4. are Class C labs (low fire hazard) and exceed 1000ft2 in work area,
5. have a lab fume hood located near a primary lab exit,

6. contain a compressed gas cylinder larger than lecture bottles containing a flammable or cryogenic gas with a NFPA Health Rating of 3 or 4.

B. Equipment

Table 2 provides an analysis of the questions posed to the participating teachers relative to equipment items. Certain equipment items are essential for safety in today's academic science laboratories.

Table 2. Responses to the Equipment Part of the Survey.

Summary of Q1 (GFI/GFCI)			Summary of Q2 (Fire Extinguisher)			Summary of Q3 (Eye Wash)		
Response	**Count**	**%**	**Response**	**Count**	**%**	**Response**	**Count**	**%**
Yes	77	37.20	0	24	11.59	0	51	24.52
No	36	17.39	1	166	80.19	1	142	68.27
I don't know	94	45.41	2	16	7.73	2	13	6.25
			3	1	0.48	3	2	0.96
			4	0	0.00	4	0	0.00
Total	207	100	Total	207	100	Total	208	100

Summary of Q4 (Eye Protective Equipment)		
Response	**Count**	**%**
Yes	159	75.36
No	31	14.69
I don't Know	21	9.95
Other	0	0.00
Total	211	100

Ground Fault Interrupters (GFI) or Ground Fault Circuit Interrupters (GFCI) are examples of such simple, strategic items (Kaufman, 1995). While only 37% of the participating teachers' labs had GFI/GFCI's, this may be due in part to the age of the buildings. Approximately 17% indicated that they do not have GFI/GFCI protection. However, 45% do not know if their electrical outlets are protected and 17% percent do not have such electrical protection. GFI/GFCI's are essential to protect teachers and students from electrocution through unwanted grounding via water pipes, etc. (State of South Carolina, 1995)

For the purpose of the South Carolina Facilities Planning Guide:

> "an existing building shall be any building that has been occupied for a period of 6 years or more.... Ground Fault Protection: Ground fault protection shall be provided in accordance with NFPA 70 and for all receptacles convenience outlets) installed outdoors, in toilets and near sinks... Science laboratories, home economics departments, business education departments, shops, and other instructional areas where a considerable amount of electrical equipment is to be used should be provided with outlets of the proper type and number to meet the needs of each area. In such areas, consideration should be given to providing a main disconnecting means to enable the disconnection of all instructional electrical loads from the power supply (lighting not included) and should be

provided unless obviously not needed for safety or control, or if not desired by the school district."

Fire extinguishers are another essential piece of equipment for science lab settings. On a positive note, approximately 88% of the participating teacher's labs had at least one appropriate fire extinguisher, however, nearly 12% had none. It is hard to imagine a science laboratory that will not need an ABC tri-class fire extinguisher at some time. Teachers should also arrange to receive training in their proper usage.

Eyewash stations are another essential piece of safety equipment for science labs. According to OSHA and the South Carolina Facilities Planning Guide these are vital to safety and are listed as Specific Requirements at the elementary and secondary school levels. Just under 25% of participating teachers indicated that either they did not have this equipment or did not know if they did.

Eye protective equipment is another essential safety item for all science labs. Both OSHA 1910.133 (Vogel, 1998) and South Carolina Safety Program and Policy Manual (State of South Carolina, 1998) require such equipment. Over 75% of the responding science teachers reported that they had the essential equipment. However, 25% either did not have the equipment or did not know. The South Carolina Eye and Face Protection Legislation states:

> Policy
> Each affected employee shall use appropriate eye and face protection when exposed to eye or face hazards from flying particles, molten metal, liquid chemicals, acids or caustic liquids, chemical gases or vapors, or potentially injurious light radiation. Employee is defined as a full-time permanent, a full-time probationary, or a time-limited employee. Affected teams include, but are not limited to OGS teams: Mechanical, Electrical, Maintenance, EMFS, Horticulture, and Statewide Building Services.
>
> Procedures
> 1. Equipment used to protect the eyes and face shall be approved by the American National Standards Institute(ANSI). Eye protection shall comply with Z 87.1 - 1989 "American National Standards Practice for Occupation and Educational Eye and Face Protection," or later edition. Safety glasses shall be equipped with permanent side shields.
>
> NOTE: Although the lenses in prescription glasses are referred to as "safety glass," these lenses do not meet the requirements for workplace safety. Safety glasses shall be distinctly marked with the manufacturer's name and other identification as well as ANSI Z 87.1 -1989.

C. Teacher Procedures

Table 3 provides a summary of procedural questions posed to the participating teachers. It is often assumed that teachers have received Safety Training for all of the essential duties that they are asked to perform. From the data below, it can be seen that this assumption can be wrong.

Table 3. Responses to the Procedures Part of the Survey.

Summary of Q1 (Safety Training)			Summary of Q2 (Contact Lenses)			Summary of Q3 (Safety Contracts)		
Response	**Count**	**%**	**Response**	**Count**	**%**	**Response**	**Count**	**%**
Never	99	47.37	Never	38	18.54	Yes	151	71.90
0-5 yrs	77	36.84	W/safety	132	64.39	No	59	28.10
5-10 yrs	21	10.05	W/nonvented	34	16.59			
10+ yrs	12	5.74	W/faceshield	1	0.49			
			Don't know	0	0.00			
Total	209	100	Total	205	100	Total	210	100

Summary of Q5 (Safety Tests)		
Response	**Count**	**%**
Yes	149	70.62
No	61	28.91
Don't Know	1	0.47
Total	211	100

Over 47% of the participating teachers had never received science safety training, while just under 6% had not had any in the last 10 years. This is quite disconcerting given the recent proliferation of codes and standards.

Contact Lenses are becoming a common item in an increasing percentage of our adolescent population. When these are worn in science labs, the potential for unnecessary injury increases. Teachers should know which students are wearing contacts and be prepared to address their emergency medical needs relative to the science activities being performed. In April 1994, the Occupational Safety and Health Organization (OSHA) published its Personal Protective Equipment (PPE) for General Industry Standard (29 CFR 1910; Final Rule). Part of the preamble stated (Chemical Health & Safety, 1998):

> OSHA believes that contact lenses do not pose additional hazards to the wearer, and has determined that additional regulation addressing the use of contact lenses is unnecessary. The Agency wants to make it clear, however, that contact lenses are not eye protective devices. If eye hazards are present, appropriate eye protection must be worn instead of, or in conjunction with, contact lenses.

The question then becomes, what is "appropriate eye protection." For most activities, indirectly vented, or non-vented, safety goggles would be most appropriate, however, when using injurious chemicals that can be caustic to eye tissue. Fewer than 19% of participating teachers indicated that they never allow the wearing of contact lenses in labs. This seems to be extreme. Over 64% stated that they allow contact lenses with safety goggles, while 16% only allow them with non-vented cover goggles. Less than 1% said they would allow them only with a face shield. Recall that face shields cannot supplant goggles, they can only be a supplemental to them in lab settings.

On a positive note, approximately 72% of participating teachers indicated that they required student Safety Contracts and over 70% required students to take Safety Tests as a way of

gauging their safety understanding. Teachers might also wish to incorporate safety as regular parts of their lesson plans and student lab/inquiry reports.

D. Teacher Understanding of Laws, Codes, Professional Standards

Table 4 provides an analysis of the questions posed relative to the participating teacher understanding of applicable laws, codes, and standards. Due to space limitations, not all items are included in this report.

Table 4. Responses to the Laws/Codes/Standards part of the Survey

Summary of Q1 (Federal OSHA)			Summary of Q2 (Right-to-Know)		
Response	**Count**	**%**	**Response**	**Count**	**%**
Yes	161	75.23	Yes	109	51.90
No	6	2.80	No	6	2.86
Don't Know	47	21.96	Don't Know	95	45.24
Total	214	100	Total	210	100

Summary of Q3 (Lab Standard)			Summary of Q4 (Bloodborne Pathogens)			Summary of Q5 (Good Samaritan)		
Response	**Count**	**%**	**Response**	**Count**	**%**	**Response**	**Count**	**%**
Yes	125	59.52	Yes	172	81.13	Yes	63	29.86
No	3	1.43	No	0	0.00	No	10	4.74
Don't Know	82	39.05	Don't Know	40	18.87	Don't Know	138	65.40
Total	210	100	Total	212	100	Total	260	100

It was interesting to note that nearly 25% of participating teachers did not know that South Carolina had its own version of OSHA (although identical to the federal standards). When asked whether South Carolina public school science teachers must follow OSHA (1990) legislation for Right to Know, Lab Standard (Chemical Hygiene Plan) and Bloodborne Pathogens, the responses were quite varied. Less than 52%, 60%, and 81% of respondents were aware of the OSHA Right-to-Know , Lab Standard (Chemical Hygiene Plan), and Bloodborne Pathogen legislation respectively. These three codes provide much of the backbone for safety in our nation's schools and should be carefully analyzed by all science teachers.

It was interesting to note that only 29% of the participating teachers knew that South Carolina had a Good Samaritan Law (State of South Carolina, 1998) that protected citizens rendering emergency aid to another. The legislation parallels the tort legislation discussed earlier. Generally it allows teachers, as citizens to assist others within the "reasonable and prudent judgment" parallel when it states:

> (S.C. Code Ann.§ 15-78-40)
> Any person, who in good faith gratuitously renders emergency care at the scene of an accident or emergency to the victim thereof, shall not be liable for any civil damages for any personal injury as a result of any act or omission by such person in rendering the emergency care or as a result of any act or failure to act to provide or arrange for further medical treatment or care for the injured person,

except acts or omissions amounting to gross negligence or willful or wanton misconduct.

The remainder of the questions posed to the teachers focused on their knowledge of South Carolina statutory requirements and professional standards relative to safety items. The items have already been discussed as part of the other three categories above. A reasonable summary would be that the participants were quite uninformed about the items.

E. Workshop Evaluation Results

At the close of each training session, evaluations were conducted concerning the participating science educators' perceptions of the value of the workshop and the *South Carolina Secondary Edition – Total Science Safety System CD* in meeting their safety needs. A total of 280 secondary science educators participated in the training sessions. Table 5 provides an analysis of the post-workshop responses from 253 of the participants who returned their forms.

Table 5. Summary of Training Evaluations

Question	Ave. of 253 Responses Participant Score/Possible Score
1. Session accomplished objectives overall	4.6/5.0
2. Session accomplished content objectives	4.6/5.0
3. Session methods supported the objectives	3.9/5.0
4. Session was relevant and interesting	4.6/5.0
5. Enough time spent on useful issues	4.2/5.0
6. Knowledgeable, well prepared presenters	4.3/5.0
7. Methods and activities appropriate to needs	4.5/5.0
8. Questions were encouraged-discussion kept focus	4.7/5.0
9. Relevant, useful handout materials	4.8/5.0
10. Comfortable space and facilities	4.3/5.0
11. Overall, worth time and effort to attend	4.6/5.0

Generally, the science educators were positive about the workshops. They were, however, most impressed with the questions that encouraged discussion and focus for the workshops as well as the relevance and usefulness of handout materials (probably the CD-ROM's). By contrast, they were least impressed with the methods used to meet the objectives.

DISCUSSION

Most (75%) of the reporting science educators are violating the National Science Teachers Association (NSTA) recommendation (1080 ft2 of floorspace) for laboratories accommodating 24 students as well as South Carolina law for 900-1000 ft2. The situation appears worse for lab/classroom combination rooms where only 7% of participating science educators could accommodate 24 students at 60ft2 (1440 ft2) recommended by the NSTA.

There were also several equipment concerns raised by the study, including: the lack of such strategic safety equipment items as: GFI/GFCI protected electrical outlets, appropriate fire extinguishers, approved eyewash stations, and approved eye protective equipment.

Very few of the workshop participants could identify the most appropriate protection for contact lens wearers during science activities. It was also quite apparent that a high percentage of the participating science educators were unaware of federal and South Carolina laws and OSHA codes. Much of this could be explained by the fact that a high percentage of the participating science educators either have never had any safety training or had it over 10 years ago.

Workshop participants felt that the training sessions were relevant and interesting, encouraged discussions, and provided useful handout materials such as the *South Carolina Secondary Edition – Total Science Safety System CD-ROM.*

LITERATURE CITED

Biehl J., Motz L., West S. NSTA Guide to School Science Facilities. Arlington; 1999

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, U.S., Supt. of Documents, Government Printing Office, Washington, D.C.

Gerlovich J. Whitsett J., Lee S., Parsa R. Surveying Safety: How Researchers Addressed Safety in Science Classrooms in Wisconsin. The Science Teacher. 2001; 68: 31-36.

Gerlovich, J. Safety Standards: An Examination of What Teachers Know and Should Know About Science Safety. The Science Teacher. 1997; 64: 46-49.

Gerlovich J., Parsa R., Wilson E. Safety Issues and Iowa Science Teachers. Journal Iowa Academy of Science. 1998; 105:152-157.

JaKel, Inc. South Carolina Secondary Edition – Total Science Safety System [CD-ROM], Waukee: 2001.

Kaufman, J. Don't be Shocked. Chemical Health & Safety. 1995: 2; 4, 29.

National Fire Protection Association. Laboratories Using Chemicals. NFPA Standard 45. Batterymarch Park, Quincy, MA. 1991.

State of South Carolina, Office of General Services. Eye and Face Protection. Safety Program and Policy Manual, Number: 98-0102, October 1, 1998.

State of South Carolina. South Carolina School Facilities Planning and Construction Guide, Office of District Facilities Management, Division of Support Services, South Carolina Department of Education, April. 1995.

Vogel, M. Looking at Protective Eyewear. Chemical Health & Safety. 1997. 4, 2. 31-35.