RESEARCH ARTICLE

Keeping it safe: Chemical safety in the high school laboratory

In an effort to (1) assess the current state of laboratory safety, (2) explore the necessity for laboratory safety training, and (3) garner feedback on laboratory training needs, a Likert survey was developed and administered. Surveys were mailed to 120 West Virginia public high schools with response of 64%. Results indicate that West Virginia high schools have science laboratories dedicated to chemistry courses but these laboratories are not adequate for current or projected student enrollment needs. These laboratories are well-equipped in terms of chemical storage facilities but may lack regularly inspected safety equipment. Although there is a general lack of formalized safety training for in-service chemistry teachers, most self-report following safety guidelines analogous to the OSHA Lab Standard. Assistance with disposal of chemical waste was the most requested form of help. Overwhelmingly, in-service teachers recommend inclusion of chemical safety training as part of the collegiate educational experience. However, neither the traditional nor non-traditional paths to science teacher certification include a focused effort in chemical laboratory safety. Current in-service teachers are receptive to enrolling in a chemical safety online course especially if continuing education credits are offered. Survey feedback is assisting to provide content for the generation of a website geared toward high school chemistry teachers, helping to forge a relationship between our institution and high school chemistry teachers, and guiding us in developing a chemical safety continuing education curriculum at both the pre-service and in-service levels.

By Michelle Richards-Babb, Jennifer Bishoff, Jeffrey S. Carver, Kimberly Fisher, Jennifer Robertson-Honecker

Michelle Richards-Babb *is affiliated with C. Eugene Bennett Department of Chemistry, 217 Clark Hall, PO Box 6045, West Virginia University, Morgantown, WV 26506-6045, United States (Tel.: 304 293 3435x6416; fax: 304 293 4904; e-mail: Michelle.Richards-Babb@mail.wvu.edu).*

Jenny Bishoff *is affiliated Southern Garrett High School in Oakland, MD 21550, United States.*

Jeffrey S. Carver *is affiliated with Department of Curriculum and Instruction/Literacy Studies, West Virginia University, Morgantown, WV 26506-6122, United States.*

Kimberly Fisher *is affiliated with Department of Chemistry, Rhodes College, Memphis, TN 38112-1690, United States.*

Jennifer Robertson-Honecker *is affiliated with C. Eugene Bennett Department of Chemistry, West Virginia University, Morgantown, WV 26506-6045, United States.*

INTRODUCTION

"Lab safety is a topic that needs more attention. Fear is driving many school districts to cyber labs. This is robbing chemistry students of lab experience that restricts thought." (West Virginia public high school chemistry teacher, 2008; Teacher 1).[1] In effect, this quote summarizes our reasons for researching the status of laboratory safety and safety training of high school chemistry teachers within the state of West Virginia-teachers have an insufficient background in chemical laboratory safety to implement a quality laboratory-based instructional environment, depriving students of authentic experiences in chemistry at the high school level. A recent change of the graduation requirements in West Virginia has made this initiative even more pressing. Content specific coursework (physical science, biology, and chemistry) through the junior year of high school was recently mandated within the state. As a result, chemistry coursework (formerly an elective) will be required of all 11th grade students beginning with year 2010 9th grade students (i.e., for the 2014 graduating class).[2] To further improve the educational proficiency of all students, in agreement with the Federal education initiative No Child Left Behind,[3] the West Virginia Board of Education's Strategic Goal #5 states: "All students shall be educated by highly qualified personnel."[4] Thus, more teachers with chemistry specific teacher certification are essential for meeting state and federally mandated educational goals of (1) content specific chemistry coursework taught by (2) highly qualified personnel. Additionally, since it is unlikely that the demand of highly qualified chemistry teachers can be met by current teacher education programs and in-service training initiatives, safety training for individuals who do not have a chemistry specific certification will be prudent to improving safe practices of teachers and students in West Virginia's science classrooms.

Currently, a shortage of qualified chemistry teachers exists and is endemic throughout West Virginia as indicated by the U.S. Department of Education's "Teacher Shortage Areas Nationwide Listing" for 2007–2008.[5] This shortfall is expected to worsen as approximately 25% of West Virginia's 24,000 teachers are eligible to retire in 2009.[6] Alternative programs for teacher certification in content areas projected for critical shortage (e.g., chemistry) have been devised. One program, Project REACT (**R**esolve to

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Educate Aspiring Chemistry Teachers), trains in-service science teachers without a chemistry specific certification to teach chemistry.[7] A second, the Transition to Teaching Program, allows a B.S. scientist (e.g., chemist, engineer), potentially a mid-career scientist interested in changing careers, to earn teacher certification in a high needs content area. Participants in this program complete an individualized online program concurrent with teaching in that content area.[7,8] However, if these programs cannot provide an adequate number of qualified chemistry teachers by 2013, the number of teachers responsible for teaching chemistry out of their content area will increase.

As a result, in addition to other content initiatives, laboratory safety training for in-service and pre-service teachers is crucial to successful implementation of West Virginia's mandated educational goals. The safety survey and results discussed herein were intended to (1) explore the current state of laboratory safety at the high school level, (2) explore the necessity for laboratory safety training, and (3) garner feedback from in-service teachers on current laboratory safety issues and concerns. The results of this survey will guide us in (a) creating a website specifically tailored to the needs of high school science teachers (including chemistry), (b) developing a pre-service teacher education course focused on safety in the science classroom, and (c) developing a continuing education course that focuses on laboratory safety in the high school setting. Dissemination of safety information via the website will be used as a first step prior to development of a full-blown safety training course. This website is expected to expand the ties between high school chemistry teachers and university faculty within the Eberly College of Arts and Sciences and the College of Human Resources and Education at our institution.

SURVEY AND DATA COLLECTION METHOD

The safety survey instrument, entitled "High School Chemistry Teacher Safety Survey," consisted of 40 Likert-type statements and three free response questions. Likert-type statements covered topics of laboratory availability, safety equipment, chemical storage, safety information policy, and teacher education. A five point Likert scale (a = strongly disagree, b = disagree, c = neutral (or neither agree or disagree), d = agree, and e = strongly agree) was used to assess the extent of agreement with each of the 40 Likert statements. Twenty-four (of 40) Likert statements were obtained from a high school chemistry safety survey developed by Senkbeil in 1991.[9] Free response questions were structured so that teachers could provide comments on (1) how our departments can help high school chemistry teachers, (2) content to be included on a website tailored to the needs of high school chemistry teachers, and (3) any other issues of relevance. The survey instrument was reviewed and granted exemption by the West Virginia University Institutional Review Board (IRB). The survey and associated materials were sent to the 120 public high schools within West Virginia. Anonymity was maintained using a dual mail-in system. Further details on the survey method used in this study can be found in Appendix A.

By June 2008, a total 77 survey responses (64% rate of return) had been received. Survey responses were not limited to one geographic area or region within the state and responses were received from high schools in a minimum of 46 of West Virginia's 55 counties. Thus, survey results are representative of 84% of West Virginia's counties.

It is important to keep in mind that the data are self reported by one member of the chemistry teaching faculty at any particular school.

RESULTS AND DISCUSSION

It is important to keep in mind that the data are self reported by one member of the chemistry teaching faculty at any particular school. However, given the nature of the dissemination and the high rate of return it is believed that a representative sample of chemistry teachers across the state has been obtained. The self-reporting nature of the data may provide additional insights into the status of safety awareness of science teachers in general and chemistry teachers specifically.

LABORATORY AVAILABILITY

As shown in Figure 1, 85% of teachers surveyed were in general agreement (i.e., strongly agreed or agreed) with the statement: "The high school at which I teach has a science laboratory that is dedicated to chemistry courses

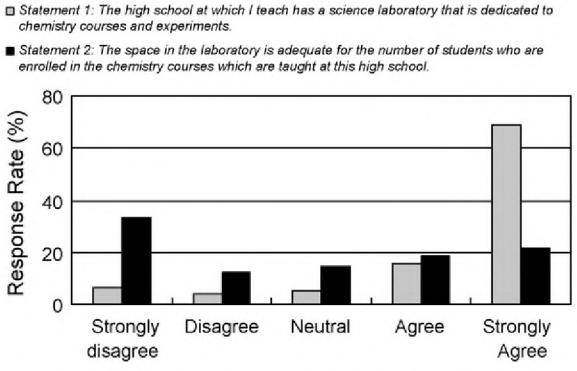

Figure 1. High school chemistry teacher response rate (%) in terms of agreement with the statements in 1 and 2. The total number of respondents for statements 1 and 2 were *N* = 77 and *N* = 75, respectively.

Table 1. Response Rate (in %) of the Availability of Laboratory Safety Equipment Specified in Statements 4–15. Number of Responses Indicates the Total Number of Teachers who Responded to the Given Statement.

Statement	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Number of Responses
4. An appropriate eyewash station is in working order and is inspected on a regular basis.	31%	14%	14%	21%	21%	72
5. There is a safety shower in the lab and it is inspected on a regular basis.	32%	14%	14%	21%	19%	72
6. Students are required to wear chemical splash goggles.	5%	14%	9%	15%	57%	74
7. There are fire extinguishers in the lab that are appropriate for the chemicals that are handled and stored in the lab.	8%	3%	7%	18%	64%	73
8. There is a master gas shut off valve in the lab and I know its location.	6%	6%	6%	10%	74%	72
9. I have been trained and certified in first-aid and CPR.	14%	11%	20%	18%	38%	74
10. There is an approved fire blanket present in the lab.	19%	10%	16%	12%	42%	73
11. An enclosed fume hood is present in the lab and it is inspected on a regular basis.	7%	10%	21%	25%	38%	72
12. Chemical spill kits are available in the lab and it is inspected on a regular basis.	25%	14%	11%	21%	29%	72
13. Fire alarm procedures are posted and exits marked.	10%	7%	7%	11%	66%	73
14. Glass disposal boxes are available in the lab.	16%	10%	8%	14%	52%	73
15. The laboratory ventilation system is separate from the classroom ventilation system.	40%	7%	15%	10%	28%	68

and experiments." On the other hand, only 40% were in general agreement with the statement: "The space in the laboratory is adequate for the number of students who are enrolled in the chemistry courses which are taught at this high school." More importantly 45% of respondents disagreed (i.e., disagreed or strongly disagreed) with this statement indicating a general lack of adequate laboratory facilities at a large percentage of high schools throughout the state. In answer to free-response questions, several teachers made reference to the lack of available laboratory facilities now and in the future. Representative responses include:

"We should have authority to limit number of students per class based on available facilities."

"All students should not be required to take chemistry as they will be in 2010-11. There is no way that they will be ready plus the facilities will not be in place to safely teach chemistry as a lab science."

Clearly, current in-service chemistry teachers are concerned about their school's ability to provide meaningful and safe chemical laboratory experiences to all 11th grade students beginning in 2013.

AVAILABILITY OF SAFETY EQUIPMENT

As is to be expected in a state with a large rural population, a low tax base, and where 45.5% of children under 19 years of age live at or below 200% of poverty, some laboratory safety features are lacking or in need of regular inspection in high school laboratories.[10] Table 1 summarizes teacher responses to 12 Likert statements on availability, use, and inspection of laboratory safety equipment. In particular, 45% of those responding either do not have an eyewash station or do not have a station that is inspected on a regular basis. The lack of safety showers or regular inspection of safety showers is also indicated by 46% of those responding and 39% indicate the lack of chemical spill kits. It has been noted that several of these statements require the teachers to consider two issues, presence of the safety item and inspection of the safety item, which may, in turn, inflate the negative responses (e.g., see statement 12 which

asks for agreement on chemical spill kit availability and chemical spill kit inspection). However, lack of regular inspection can be as serious of a safety concern as lack of the item. The survey design will be altered in future surveys to reflect this. That students are required to wear some type of chemical splash goggles is indicated by 72% of teachers. This does not, however, imply that in 28% of high school laboratories, students are not wearing any type of eye protection. The statement's reference to chemical splash goggles relative to safety glasses may have prevented some respondents from agreeing. Unfortunately, the author's experiences with middle and high school classroom observations indicate that even this minimal amount of protection is lacking in some situations. The majority of respondents (84%) indicate the existence of a master gas shut off valve for the laboratory and 66% indicate some form of glass disposal box available in the laboratory.

Answers to the open-ended questions provided insight as to the thoughts on the minds of chemistry teachers in terms of safety equipment and training for their students and what information they would like to see on a website.

"An online tutorial (sic lab safety) geared for students would also be beneficial."
"The program could provide additional safety guidelines and methods of instructing students on such issues."
"Flinn Scientific has a lot of info. on their site about safety, it has been a great help to me."
"Explanations of state laws regarding science safety in the classroom..."
"I would like a safety video to show students, interactive links to teach safety to students. A safety quiz that student (sic) could take."
"I would like a link for who to get in touch with for doing things like inspecting lab equipment (e.g. fume hoods)."
"Teachers should be required to take the Flinn Safety Conference every yr."
"Thank you that someone is showing an interest in this area; We need to get to a point where this is state-mandated, I worked an entire summer developing a chemical hygiene plan that died in my system."
"I always start the year with laboratory safety it would be wonderful to find a place that has updated safety standards and a place for continually (sic) support."
"I have had Chemis training and it really helped me. I think what you are trying to do is very important. As the teacher across the hall or in the next room, my word doesn't have much clout – but the word of a university would."
"I would love to see undergraduates learn proper safety procedures. We have a Biology teacher doing $KMnO_4$ titrations telling kids that Goggles are optional..."
"Please really stress the need for Goggles and hygiene and don't make it just for chemistry teachers but have a general section for all lab science teachers as well."

From these responses it is obvious that the high school chemistry teachers surveyed are concerned about safety and, in general, have the wherewithal to deliver safe laboratory experiences to their students. However, chemistry teachers are concerned about the safety actions of younger chemistry teachers and other science teachers within their schools. These teachers expressed a need for safety training of all science teachers regardless of discipline. In addition, the Flinn Scientific website (http://www.flinnsci.com) was mentioned by several respondents as a place to obtain quality information on laboratory safety.[11] This site is particularly geared toward the needs of middle and high school science teachers and includes handouts on goggle safety, eyewash and shower safety, chemical safety in the lab, chemical labeling, and safety contracts as well as safety exams in both Spanish and English languages. Other respondents mentioned safety training available through CHEMIS (Chemical Health & Environmental Management Information System), a web-based application to equip educators with safety tools (lesson plans, reports, management of chemical inventory, etc.).[12]

CHEMICAL STORAGE

According to our survey, chemistry teachers within West Virginia high schools are self reported to have laboratory classrooms that are particularly well-equipped in terms of chemical storage

Table 2. Response Rate (in %) to Statements Involving Chemical Storage as Specified in Statements 16–21. Number of Responses Indicates the Total Number of Teachers who Responded to the Particular Statement. Responses of Strongly Disagree and Disagree Have Been Collapsed and are Shown Together; Likewise, Strongly Agree and Agree Responses are Shown Together.

Statement	Strongly Disagree or Disagree	Neutral	Strongly Agree or Agree	Number of Responses
16. A stockroom to store chemicals is available at my facility.	11%	0%	89%	73
17. Chemicals are stored so as to separate incompatible chemicals.	11%	4%	85%	72
18. Appropriate flammable cabinets are being used.	10%	3%	88%	72
19. Appropriate acid cabinets are being used.	13%	6%	82%	72
20. Stockroom shelves have safety lips.	25%	7%	68%	71
21. The stockroom is locked and not generally available to students.	10%	5%	84%	77

Table 3. Response Rate (in %) to Statements Involving Safety Information Policy as Specified in Statements 22–33. Number of Responses Indicates the Total Number of Teachers who Responded to the Particular Statement. Responses of Strongly Disagree and Disagree Have Been Collapsed and are Shown Together; Likewise, Strongly Agree and Agree Responses are Shown Together.

Statement	Strongly Disagree or Disagree	Neutral	Strongly Agree or Agree	Number of Responses
22. There is a state safety manual available to teachers.	47%	20%	32%	74
23. Routine laboratory inspections are mandatory.	44%	19%	36%	72
24. Safety workshops to update safety programs are of high priority in my county school system.	56%	25%	19%	72
25. The OSHA Lab Standard has been explained to teachers.	65%	18%	17%	72
26. A chemical inventory list is maintained and updated.	24%	12%	64%	74
27. MSDS sheets are on file and readily available to teachers.	14%	8%	78%	73
28. A written student safety policy is explained to students and signed by them.	14%	8%	78%	72
29. Accident reports are maintained by the teacher.	20%	19%	61%	74
30. Chemical orders are handled through one individual.	34%	16%	49%	73
31. New science personnel are required to go through a safety training program.	79%	11%	10%	71
32. Lists of hazardous chemicals, which are suggested not to be used in high school laboratories, are available.	38%	25%	37%	73
33. A hazardous waste management policy is set up and functioning at the school.	48%	25%	27%	75

facilities. Table 2 summarizes teacher responses to six Likert statements on issues of chemical storage. Stockrooms, flammable cabinets, and acid cabinets are available at 89%, 88%, and 82% of high schools surveyed. In addition, the average chemistry teacher stores incompatible chemicals separately (85%) and limits student access to the stockroom (84%).

SAFETY INFORMATION POLICY

Table 3 summarizes teacher responses to 12 Likert statements on issues of safety information policy. The availability of safety policies (in the form of a state safety manual), routine laboratory inspections, and on-going safety workshops within the high school setting is somewhat limited as indicated by a general lack of agreement with statements 22–24. In addition, the OSHA Lab Standard, a tailored set of minimum standards for occupational exposure to hazardous chemicals in the workplace, has been explained to only 17% of chemistry teachers.[13] In fact, the state of West Virginia does not have an OSHA approved state plan for job safety and health programs and, even if it did, OSHA regulations apply to private not public employees.[14] However, practices associated with the OSHA Lab Standard (e.g., MSDS sheets are available, chemical hygiene plan that explains chemical hazards to students, accident report records maintained) are reported to be in place in a by a majority of high school chemistry teachers. For example, chemical inventory lists are maintained/updated (64%), MSDS sheets are on file and available (78%), written student safety policy is explained to students and signed by them (78%), and accident reports are maintained (61%). Thus, even though the OSHA Lab Standard has not been explicitly explained to chemistry teachers and teacher adherence to its standards is not required, a majority are implementing the intended practices of the OSHA Lab Standard within their laboratory setting.

Our survey indicates a general lack of safety training for new science personnel within the high school setting. Only 10% of chemistry teachers surveyed agreed that new science personnel attend some type of safety training program and 79% disagreed with this statement indicating a clear need for a laboratory safety training program, particularly for pre-service and newly certified in-service teachers. It was evident from teacher comments that chemistry teachers are very worried about safety training of new science personnel. Besides training of new science personnel, the biggest issue on the minds of chemistry teachers was hazardous waste management and disposal, which could imply a deeper issue of safety surrounding the uniformed use of materials that generate hazardous waste for disposal. Only 27% of teachers indicate that their school has a hazardous waste manage-

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ment policy. Assistance in identification, management, and disposal of hazardous chemical waste was mentioned a minimum of 23 times in the free response questions.

Open-ended question responses provided details related to safety information policy. Representative comments include:

"Providing links to OSHA sites containing information regarding current safety practices/procedures, to sites devoted to MSDS and other sites pertaining to local/state/federal laws, guidelines and policies, would be greatly beneficial."
"HAZMAT resources in all areas of the State; Poison Control Information, where to go for research on chemical disposal, and any other informative websites."
"Help disposing of waste materials!!"
"answer questions like how to dispose of _____(how to neutralize to be able to pour down the drain. . .)"
"List of chemicals not recommended for high school; Updates on safety concerns, disposal methods, etc."
"Safe handling of chemicals; Disposal of chemicals, especially old chemicals in storage; Experiments that reduce hazardous chemicals."
"MSDS listings for chemicals commonly found in a HS lab; A list of chemicals that should NOT be in a HS lab; How to dispose of chemicals safely."
"I would benefit from a guide that tells me how to dispose of common chemicals. I need one that is easy to read."
"For the teach (sic) it would be nice to have proper stockroom organization tips, links to OSHA and MSDA (sic) sheets and place to attend safety training both laboratory workshops and CPR training."

TEACHERS' EDUCATION

"The issues of training and updating training is (sic) often overlooked in both the training of future science teachers and school boards. Everyone believes it is the responsibility of someone else to train teachers about safety. My training is the result of having worked in a laboratory and through my own pursuit of updated information. Neither my teacher training nor my school board has provided me with safety training." (West Virginia public high school chemistry teacher, 2008; Teacher 2).[1] This elegant comment validates the need for studying laboratory safety in high school settings and then using this information to develop and deliver laboratory safety training to both pre-service and in-service teachers in an on-going manner. As shown in Figure 2, the majority of West Virginia high school chemistry teachers indicate that their collegiate education lacked laboratory safety training (55% of teachers disagreed/strongly disagreed and only 26% agreed/strongly agreed with statement 34). Likewise, a significant percentage of high school teachers did not receive this training during their student teaching (61% of teachers disagreed/strongly disagreed and only 22% agreed/strongly agreed with statement 35). In effect, 48% of high school teachers are learning about laboratory safety prior to assuming their teaching duties-26% during collegiate educational training and 22% during student teaching. What about the remaining 52% of teachers? Of the remaining 52%, a minimum of 37% indicate (agree/strongly agree) that they have not learned about laboratory safety beyond general chemistry coursework. So, a small percentage of teachers are learning about laboratory safety on their own using online resources (e.g., Flinn Scientific, CHEMIS) or during workshops and trainings (e.g., Advanced Placement (AP) Chemistry training, Flinn Scientific Safety Workshop). Nevertheless, a large percentage of high school chemistry teachers (37%) are teaching with minimal laboratory safety training and are not comfortable in delivering a quality laboratory experience to their students (see representative comments below).

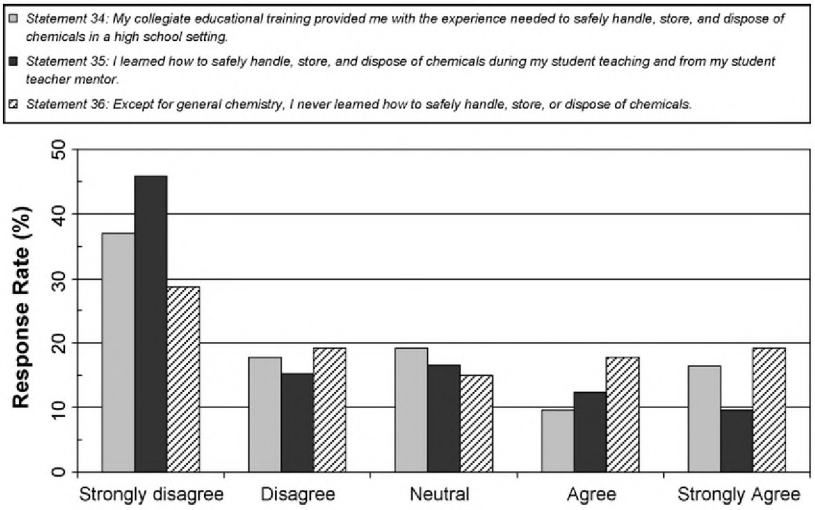

Figure 2. High school chemistry teacher response rate (%) in terms of agreement with the statements in 34–36. The total number of respondents for statements 34, 35, and 36, were *N* = 73, 72, and 73, respectively.

"As a teacher who got my certification through an alternative route program, I do not have the lab background to run labs effectively and efficiently."
"We have very little funds to supply a lab. I do the best I can with what we have. Honestly, I don't feel comfortable with the students in the lab and their safety."
"Labs are the heart & soul of a science class and when I taught biology, I had a lot of background in the field to design my own labs and games, but in chemistry I don't have nearly the background and thus don't have the tools to be creative. The way the chemistry curriculum is laid out, I feel that their (sic) ought to be lots of lab activities and demos that can be used for everything, but I don't have the chemical background to come up with them on my own. I feel like I'm learning right along with the students most of the time, and that's not good enough for them."

More than 92% of chemistry teachers agree/strongly agree that the proper place for training in the safe handling, storage, and disposal of chemicals is during the collegiate educational experience (see Figure 3). Comments on this subject ranged from *"Teach your students safety in the science classroom before the (sic) do*

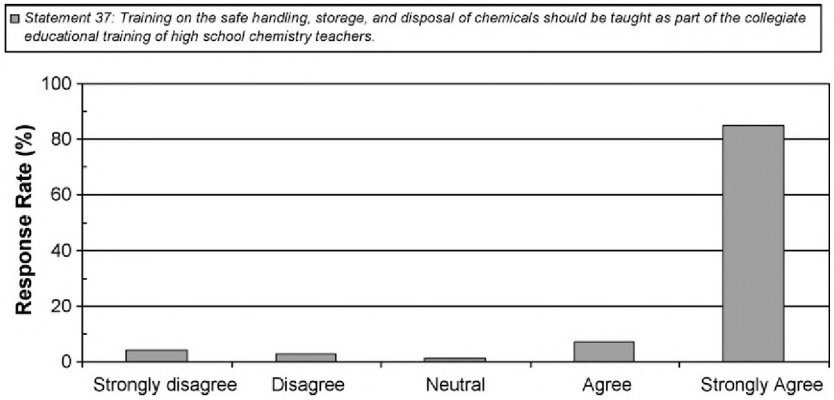

Figure 3. High school chemistry teacher response rate (%) in terms of agreement with the statement in 37. The total number of respondents for this statement was 72. Overwhelmingly, high school teachers agree that safety training should be a part of the collegiate training program for chemistry teachers.

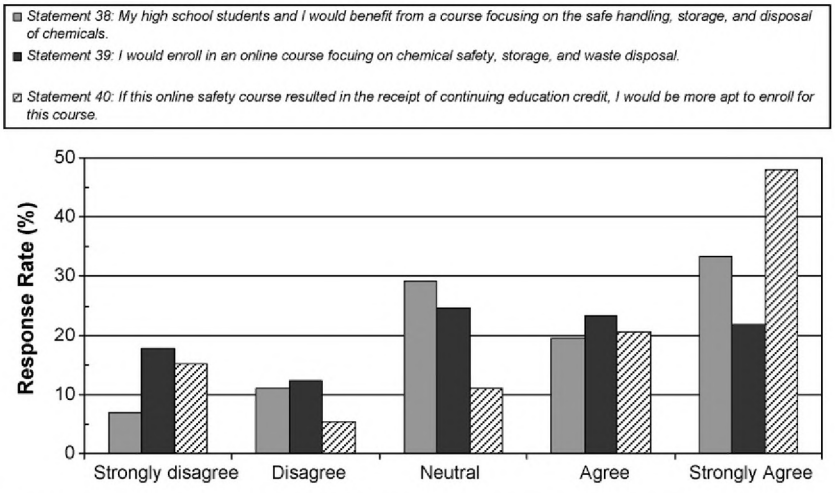

Figure 4. High school chemistry teacher response rate (%) in terms of agreement with the statements in 38–40. The total number of respondents for these statements was *N* = 72, 73, and 73, respectively.

their student teaching."...to..."*As a teacher, I would like to see new teachers already trained in lab safety because I could have been a better teacher years ago if I had been prepared better.*" Several teachers expressed the need for collegiate laboratory safety training for all science teachers: biology, general science, physics, and chemistry. This further supports the idea that teachers are teaching chemistry without the appropriate chemical training which also includes a lack of safety training appropriate for a teacher to develop and maintain a safe chemical laboratory environment.

The results of this survey will guide us in developing a continuing education course that focuses on laboratory safety in the high school setting. However, if we develop such a course, will in-service high school teachers enroll? Responses to the last three survey statements (see Figure 4) indicate that the majority of teachers are interested and believe they would benefit from a course focusing on laboratory safety (e.g., 53% agreed/strongly agreed). However, they would be more apt to enroll if course completion resulted in receipt of continuing education credit (e.g., 68% agreed/strongly agreed).

The results of this survey will guide us in developing a continuing education course that focuses on laboratory safety in the high school setting.

CONCLUSION

Overall, survey results indicate that West Virginia high school chemistry teachers have dedicated chemistry laboratory facilities that, in general, are not presently adequate for the number of students enrolled in chemistry coursework. Teachers are genuinely concerned about their school's ability to provide meaningful chemistry laboratory experiences to all 11th grade students by 2013 as mandated by the West Virginia Board of Education. This is primarily due to the insufficient number of laboratory facilities and the availability of qualified chemistry faculty. Basic laboratory safety equipment (e.g., safety showers, eyewash stations, and chemical spill kits) is somewhat lacking but the majority of teachers require their students to wear chemical splash goggles, (i.e., the most basic form of personal protective equipment). However, there is some indication that even this basic form of personal protective equipment may be lacking in some classrooms. The general lack of laboratory safety training of non-chemistry science personnel was of concern to a number of teachers and our institution was asked to address this deficit by requiring all pre-service science teachers to take a course in chemical safety. Self report data suggests that West Virginia high school chemistry laboratories are particularly well-equipped in terms of chemical storage facilities (e.g., stockroom, flammable cabinets, acid cabinets) and teachers are storing incompatible chemicals separately. The majority of teachers are maintaining chemical inventory lists, accident

report forms, keeping MSDS sheets on file, and requiring students to read and sign a safety policy statement. However, there is a general lack of safety training for new science personnel and few schools have hazardous waste management plans. In fact, assistance with identification and disposal of hazardous waste was the single most requested item in the free response section of this survey. Pre-service teacher training on laboratory safety and chemical management issues was generally not provided during teachers' collegiate education or student teaching, indicating another area of improvement in pre-service teacher education. The majority of teachers agree that laboratory and chemical safety training should be provided as an integral part of the educational coursework for all pre-service science teachers. In-service teachers were receptive to enrolling in an online course geared toward chemical safety especially if continuing education credits were offered for course completion.

Based on the results of this survey, we have designed a website (http://wvhschemteachers.wvu.edu) specifically tailored to the needs and desires of West Virginia high school chemistry teachers. This website includes information on and links to (1) laboratory safety, (2) careers in chemistry, (3) opportunities for chemistry teachers and their students, (4) examples of college level curriculum/syllabi/exams, (5) contacts for teachers (e.g., safety, chemistry content, and chemistry specific content standards and objectives or CSOs), (6) other helpful links, and (7) teacher blogs on safety issues, student preparedness, etc. In addition, electronic copies (CD form) of the "School Chemistry Laboratory Safety Guide" developed by NIOSH[15] and a card with the above named website address have been sent to all public high schools within West Virginia. Website launch and the ensuing interactions that result are expected to forge a relationship beneficial to all parties involved, high school chemistry teachers and faculty at our institution. The next step will be to convene representatives from all stakeholder groups (State science coordinators, K-12 administration and science faculty, university science faculty, science education faculty and safety personnel) in order to develop a laboratory safety curriculum for pre-service science teachers as well as an on-going continuing education course on laboratory and chemical safety applicable to all in-service high school science teachers (including chemistry).

It should be noted that the intention here is not to point fingers at high schools with inadequate laboratory safety equipment or training or universities with insufficient undergraduate and graduate education programs. Rather it is to provide teachers with a qualitative measure of how their school's laboratory safety equipment and training compares to that of other school's throughout the state. Teachers armed with this safety information will be better prepared to lobby their administrations and Boards of Education for improved laboratory safety equipment, facilities, and training.

ACKNOWLEDGEMENTS

We would like to thank Barbara Foster, West Virginia University Safety Director, for her feedback on the safety survey during its development and John Palassis, NIOSH Centers for Disease Control and Prevention, for generously providing 120 CD copies of the "School Chemistry Laboratory Safety Guide". In addition, we would like to thank West Virginia public high school teachers for taking the time out of their busy schedules to fill out the survey and the principals for thinking the survey important enough to forward to the chemistry teachers.

APPENDIX A

Teacher participation in the survey, "High School Chemistry Teacher Safety Survey," was voluntary and anonymous. Teachers were instructed not to sign the survey or associated scantron. In late December 2007, survey materials were sent to the principals of the 120 public high schools within the state of West Virginia. Vocational schools, private schools, and parochial schools were not included in the survey pool. Survey materials included (1) a cover letter to the principal, (2) a cover letter to the chemistry teacher, (3) the survey instrument and associated scantron, and (4) a reply postcard coded with a school identifier. Principal cover letters explained the purpose of the survey and requested that the principal forward the survey to one teacher responsible for teaching chemistry at the school. Separate cover letters to the teachers explained the survey's purpose and asked for their assistance in completing and returning the survey.

Anonymity was preserved using a dual mail-in system involving (1) the survey sheet and associated scantron and (2) a postcard coded with four-digit number. Respondents return mailed completed survey sheets and scantrons in the stamped, self-addressed envelopes provided. Under separate cover, respondents return mailed stamped, self-addressed postcards. Once received, the four-digit numbers on the postcards allowed for removal of respondent schools from a master list of public high schools within West Virginia.

After two months (February 2008), the survey return rate was 41%. Non-responding schools were sent a second mailing of all survey materials in February 2008. By June 2008, a total of 66 postcards (55% rate of return) and 77 survey responses (64% rate of return) had been received. It should be noted that there were no envelopes returned with multiple surveys, so the lower return rate on the postcards is not indicative of multiple surveys from the same school.

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