RESOURCE ARTICLE

The value of safety and practicality: Recommendations for training disabled students in the sciences with a focus on blind and visually impaired students in chemistry laboratories

We strive to make chemistry more available and exciting for disabled scientists by developing accessible and safe methodologies to be employed by high school, undergraduate, and graduate students. We share philosophies and methods that were found to be effective in ensuring a safe laboratory environment. Namely, an accessible and safe chemistry laboratory requires assistance and extensive contributions from everyone involved. A discussion of technologies that make our computational chemistry laboratory accessible to blind and visually impaired (BVI) researchers follows. These recommendations are derived from our personal experiences with learning and teaching chemistry, with serving on a chemistry accessibility committee and with organizing and running chemistry camps for BVI students. In addition, we have begun work with sighted high school students who perform visual activities under blindfold. These experiences challenge the student under blindfold to learn how to function without all five senses while simultaneously training a sighted peer to safely and accurately assist with non-visual cues.

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INTRODUCTION

Safety in any chemical laboratory should always be the first priority. While the role of maintaining a safe and hazard-free working environment falls heavily on safety officers, lab managers and instructors, students participating in laboratory experiments also contribute to the overall safety of the space. Teaching labs are perhaps the most difficult to keep safe because Q2 the students are only present for a few hours a week, and compared to a research scientist, students do not necessarily share the same knowledge or passion for keeping the workspace

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1871-5532
http://dx.doi.org/10.1016/j.jchas.2015.02.003
© Division of Chemical Health and Safety of the American Chemical Society
Published by Elsevier Inc.

Please cite this article in press as: Nepomuceno, G. M., et al., The value of safety and practicality: Recommendations for training disabled students in the sciences with a focus on blind and visually. . .J. Chem. Health Safety (2015), doi:http://dx.doi.org/10.1016/j.jchas.2015.02.003

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safe. Furthermore, safety precautions that might strike an experienced scientist as obvious are often new to many students. Teaching laboratories, like classrooms, must be accessible to all types of students and although working with students with disabilities in lab may be daunting to personnel, it is entirely doable despite the challenges it poses. Herein, we describe methodologies and recommended best practices for making the teaching laboratory accessible to students with disabilities. HW, a coauthor of this article, is congenitally completely blind and thus blindness will be used as a lens through which we view physical disabilities in the laboratory in general.[1] In practice, these methods have made it possible for HW to work through high school and undergraduate chemistry courses. As a graduate student, he now researches computational chemistry at a level comparable to his sighted peers.

Though not yet extensive, some work has been published in making chemistry laboratory experiments accessible to people with disabilities.[2] Working with blind or visually impaired (BVI) students in the laboratory is possible if everyone in and around the lab space, including the BVI student, intentionally practices safe habits. BVI students are not typically encouraged to study seemingly visual subjects like science, technology, engineering or math (STEM) fields due to the apparent need for constant assistance and the potential safety risks that coincide with having one less sense in a lab. Consequently, there are few known blind Ph.D. scientists in the United States. Despite the low number, respectable research has been produced by BVI scientists in the areas of scientific discovery,[3] chemistry education,[4] and in making chemistry more accessible to the blind.[5] For example, Skawinski and Wohlers are blind chemists and Fantin is a blind biophysicist. Supalo is a blind chemist who has made strides in BVI accessible chemical education. We are confident that with knowledge, practical thinking, and appropriately matched assistants, BVI students can study visual sciences and excel in them.[6]

INITIAL DISCOVERIES IN ACCOMMODATING A BVI STUDENT IN A HIGH SCHOOL LABORATORY

When HW entered high school, he was initially discouraged from enrolling in an honors chemistry course because the lab work was thought to be unsafe for him or the students around him. However, HW's passion for chemistry and his belief that the subject was not solely visual drove him to work with LB, the instructor of the course, to find a compromise. A team was established to address any safety concerns and to resolve any issues as they arose. From previous experiences, HW knew that the first necessity was to have an assistant in the laboratory space. That is, an assistant would act as HW's eyes because many high school chemistry experiments are structured so that students are engaged by color changes or other visual observations. The assistant was asked to explain precisely the setup for each lab, mix chemicals, and provide HW with data that he could not obtain otherwise. Note, that HW is passionate about doing as much of the experiment himself as possible, but an assistant was available to perform visual tasks such as measuring precisely. However, the assistant's most important jobs were maintaining a safe workspace and letting HW guide what was needed.

There were instances where aspects of the experiments could not be made accessible and many of the common procedures highlighted another major safety concern when working with BVI students: acquiring important information by feeling around and independently discovering the layout of a space. In a laboratory where safety hazards can be out in the open, LB and school administrators strictly instructed HW to acquire information verbally instead of tactilely. Additionally, if something potentially dangerous was occurring or had recently occurred, HW waited in the classroom area until he was told it was safe to return to the lab area. These practices led to an environment that was comfortable and extremely safe for HW and the rest of the lab participants.

HW learned early that safety was just as much his responsibility as it was the responsibility of the instructor and his lab assistant. In order to ensure that he played an active role in each experiment and still maintained a safe working environment, HW met with his lab assistant for at least one hour outside of class prior to the laboratory period to ensure that both he and the assistant understood the experiment and that each knew his or her roles. HW knew that it was his responsibility to ensure that the assistant could perform the chemistry correctly while maintaining the safety of himself, his assistant and any others sharing the space. The student/assistant etiquette developed by HW and LB led to a thorough understanding of how to work with an assistant and make the workspace as safe as possible. Ultimately, we found a good, knowledgeable student/assistant pair is one where the student guides the assistant through the experimental procedures and neither person in the pair deviates from what had been previously discussed unless there is an imminent safety risk. Moreover, good assistants do not complete the laboratory experiment while the disabled student contributes nothing; each step is discussed and the assistant waits for direction from the student.

RECOMMENDED BEST PRACTICES FOR STUDENTS WITH DISABILITIES IN UNDERGRADUATE LABORATORIES

Students with disabilities are accustomed to being in high school where assistants were readily provided. When students arrive at undergraduate institutions, assistants are legally required to be provided by Disability Resources Centers (DRCs), however, these assistants often lack knowledge and working assistant skills necessary for a science lab. Thus, in addition to experiencing the stress of beginning college, disabled students in STEM must often also find competent assistants on their own. Whether an assistant is sought for a lecture course or a laboratory class, disabled students can be matched with incompetent assistants for a number of reasons: (1) the disabled student simply does not know how to judge a good assistant, (2) the

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