AN ANALYSIS OF INCIDENT/ACCIDENT REPORTS FROM THE TEXAS SECONDARY SCIENCE SAFETY SURVEY 2001 AND 2003

THESIS

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ABBREVIATIONS

AEIS	Academic Excellence Indicator System
ANSI	American National Standards Institute
CSSS	Council of State Science Supervisors
LSI	Laboratory Safety Institute
NABT	National Association of Biology Teachers
NRC	National Research Council
NSELA	National Science Educational Leadership Association
NSTA	National Science Teachers Association
OSHA	Occupational Safety and Health Administration
STAT	Science Teachers Association of Texas
TAC	Texas Administrative Code
TEA	Texas Education Agency
TEADAC	Texas Education Agency Data Analysis
TEC	Texas Education Code

GLOSSARY

Accident. An occurrence that includes human injuries that occur during activities in the classroom, lab, or field that *may or may not* require medical attention.

Incident. An occurrence that includes spills, broken glass, excessive fumes, small fires, liquids boiling over, etc., during activities in the classroom, lab, or field that do NOT involve injury.

ABSTRACT

AN ANALYSIS OF INCIDENT/ACCIDENT REPORTS FROM

THE TEXAS SECONDARY SCHOOL SCIENCE SAFETY SURVEY 2001-2003

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Safety issues are of top concern in today s science classes in secondary schools. More and more, science activities are resulting in serious accidents and near-misses. To date, very little research has been conducted in the area of science safety in secondary school courses. Furthermore, no significant relationships have been identified between mishaps and facility, classroom management, or safety training issues. To add to the research base and to search for possible factors that may increase the occurrence of incidents and accidents, this study investigated safety in Texas secondary school science laboratory, classroom, and field settings during the 2002-2003 school year. Texas Education Agency drew a random representative sample consisting of 199 secondary public schools in Texas. There were a total of 332 reports responses in this study. All of the reports were anonymous, and predominantly unstructured and open-ended. They are unique in capturing the strengths and weaknesses of safety practices in science classrooms, laboratories, and field sites as perceived by science teachers. To identify possible variables that may increase the likelihood of mishaps, frequency distributions were utilized. Pertinent findings from the completed reports include: 1) mishaps appear to increase with increasing class size in middle school and high school, 2) mishaps appear to increase with decreasing room size in middle school and high school, 3) a large portion of science teachers are not being trained in safety, which appears to relate to mishaps, and 4) lack of teaching experience appears to also relate to mishaps. In addition to these findings, this study also identified the most frequent incidents and accidents reported in middle schools and high schools in the sample. The findings of this study can be used to develop science classroom, lab, and field safety guidelines on a classroom, school, district, state, and a national level.

CHAPTER 1

INTRODUCTION

Monday, March 11, 2002, seemed to be a typical spring day at New Berlin West High School in New Berlin, Wisconsin, until something horribly unexpected occurred during a chemistry demonstration in the school auditorium. A chemistry teacher was igniting chloride and methyl alcohol mixtures to show the variety of chloride emissions when a sudden burst of flames shot into the audience of students. Immediately, four female students suffered extensive burns to the face, neck, hands, and arms. (Hetzner, 2002).

Although headline-producing articles capture our attention, most safety issues in the classroom, laboratory, and field are not publicized. For example, a student may inadvertently knock over a graduated cylinder while taking volume measurements. No one is injured. Although *incidents* like this one do not make it into the headlines, such situations may have the potential for more serious *accidents* to occur. If the glassware had shattered and struck an eye or contained a hazardous chemical, the likelihood of injury may have increased.

Percentages of teachers reporting accidents vary from 29% to 65%, indicating that teachers are facing many hazards in science settings (Young, 1970; Young, 1972; Ward & West, 1990; West & Cielencki, 1992). It also appears that the conditions that surround an incident without human injury may also surround injury-causing accidents. The purpose of this study is to attempt to identify some conditions that may lead to an increased likelihood of a mishap.

Although much of the literature regarding safety in school science is not recent and does not include scientifically designed studies, the reports identify key factors that are consistent with anecdotes from the field and provide insight into the design for new scientifically designed studies. Such studies are needed in order to provide credible information about specific science safety issues to state education agencies, state boards of education, and professional organizations for administrators, architects, facilities planners, and science teachers.

It is important to conduct more studies in this area because there are no current data concerning safety in secondary school science classrooms, laboratories, and field settings in Texas. This is due in part to: 1) the last Texas Education Agency (TEA) safety survey occurred in 1991; 2) there is no requirement for reporting incidents or accidents; 3) there is no mandated and documented annual safety training for science teachers; and 4) there is no systematic data collection on conditions of safety in science (or other) classrooms. Additionally, new national science education standards-based requirements were implemented in Texas (TAC 19:74, 1996). A current research-based description of today s school science settings will provide a basis for making decisions to implement the above requirements.

Historically there have been conditions reported in the science classroom that have been associated with an increase in accidents.. Based on these reports, it is hypothesized that overcrowding, lack of discipline, lack of safety training, and having little teaching experience may increase the likelihood of incidents and accidents. The Texas Science Safety Incident/Accident Form was used to attempt to address/research these areas and to add to the small existing research base.

Overcrowding

Overcrowding, due to large class size and inadequate room size, may be a factor that leads to mishaps in science settings. Science teachers consider overcrowding to be a significant safety problem (Horton, 1988; Rakow 1989, S3; West et al., 2001). The higher the classroom enrollment and the lower the amount of classroom or laboratory space, the more frequent and more serious the accidents (Macomber, 1961; Brennen, 1970; Young, 1972; West et al., 2001). Overcrowded conditions also make it very difficult for teachers to manage activities in their classrooms properly and may significantly compound safety issues.

Class Size. Due to overcrowding concerns, many professional organizations recommend that class size be limited to 24 students (National Science Educational Leadership Association [NSELA], 1996; National Association of Biology Teachers [NABT], 1994; Council of State Science Supervisors [CSSS], 1999). Although there are also many state recommendations, only one state, New Hampshire, has a requirement for limiting the number of students in any one class to 24 students (New Hampshire Code of Administrative Rules, Ed 306.36). Classroom and laboratory class sizes that are greater than the design load of the facilities do not meet the standards. More importantly, environments under such conditions are potentially unsafe for students and teachers (Kaufman, 1999). Credible evidence that indicates limited class size may reduce incidents and accidents is needed to make a powerful case for a class size limitation requirement.

Room Size. Science is often taught in rooms that are too small to accommodate the activities conducted. Room dimensions continue to be a key concern in science safety with a range of 59% to78% of science classes taught in rooms with less than 1000 $ft.^2$, and about 29% taught in rooms with less than 750 ft^2 (Fuller, 2001; West et al., 2001; Gerlovich, et. al., 2001; Gerlovich & Parsa, 2002). NSTA recommends minimum room size measurements for school science facilities by using the gross footage per student, which is the square footage divided by the maximum number of students in any one class. For a class of 24 students a minimum of 1440 ft^2 should be allowed for any combination classroom/laboratory, and a minimum of 1080 ft^2 for any pure science laboratory room. In Texas, if a school plans to exceed the science class enrollment recommendation of 24 students at the secondary level, the school must comply by building a science room to maintain the square footage per student as outlined by the Texas School Facilities Standards (TAC 19:61, 2003). Research relating inadequate room size with incidents and accidents is needed for strict room size requirements to be adopted by state education agencies.

Classroom Management

There is a need for discipline in order to maintain a safe working environment, which includes school science classrooms and laboratories. Horseplay in the laboratory that results from inadequate classroom discipline is a factor contributing to accidents (Macomber, 1961; Krajkovich, 1983). More serious accidents also occur when horseplay is involved (Macomber, 1961). Science activities demand an environment free from inappropriate behavior for the safety of all of the students and the teacher. In Texas, teachers have the authority to remove a disruptive student from the classroom (Texas Education Code [TEC]: Alternative Settings for Behavior Management, Title I, 37.002, 1995). This policy is consistent with findings on the effects of class size on discipline where teachers with smaller classes reported a reduction in discipline issues (Halbach, Ehrle, Zahorik, & Molnar, 2001).

<u>Adequate Science Equipment and Facilities</u>

Science equipment such as safety goggles are needed in science classrooms and other facilities where humans are employed. A number of safety recommendations have historically been made based on prudent practices (Occupational Safety and Health Administration [OSHA], 1991). Chemical splash-proof safety goggles are necessary to protect the eyes from liquid splashes, contaminated fingers touching the eyes, and flying objects. Due to concern for the use of proper eye protection, school districts in states such as Texas, Nebraska, and Wisconsin have regulations regarding when protective eye devices must be worn, as well as the proper type of eye device that should be worn under the conditions of the activity (TEC: Protective Eye Devices in Public Schools, 1995; Gerlovich & Woodland, 2001; Gerlovich, et. al, 2001). Other states have similar policies of their own regulating the use of protective eye equipment.

The prevention of electrical shock in the laboratory is another important aspect of laboratory safety. Science teachers should be aware of ignition sources and the proper use, maintenance, and storage of flammable reagents, electrical cords, outlets and ground fault interrupters. Also, an inventory of all chemicals and protective devices should be conducted (West & Cielencki, 1992). The inventory will reveal any unwanted chemicals which can be disposed of properly, and any malfunctioning safety equipment or lack of such equipment (OSHA, 1991; West & Cielencki, 1991; Fuller, et. al., 2001).

Safety Training

Safety training is paramount in order to promote and maintain a safe working environment in science settings. The OSHA Laboratory Standard (OSHA 29 CFR 1910.1450) requires the Chemical Hygiene Officer to implement a Chemical Hygiene Plan that requiring safety training for teachers that includes the use of Material Safety Data Sheets (OSHA, 1991; Mandt, 1995, Young, 1997). However, not all states have adopted the OSHA standard, and many teachers have not been trained in safety (Krajkovich, 1983; Ward & West, 1990; Gerlovich, Hartman, & Gerard, 1996; Gerlovich et al. 2001; Stallings, et. al., 2001). In 1989, 61% of Texas chemistry teachers reported they did not have any safety training (Ward & West, 1990). Many teachers have been poorly informed in several key safety areas, including understanding of ground fault interrupters, types and uses of fire extinguishers, ANSI symbol for safety goggles, and class/size limitations for laboratories (Gerlovich, 1997). Even in 1999, only 47% of teachers surveyed in Wisconsin had received safety training, and only 14% from that survey knew the purpose of MSDSs (Gerlovich, et. al., 2001).

Teachers who have had proper safety training seem to have fewer accidents (Ward & West, 1990). When a teacher is trained in safety, such practices are modeled and passed on to the students by describing safety precautions, devoting a class period to safety, or testing students on safety (Krajkovich, 1983; Ward & West, 1990). Research is needed in this area to gather evidence of a relationship between safety training and mishaps in school science settings.

The main goals of this study are to: 1) determine if limited class size appears to reduce mishaps, 2) determine if inadequate room size appears to relate to an in increase in mishaps, 3) determine if there appears to be a relationship between safety training and mishaps, and 4) determine if lack of teacher experience appears to relate to mishaps. By providing credible evidence in these areas, this study will provide noteworthy additions to the small existing research base.

CHAPTER 2

MATERIALS AND METHODS

A description of safety issues associated with science settings in Texas secondary schools as perceived by secondary science teachers was devised by using the Texas Science Safety Incident/Accident Form, 2001 and 2003. The report form used in this study is included in a joint research project between Texas State University and Texas Education Agency. The instrument will be used bi-annually to aid in assessing the safety issues in secondary science settings across the state. Due to the small body of existing research concerning school science safety, frequency distributions will be used to determine the relative frequency of teacher responses to overcrowding, discipline, safety training, or teacher experience appear to be related to incidents and accidents. It is hypothesized that overcrowding, lack of discipline, lack of safety training, and having little teaching experience may increase the likelihood of incidents and accidents.

The Incident/Accident Form is a product of research that began with a 1989 free-response safety survey, the 1990 Laboratory Safety Survey for Chemistry, and revisions made specifically for use in this study (Ward & West, 1990). The instrument was presented to the Texas Education Data Analysis Committee (TEADAC) for review in 2000. TEADAC approved the Texas Science Safety Incident/Accident Form to be included with each Texas Science Safety Survey packet mailed out, as well as principal and superintendent letters that would precede the arrival of the survey packet. They also gave approval for the study to be conducted bi-annually.

The Texas Science Safety Incident/Accident Form, 2001, was then piloted with the Texas Science Safety Survey the same year. Initially, the report was optional and anonymous, and only 81 out of 856 respondents returned the form. It contained 16 items that covered a variety of science safety issues (see Appendix A). The 2001 report form was revised for the 2003 study. It is no longer optional, but it is anonymous. The instrument now consists of 19 major items (see Appendix B). The items are a combination of unstructured open-ended questions and closed-ended yes/no questions.

At the request of Texas State University-San Marcos, a random representative sample of 199 secondary campuses that reflect Texas public school student population was drawn by Texas Education Agency Division of Performance Reporting using the Academic Excellence Indicator System (AEIS). The sample was stratified, random, and selected based on the following criteria: 1) district type, 2) percentage of economically disadvantaged students on the campus, and 3) percentage of students of different ethnicities on campus (Texas Education Code, 2002).

The districts are classified on a scale ranging from major urban to rural. Factors such as size, growth rate, student economic status, and proximity to urban areas are used to determine the appropriate group. The community types are:

Major Urban — The largest school districts in the state that serve the six metropolitan areas of Houston, Dallas, San Antonio, Fort Worth, Austin, and El Paso. Major urban districts are the districts with the greatest membership in counties with populations of 650,000 or more, and more than 35% of the students are identified economically disadvantaged. In some cases, other size threshold criteria may apply.

Major Suburban — Other school districts in and around the major urban areas. Generally speaking, major suburban districts are contiguous to major urban districts. If the suburban district is not contiguous, it must have student population that is at least 15% of the size of the district designated as major urban. In some cases, other size threshold criteria may apply.

Other Central City — The major school districts in other large, but not major, Texas cities. Other central city districts are the largest districts in counties with populations between 100,000 and 650,000 and are not contiguous to any major urban districts. In some cases, other size threshold criteria may apply.

Independent Town — The largest school districts in counties with populations of 25,000 to 100,000. In some cases, other size threshold criteria may apply.

Non-Metro: Fast growing — School districts that are not in any of the above categories and that exhibit a five-year growth rate of at least 20%. These districts must have at least 300 students in membership.

Rural — School districts that do not meet the criteria for placement into any of the above categories. These districts either have a growth rate less than 20% and the number of students in membership is between 300 and the state median, or the number of students in membership is less than 300.

Charter Schools — The open-enrollment schools granted a charter by the State Board of Education and in operation by the fall of the 2002-2003 school year.

TEA provided most of the materials for the study including: 1) a list of the superintendents of the schools, 2) 199 superintendent letters with envelopes and mailing labels, 3) a list of principals of the schools, 4) 199 principal letters with envelopes and mailing labels, 5) 199 science department chair letters, 6) 1,600 Texas Science Safety Surveys, and 7) 1,600 Texas Science Safety Incident/Accident Forms. In addition to these materials, TEA also provided two-way postage for each survey packet. Southwest Texas State University supplied the scantrons for the completion of the 150-item multiple-choice surveys.

In spring 2003, Incident/Accident Forms were sent out with the Texas Science Safety Survey to approximately 1,600 science teachers who taught at the 199 randomly selected secondary schools in the sample. Although the forms were sent out to a large random representative sample, this study reflects only the self-report from the sample returned with the Texas Science Safety Survey packets. The Incident/Accident Form was not optional, and the respondents chose whether or not to complete and return them. As a result, the representative results may be affected by potential problems. Those that returned the Incident/Accident Form may not report the true extent of mishaps that occurred in their classes, and as a result, self-report such as this may not reflect accurate information. Respondents could under-report the truth for fear of embarrassment, punishment, or forgetfulness, or they could over-report by exaggerating the truth. Others may not understand or misinterpret a question, resulting in providing misinformation.

However, by completing the Incident/Accident Form the participants were able to report and describe any incidents or accidents that they could recall. The report forms contained the definitions of *incidents* and *accidents* as classified in this study for reference. This was included to aid in helping the respondents to understand the importance of reporting both major and minor mishaps. Participants indicated the factor(s) that they believe may have contributed to the incident or accident that occurred in their classes. In their own words, respondents also provided information on class size, room size, injuries, and the procedures that immediately followed the mishap they described.

As report responses were received, a series of tasks were performed for each packet to ensure that all the materials received were accounted for. The procedure for this process is as follows:

1. The school code on each survey packet was verified using the list of school codes.
2. Each school that responded was highlighted on the school list as being returned.
3. The contents of each package was placed in a separate folder and labeled with the district name, school name, number of surveys sent, number of responses received, and number of Incident/Accident Reports completed and returned.
4. All Incident/Accident Forms were labeled with the school code, the school name, and the district name.
5. An Excel file was constructed, and all of the report responses were entered into the database.
6. The text of the responses was converted into a numeric code.
7. The Excel file containing the numeric code was converted to SPSS.

8. Percent frequency distributions were utilized to analyze the data. Frequency distributions organize data into categories that show the numberof observations in each category. They can be expanded to also show the relative frequency and the percent values.

CHAPTER 3

RESULTS

This study indicates there are several key areas of concern existing within science classrooms, laboratories, and field settings that may be related to incidents and accidents. These areas include overcrowding, poor discipline, lack of safety training, and lack of teaching experience. This study also identified the most frequent types of incidents and accidents that occurred within the sample. It is important to include both accidents *and* incidents when dealing with safety concerns because it is in the *incidents* where potential lies for *accidents* to occur.

The Texas Science Safety Survey Incident/Accident Form was piloted in 2001 and implemented in 2003 with the Texas Science Safety Survey. In the spring of 2003, the reports were mailed to approximately 1,600 secondary science teachers. Seven hundred forty-three teachers completed and returned the Texas Science Safety Survey. Of those 743, a total of 332 responses to the Incident/Accident Forms were also returned. Fifty percent of the middle school teachers and just over one-third of high school teachers reporting mishaps were from schools located in major suburban school districts (Table 1). A total of 158 reports were from middle schools (grades 6-8), and 174 were from high schools (grades 9-12).. In both middle schools and high schools, about one-third of the mishaps reported are classified as *accidents*, and over half of the reports are classified as *incidents*. Only about 10% of each group reported no incidents or accidents (Table 2).

Incidents

At grade levels 6-8, most incidents (30.4%) were reported in 8th grade science classes, and about one-fourth occurred in both 6th and 7th grade science classes. Incidents in chemistry (39.8%), biology (26.1%), and IPC (15.9%) were the most prevalent at the high school level (Table 3).

It appears the most common incidents may be due to broken glass, spills, and broken thermometers in both middle schools and high schools. Broken glass was involved in almost 70% of both middle school and high school incidents. Teachers reported spills in 20.7% of middle and 14.8% of high school incidents. Broken thermometers were reported in 6.5% of middle and 8% of high school of incidents (Figure1).

Accidents

A total of 117 accidents were reported, 52 in middle schools and 65 in high schools. Of the middle school accidents that were reported, 34.6% occurred in 7th grade science, 23.1% in 8th grade, and 13.5% occurred in 6th grade science classes. Accidents reported in high schools occurred most often in biology (36.9%), chemistry (24.6%), and IPC (16.9%) classes (Table 3).

In both school types, cuts and burns appeared to be the most prevalent. Cuts were reported by 28.8% of the middle school respondents and by 41.5% of the high school respondents. About one quarter of the accidents reported in both middle schools and high schools involved burns. The burns were mostly related to touching hot objects and glassware. About 15% in grades 6-8 and 8% in grades 9-12 involved chemicals in the eyes. Almost 10% of accidents in grades 6-8 and 5% in grades 9-12 were reportedly due to chemicals on the body. Electrical shock was involved in 7.7% of middle school and 6.2% of high school accidents. Bites were reported by 3.8% of middle school respondents, and ingestion was involved in approximately 2% of middle school and 5% of high school accidents. Other accidents reported involved various injuries to specific areas of the body such as the head, fingers, and mouth, as well as an allergic reaction (Figure 2).

Overcrowding

Overcrowding appears to be a factor that may be related to mishaps. Of those who reported mishaps in middle schools, 30% having incidents or accidents reported that crowding was a factor that contributed to the mishap. In high schools, approximately 40% reporting a mishap also reported that crowding was a factor (Table 4).

It appears that class size may be related to incidents and accidents. As class enrollment increased in so did the number of incidents in both school types (Figure 3). Incidents in middle schools ranged from 1.1% in classes with 0-12 students to 57.6% in classes with more than 24 students. In high schools, incidents ranged from 0% in classes with 0-12 students to 55.7% in classes with more than 24 students. Accidents also increased with increasing class size in middle schools and high schools (Figure 4). Accidents in middle schools ranged from 0% in classes with 0-12 students to 61.5% in classes with more than 24 students. In high schools, accidents ranged from 4.5% in classes with 0-12 students to 61.5% in classes with more than 24 students.

Room size also appears to be related to incidents and accidents. As room size increased, the percentage of incidents and accidents decreased. Incidents in middle schools decreased from 33.7% in rooms with 0-800ft^2 to 8.7% in rooms with 1201-1400ft^2. In high schools, incidents decreased from 36.4% in rooms with 801-1000ft^2 14.8% in rooms with 1201-1400ft^2 (Figure 5). Accidents in middle schools decreased from 34.6% in rooms with 0-800ft^2 to 11.5% in room with 1201-1400ft^2. In high schools, the decrease is most dramatic from 29.2% in rooms with 1001-1200ft^2 to 7.7% in rooms with 1201-1400ft^2 (Figure 6).

Factors Contributing to Mishaps

The most commonly reported factors perceived to contribute to incidents and accidents are summarized in Table 4. Two of the top three contributing factors are related to classroom management. About 21% of middle school and about 16% of high school teachers reporting incidents perceived the student s failure to follow instructions to be a contributing factor to the mishaps in their classrooms. Seventeen percent at the middle school level and almost 28% at the high school level reporting accidents also perceived failure to follow instructions as a contributing factor. Of those reporting incidents, 5.4% of middle school and 12.5% of high school teachers reported student misbehavior as a contributing factor. Of those reporting accidents, about 14% of teachers at grade levels 6-8 and about 11% at grade levels 9-12 also perceived student misbehavior as a contributing factor to mishaps.

Safety Training

The survey respondents were asked if they had received any safety training within the last year. Among middle school teachers reporting incidents, 44.6% said they had received no type of safety training in the last year. About 39% of those reporting accidents in middle school also had received no safety training in the last year. High school teachers appeared to have a little more training than middle school teachers. However, 33% of those reporting incidents and 36.9% of those reporting accidents had received no safety training within the last year (Table 5). The respondents were also asked if their students had received safety training within the last year. Teachers at the both the middle school and high school level reported that only about 5-10% of their students had not received safety training within the last year (Table 6).

Teacher Experience

It appears that many incidents and accidents may occur in classes that are taught by less experienced teachers. Over one-third of incidents in both middle schools and high schools occurred in classes taught by teachers with 5 years experience or less. Forty percent of accidents were also reported by middle school teachers having 0-5 years teaching experience. Almost 60% of accidents reported at the high school level were reported by teachers having 10 years or less teaching experience (Table 7).

Table 1. Incidents and Accidents, by District Type and School Type.

District Type and School Type	Incidents		Accident	
	N	P	N	P
Middle School (6-8)				
Major suburban	50	54.3	29	55.8
Major urban	9	9.8	4	7.7
Other central city	11	12.0	6	11.5
Other central city suburban	8	8.7	4	7.7
Non-metro	10	10.9	2	3.8
Independent town	3	3.3	5	9.6
Rural	0	0	1	1.9
Charter	1	1.1	0	0
Total (middle schools)	92	100.0	52	100.0
High School (9-12)				
Major suburban	36	40.9	31	47.7
Major urban	19	21.6	8	12.3
Other central city	11	12.5	7	10.8
Other central city suburban	9	10.2	3	4.6
Non-metro	3	3.4	6	9.2
Independent town	5	5.7	8	12.3
Rural	5	5.7	2	3.1
Charter	0	0	0	0
Total (high schools)	88	100.0	65	100.0

Note: N= frequency, P = percentage

Table 2. Incidents and Accidents, by School Type.

School Type	N	Incidents (%)	Accidents (%)	None (%)
Middle School (6-8)	158	58.2	32.9	8.9
High School (9-12)	174	50.5	37.4	12.1
Total	332	54.2	35.2	10.5

Note: N = frequency

Table 3. Incidents and Accidents, by Course and School Type.

Course and School Type	Incidents		Accident	
	N	P	N	P
Middle School (6-8)				
6th grade science	23	25.0	7	13.5
7th grade science	21	22.8	18	34.6
8th grade science	28	30.4	12	23.1
Other/Unidentifiable	18	19.6	12	23.1
IPC	1	1.1	2	3.8
No Response	1	1.1	1	1.9
Total (middle schools)	92	100.0	52	100.0
High School (9-12)				
Biology	23	26.1	24	36.9
Chemistry	35	39.8	16	24.6
IPC	14	15.9	11	16.9
Physics	6	6.8	3	4.6
Aquatic Science	2	2.3	3	4.6
GMO	1	1.1	0	0
Environmental Science	0	0	1	1.5
Multiple Prep	2	2.3	0	0
Other/Unidentifiable	4	4.5	2	3.1
No Response	1	1.1	5	7.7
Total (high schools)	88	100.0	65	100.0

Note: N= frequency, P = percentage

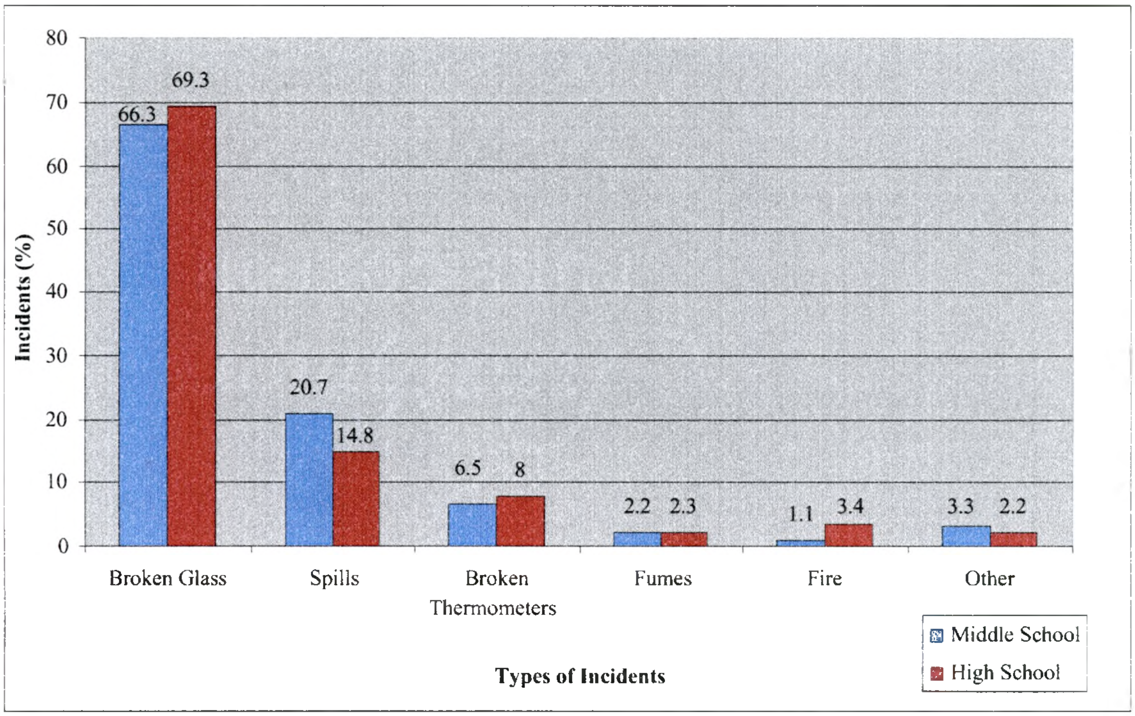

Figure 1. Types of incidents reported in middle schools and high schools.

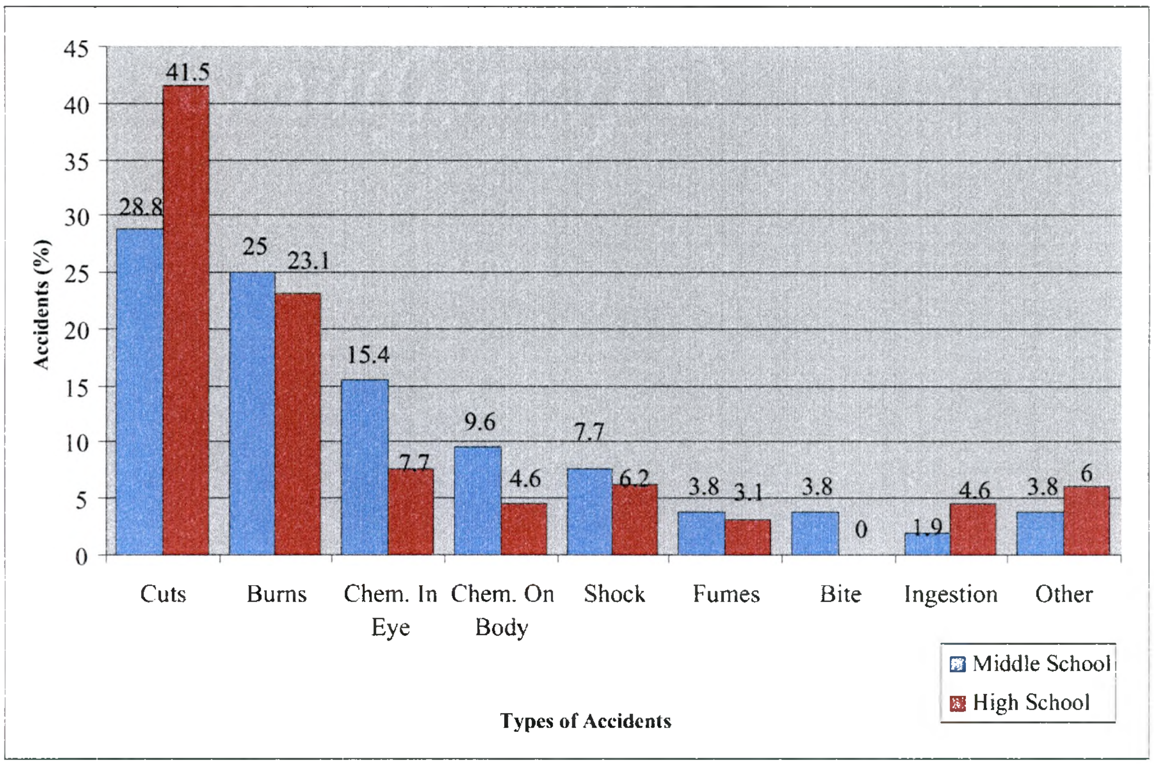

Figure 2. Types of accidents reported in middle schools and high schools.

Table 4. Incidents and Accidents, by Greatest Contributing Factor and School Type.

Factor and School Type	Incidents		Accident	
	N	P	N	P
Middle School (6-8)				
Crowded conditions	24	26.1	5	9.6
Failure to follow instructions	19	20.7	9	17.3
Student misbehavior	5	5.4	7	13.5
Housekeeping	3	3.3	0	0
Non-science room	1	1.1	0	0
Unsafe room design	0	0	1	1.9
Faulty/inadequate equipment	0	0	1	1.9
Inadequate Procedures	2	2.2	2	3.8
Failure to wear goggles	0	0	3	5.8
Inclusion	1	1.1	0	0
Carelessness	1	1.1	1	1.9
Clumsy	1	1.1	0	0
Other	9	9.8	4	7.7
No Response	26	28.3	19	36.5
Total (middle schools)	92	100.0	52	100.0
High School (9-12)				
Crowded conditions	19	21.6	17	26.2
Failure to follow instructions	14	15.6	18	27.7
Student misbehavior	11	12.5	7	10.8
Housekeeping	3	3.4	1	1.5
Non-science room	1	1.1	0	0
Unsafe room design	2	2.3	0	0
Faulty/inadequate equipment	3	3.4	0	0
Inadequate Procedures	2	2.3	3	4.6
Failure to wear goggles	0	0	1	1.5
Ventilation	1	1.1	1	1.5
Inclusion	0	0	1	1.5
Carelessness	3	3.4	3	4.6
Clumsy	1	1.1	0	0
Other	9	9.8	7	10.8
No Response	19	21.6	19	36.5
Total (high schools)	88	100.0	65	100.0

Note: N= frequency, P = percentage

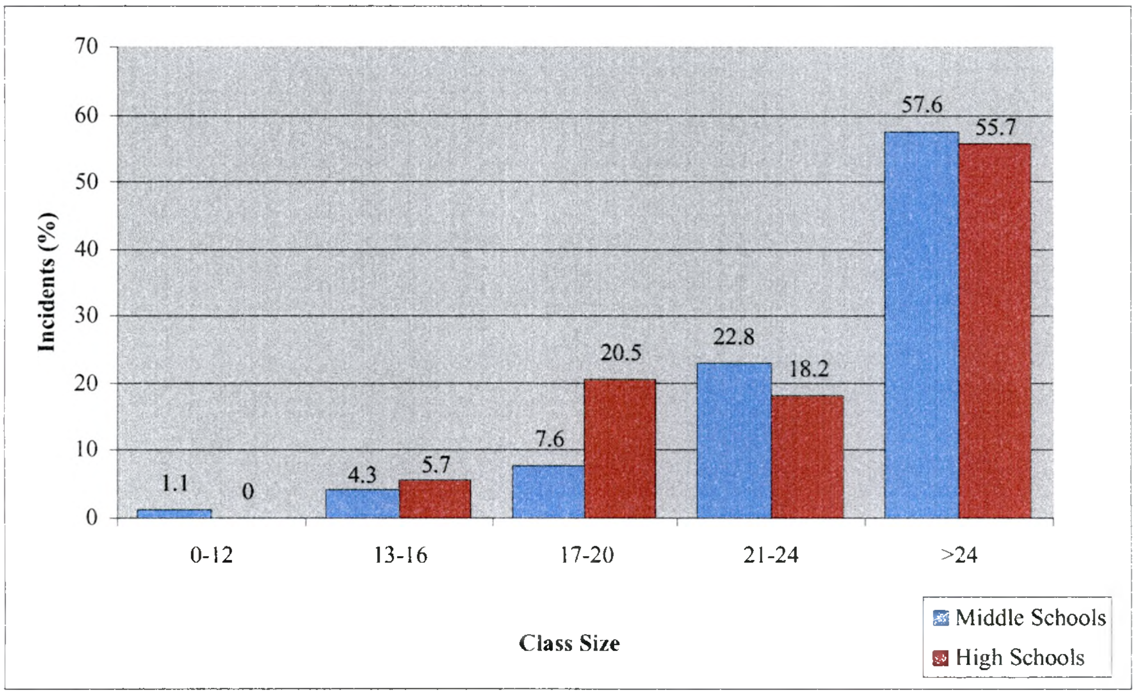

Figure 3. Incidents reported by school type and class size.

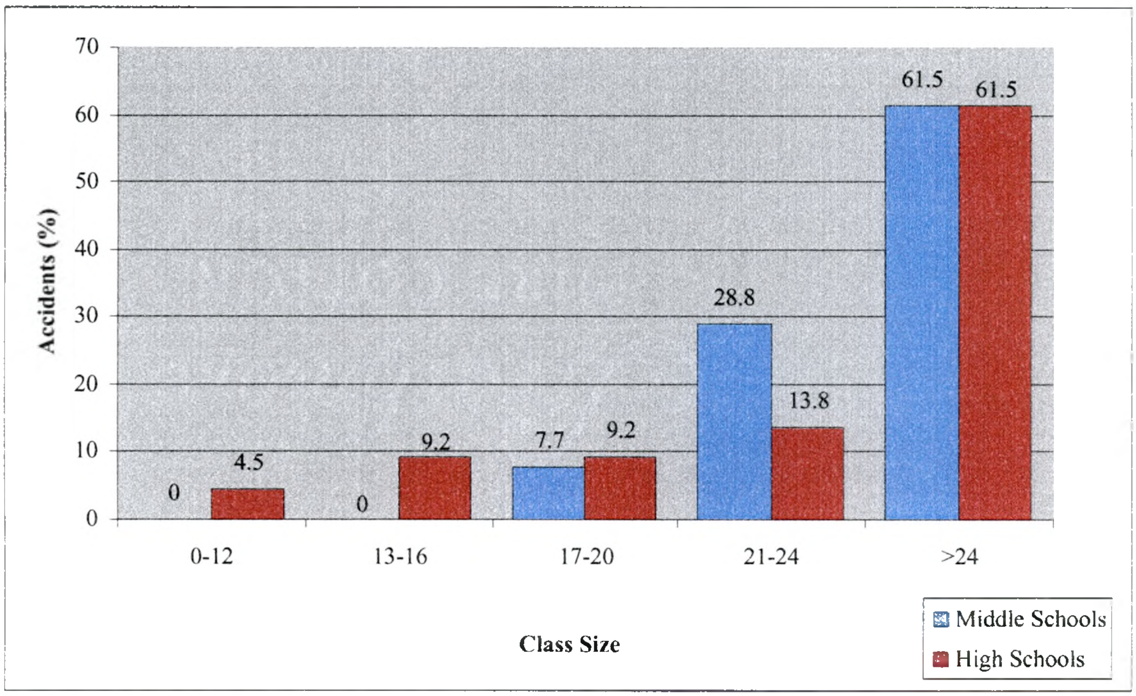

Figure 4. Accidents reported by class size and school type.

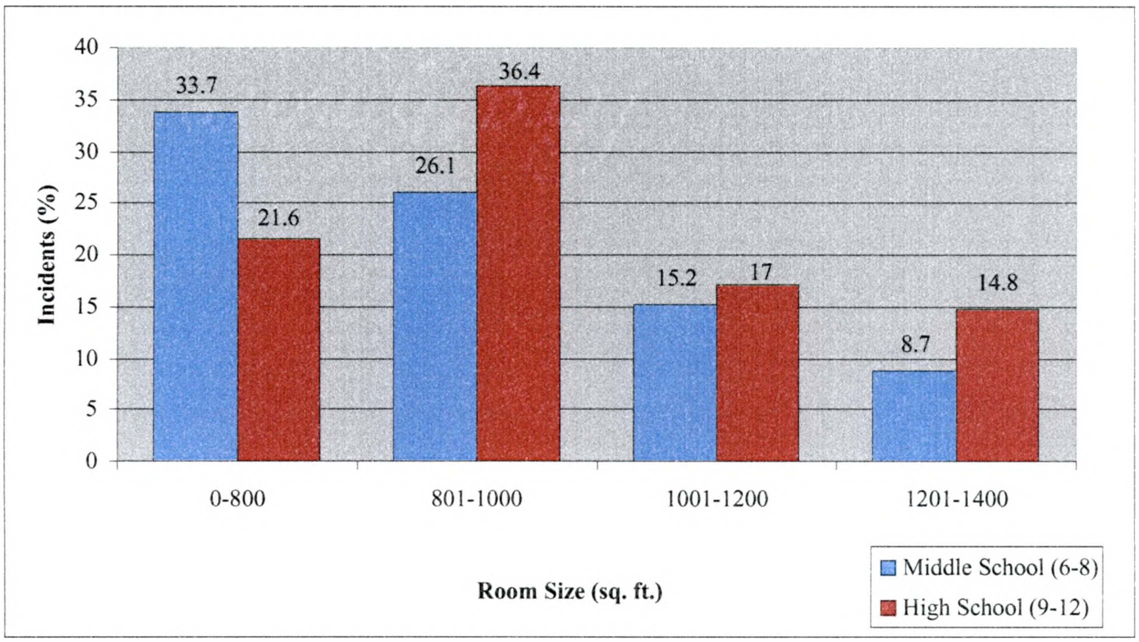

Figure 5. Incidents reported by room size and school type.

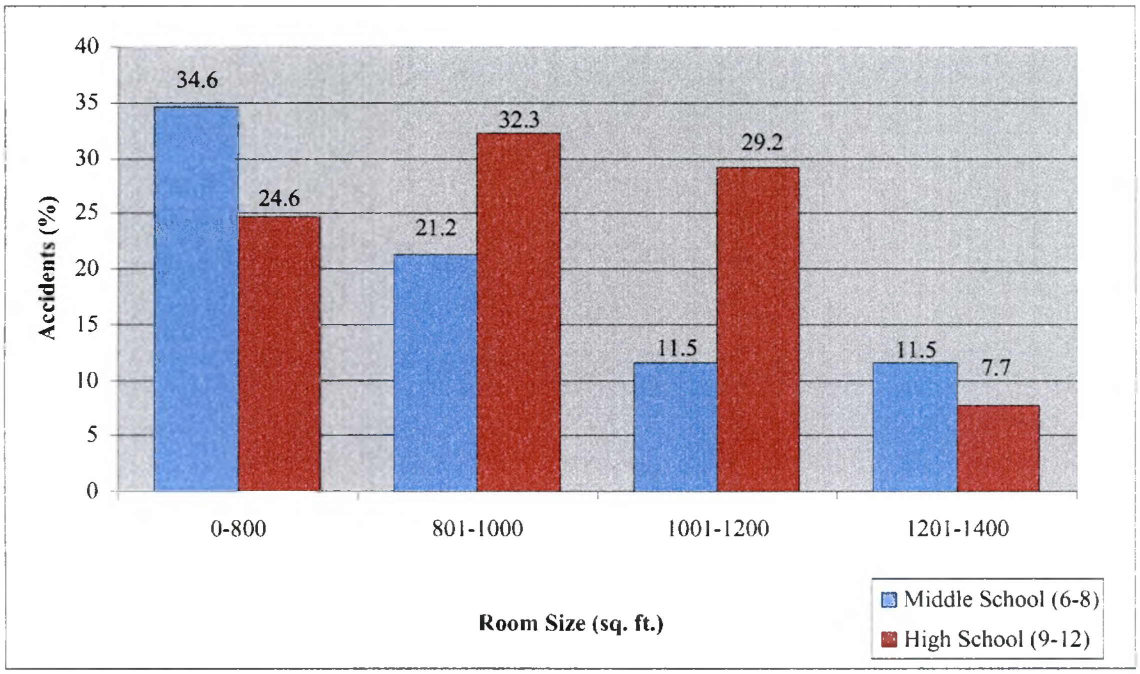

Figure 6. Accidents reported by room size and school type.

Table 5. Incidents and Accidents, by Teacher Safety Training and School Type.

Training within last year and School Type	Incidents			Accidents		
	Yes	No	No Response	Yes	No	No Response
Middle School (6-8)						
Safety Training	45.7	44.6	9.8	46.2	38.5	15.4
High School (9-12)						
Safety Training	61.4	33.0	5.7	61.5	36.9	1.5

Table 6. Incidents and Accidents, by Student Safety Training and School Type.

Training within last year and School Type	Incidents			Accidents		
	Yes	No	No Response	Yes	No	No Response
Middle School (6-8)						
Safety Training	84.8	5.4	9.8	75.0	9.6	15.4
High School (9-12)						
Safety Training	84.1	8.0	8.0	90.8	4.6	4.6

Table 7. Incidents and Accidents, by Years Teaching Experience and School Type.

Experience and School Type	Incidents		Accident	
	N	P	N	P
Middle School (6-8)				
0-5	36	39.1	21	40.4
6-10	19	20.7	8	15.4
11-15	15	16.3	8	15.4
16-20	9	9.8	8	15.4
21-25	9	9.8	4	7.7
26-30	3	3.3	2	3.8
>30	1	1.1	0	0
Total (middle schools)	92	100.0	52	100.0
High School (9-12)				
0-5	29	33.0	17	26.2
6-10	17	19.3	18	27.7
11-15	13	14.8	12	18.5
16-20	11	12.5	10	15.4
21-25	6	6.8	4	6.2
26-30	10	11.4	2	3.1
>30	2	2.3	0	0
Total (high schools)	88	100.0	65	100.0

Note: N= frequency, P = percentage

CHAPTER 4

DISCUSSION

This study is one that is unique on many levels. The Incident/Accident Forms were anonymous and predominantly unstructured and open-ended, allowing the participants to report the strengths and weaknesses of safety practices in their science classrooms, laboratories, and field sites. Frequency distributions and of the data appear to indicate that some of the current conditions under which science classes are taught today may increase the likelihood of mishaps in school science-related activities, provided that the sample is representative. However, the findings of this study provide noteworthy additions to the small existing research base and can be used for a basis for making decisions on safety policies, new safety standards, and legislation at the school, district, state, and national levels. Such information can aid in science facility design and construction, discipline in science classes, teacher safety training, development and enforcement of safety policies, and teacher preparation.

This study indicates there are several key areas of concern existing within science classrooms, laboratories, and field settings that may be related with incidents and accidents. These factors include overcrowding, poor discipline, and lack of safety training. In addition, this study also identified the most frequent types of incidents and accidents.

Incidents

The most commonly reported incidents in this study involved broken glass, spills, and broken thermometers (Figure 1). It is suspected that dealing with incidents of this nature may lead to more serious accidents. For instance, if most incidents involve broken glass, care should be taken to ensure that accidents involving cuts do not result by teaching students how to carefully handle fragile glassware through explicit instruction. It is important to include both accidents *and* incidents in incident/accident reports due to the potential for *incidents* to become *accidents*.

Accidents

It is important to know the types of accidents that occur most frequently in order to take precautions to prevent them. In this study the most common accidents involved cuts and burns (Figure 2). Many accidents result in cuts from broken glass tubing and glassware and burns from hot objects and glassware (Macomber, 1961; Krajkovich, 1983; Ward & West, 1990). Therefore, both teacher and student safety training should give specific instruction on the safe handling of sharp objects, glassware, chemicals, and heated equipment such as hot plates. Additionally, instruction on safely cleaning up broken glassware is needed.

Accidents involving chemicals in the eye are a key concern primarily because the eyes can be seriously injured in a very short period of time. This type of accident was the third most common in this study (Figure 2). Although 15.4% of middle and 7.7% of high school teachers reported accidents involving chemicals in the eye, only 5.8% of middle and 1.5% of high school teachers perceived failing to wear goggles as the greatest factor contributing to accidents in their classes. Other studies have also found chemicals being rubbed or splashed into the eyes to be very serious (Krajkovich, 1983; Ward and West, 1990). Teacher and student safety training should include instruction on the importance and proper use of eye protection such as goggles. Such protective devices should always be available and worn in any science activity that involves the use of chemicals.

Injuries involving electrical shock seem to be a safety issue that has commonly been overlooked. Surprisingly, 7.7% of the middle school and 6.2% of the high school accidents reported involved shock (Figure 2). Students experienced minor or major shock from electrical equipment and outlets in the classroom. It is important to know the location of outlets, electrical chords, and ground fault interrupters (Gerlovich, 2001) to prevent these needless accidents from occurring. NSTA (Biehle et al., 1999) recommends science labs have master and emergency cut-offs. Science teachers should be aware of ignition sources, electrical cords, outlets, ground fault interrupters, and all master and emergency cut-offs in order to maintain a safe working environment for their students and themselves.

Overcrowding

Many schools are not providing adequate space for conducting science activities, which is the most important factor in designing safe science facilities (Biehle, et al. 1999, p.21). Most safety literature identifies overcrowding as a serious classroom and laboratory safety issue (Ward & West, 1990; Kaufman, 1999; Gerlovich, et. al., 2001). In this study, respondents at the middle school and high school level identified crowded conditions as one of the top three greatest factors contributing to incidents and accidents in their classrooms (Table 4). This finding is strongly supported by the research cited concerning class size and individual workspace. The larger the class size and the less space per student, the higher the frequency of accidents (Macomber, 1961; Brennan, 1970; Young, 1972). Of 856 science teachers who responded to the Texas Science Safety Survey, 2001, 60% identified overcrowding as the single greatest hazard they face in their own classrooms (West et al., 2002).

Class Size. The findings of this study appear to indicate that class size may be related to an increase in mishaps. At both the middle school and high school levels, incidents and accidents increased with increasing class size. Less than 5% of mishaps (incidents and accidents) reported at grade levels 6-8 and 9-12 occurred in classes with 0-12 students, while about 60% of mishaps occurred in classes with more that 24 students (Figure 3, Figure 4). Historically, as class enrollment increases, more accidents occur (Macomber, 1961; Brennan, 1970; Young, 1972). For this reason several professional organizations recommend that class size is limited to 24 students (NSTA, 1993; NABT, 1994; NSELA, 1996; CSSS, 1999). However, when closely examining all of the research available, one will find that there is no magic number that will ensure that no incidents or accidents will occur. The key is to maintain a safe environment (Rakow, 1989, S5). It is not the average class size that should be limited but the maximum enrollment in any one class that should be required to make the science class setting safe for students and teachers.

Room Size. The findings of this study appear to indicate that mishaps may decrease with increasing room size. About 50% of incidents and accidents reported at the middle and high school levels occurred in rooms with 1000ft^2 or less, while 8-15% of mishaps occurred in rooms with 1201-1400ft^2. This is a startling amount, considering that about 60% of classes had more than 24 students. For a class of 24 students a minimum of 1440 ft^2 should be allowed for any combination classroom/laboratory, and a minimum of 1080 ft^2 for any pure science laboratory room. However, there were no reports of rooms having more than 1400ft^2. It seems this is not an uncommon trend (Fuller, 2001; West et al., 2001). The room sizes from this study are far smaller than the recommendations for room size, assuming that there is a maximum of 24 students in these classes. Even though this study did not inquire about the room type (combination classroom/lab or pure lab), these room size measurements are below the minimum NSTA recommendations for both room types.

<u>Classroom Management</u>

Two of the three greatest factors perceived by respondents to contribute to incidents and accidents in this study that appear to relate to more mishaps are the students failure to follow instructions and student misbehavior (Table 4). Similarly, Macomber (1961) and Krajkovich (1983) found that horseplay in the laboratory resulting from inadequate classroom discipline is a contributing factor to accidents. Having good classroom management is crucial to maintaining a safe classroom, laboratory, and field setting for hands-on science activities. Classroom discipline must be enforced by the teacher, the school, and the district, maintaining rules and consequences if those rules are broken.

<u>Safety Training</u>

Safety training of teachers is required by federal law in the Chemical Hygiene Plan (OSHA 29CFR 1910.1450) in states that choose to comply with OSHA regulations

(OSHA, 1991). However, even those under state law, in all states except Missouri, safety training of teachers is required (Flinn, 2002). In this study, many of the participants reported having had some type of safety training within the last year. Yet, there was still a large portion of middle and high school teachers reporting mishaps and receiving no safety training. In middle school, about 45% of respondents reporting incidents and 39% reporting accidents had received no safety training within the last year. Over one-third of high school respondents reporting mishaps had also received no safety training within the last year (Table 5). The findings of this study are consistent with other studies that have shown that many teachers across the United States have not been trained in safety (Krajkovich, 1983; Gerlovich, et. al., 2001).

Teachers who have safety training have fewer accidents in their classrooms (Ward & West, 1990). When a teacher is trained in safety, such practices are modeled and passed on to the students by describing safety precautions, devoting a class period to safety, or testing students on safety (Krajkovich, 1983; Ward & West, 1990). However, in this study, 75-91% of middle school and high school respondents reporting incidents and accidents also reported that their students had been trained in safety within the last year (Table 6). If such a high percentage of teachers are not receiving safety training, how are they adequately training their students? It is imperative that all districts provide adequate annual safety training for teachers in order to ensure that they understand safety policies and procedures so that they in turn pass on proper safety practices to their students.

Teaching Experience

In this study, 26-40% of respondents reporting mishaps had 0-5 years of teaching experience. According to AEIS 2002-2003 data, about 36% of teachers statewide are at this level of experience (TEA, 2003). Therefore, assuming that approximately 36% of Texas science teachers have five or fewer years teaching experience, it appears that about the same amount of science teachers at this level are having mishaps in their classrooms. Inexperienced science teachers must first be adequately trained in safety before entering into the science classroom and using science materials with students.

Recommendations

The following recommendations are based on the findings of this study and the research findings from the studies previously cited. Due to overcrowding, poor classroom discipline, lack of safety training, and lack of teaching experience, which appears to lead to an increased frequency of incidents and accidents, there are immediate actions that can be taken by school districts that include:

- limit the size of any one class to a maximum of 24 students;
- develop and enforce a written safety policy that includes a strict discipline policy for student misbehavior;
- employ teachers who are trained in safety and science classroom management; and
- provide or require annual safety training for science teachers.

Long term actions for school districts include the following:

- carefully determine the science education needs for the future;

- make accurate financial projections that will ensure an adequate funding level to build an adequate number of science rooms of adequate size; and
- design safe science facilities that meet the TEA School Facilities Standards.

APPENDICES

APPENDIX A

Incident/Accident Form
Confidential

Incident (includes spills, broken glass, excessive fumes, small fires, liquids boiling over, etc. during activities in the classroom, lab, or field)

An Incident does not involve injury to anyone.

Accident includes **human injuries** that **may or may not require medical attention.**

A **minor** accident is defined as an injury to someone that does not require major medical attention.

A **major** accident is defined as an injury to someone that does require major medical attention.

1. ______________________School year when incident or accident occurred
2. ______________________Course
3. ______________________Class size
4. ______________________Room size (wall to wall, does not include the prep or chemical storeroom, or closet)

5. Was the activity a:

Teacher (demo, prep, etc.)	Yes	No
Student conducted activity	Yes	No

6. What was the nature of the lab or field procedure? ________________________

____

(Attach the procedures or lesson plan if it will explain the procedures more easily with information on where the problem occurred)

7. Who was involved in the accident? Teacher_________ Student_________

8. If any medical attention was required, describe the injury. ___________________

____

____

9. Did the incident or accident occur:

During a class period	Yes	No
Between classes	Yes	No
After school	Yes	No

10. Which of the following contributed to the incident or accident?

Crowded conditions	Yes	No
Student misbehavior	Yes	No
Failure to follow instructions	Yes	No
Failure to wear goggles	Yes	No
Faulty or inadequate equipment	Yes	No
Unsafe room design	Yes	No
Non-science room	Yes	No
Inadequate procedures	Yes	No
Inadequate teacher safety training	Yes	No
Other	Yes	No

Please describe other

11. Which ONE of the above conditions do you think was the greatest contributing factor?

12. Were both the teacher and the student trained to respond appropriately in this situation? Yes No

13. Had the teacher received safety training within the last year? Yes No

14. Describe the incident or accident:

15. What emergency procedure was followed?

16. Does your science department have a written safety policy? Yes No

APPENDIX B

Incident/Accident Form
Confidential

Incidents include water or chemical spills, broken glass, excessive fumes, sparks, small fires, liquids boiling over, etc., that occur during activities in the classroom, lab, or field.

An Incident does <u>not</u> involve injury to anyone.

Accidents include **human injuries** that **may or may not require medical attention.**

A **<u>minor</u>** accident is defined as an injury that does not require major medical attention.

A **<u>major</u>** accident is defined as an injury that does require major medical attention.

1. ______________________School year when incident or accident occurred
2. ______________________Course
3. ______________________Years experience teaching
4. Does teaching this course involve floating or moving to different science rooms? Yes No
5. ______________________Class size
6. ______________________Room size in square feet (wall to wall)
7. ______________________Room dimensions (wall to wall, does not include the prep or chemical storeroom or closet)

8. Was the activity a:

    Teacher (demo, prep, etc.) Yes No

    Student conducted activity Yes No

9. What type of laboratory or field activity was being performed? ________________

____

(Attach the procedures or lesson plan if it will explain the procedures more easily with information on where the problem occurred)

10. Who was involved in the occurrence? Teacher_________ Student_________

Both teacher & student_____ Other adult_____

11. Please describe the incident or accident in as much detail as possible.

____

____

____

____

12. Was medical attention required? Yes No
If yes, please describe the **injury**. ______________________________
____
____

13. Please describe the emergency procedure that was followed immediately after the incident or accident. ______________________________
____
____

14. Did the incident or accident occurred:

During a class period	Yes	No
Between classes	Yes	No
After school	Yes	No

15. Which of the following contributed to the incident or accident?

Crowded conditions	Yes	No
Student misbehavior	Yes	No
Failure to follow instructions	Yes	No
Failure to wear goggles	Yes	No
Faulty or inadequate equipment	Yes	No
Unsafe room design	Yes	No
Non-science room	Yes	No
Inadequate procedures	Yes	No
Inadequate teacher safety training	Yes	No
Other	Yes	No

If other please describe. ______________________________
____

16. Which ONE of the above conditions do you think was the **greatest** contributing factor?______________________________

17. Had the teacher received safety training within the last year? Yes No

18. Had the student(s) received safety training within the last year? Yes No

19. Does your science department have a written safety policy? Yes No

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