Annals of Work Exposures and Health, 2024, **68**, 427–436
https://doi.org/10.1093/annweh/wxae016
Advance access publication 7 March 2024
Original Article

Identification of critical industry skills in an industrial hygiene graduate training program

Jillian Moore[1], William J. Brazile[1,*], Mollie Brazile[2], Jill Zarestky[2]

[1]Department of Environmental and Radiological Health Sciences, Colorado State University, 1681 Campus Delivery, Fort Collins, CO 80523-1681, United States
[2]School of Education, Colorado State University, 1588 Campus Delivery, Fort Collins, CO 80523-1588, United States
[*]Corresponding author: Email: William.brazile@colostate.edu

Abstract

Graduates of industrial hygiene training (IH) programs must be able to meet continuously evolving health and safety needs in a wide variety of occupational settings. Therefore, academic IH graduate programs must regularly evaluate their curricula and solicit input from industry professionals to make curricular changes that will better prepare their students for professional roles in industry. The purpose of this study was to identify the training gaps that existed between industry needs and the current curriculum for a United States-accredited IH graduate training program. The research team facilitated two group interviews with the IH program advisory board, collected alumni survey data, and performed a qualitative analysis to identify skills gaps/needs for the IH Program graduates. The research team identified 3 themes from participant interviews and alumni surveys (technical, applied, and essential skills) and selected several skills within each theme that interview participants thought were necessary proficiencies for junior IH professionals. The skills identified in the qualitative interview and survey data can be incorporated into the curriculum to improve the training of IH graduate students. Additionally, by using qualitative analysis, the researchers uncovered essential skills previously unidentified in IH needs assessments, providing valuable information for all IH graduate programs.

Key words: Industrial hygiene; occupational hygiene; training needs analysis; graduate studies; accreditation; qualitative analysis.

What's Important About This Paper?

This paper provides a methodology to perform a training needs analysis for occupational hygiene and other occupational health academic programs. The results of the needs analysis can assist academic programs in identifying training needs to meet industry expectations and provide documentation for academic program accreditation.

Introduction

The role of industrial hygiene (IH) professionals is to provide a "strategic approach to identifying, assessing, and managing health hazards that arise…" in the workplace (American Industrial Hygiene Association 2019). These professionals often serve as environmental, health, and safety (EHS) generalists in a wide variety of industries, from manufacturing and construction to healthcare, military operations, and research; this requires the education of IH professionals to be broad enough to solve both known and emerging safety and health issues in any context.

To support this need for a broad safety and health education and to ensure that standards of excellence are met, industrial hygiene, occupational hygiene, and occupational health and safety academic programs may apply for program accreditation at the graduate and undergraduate levels. Accrediting bodies/organizations publish academic standards and/or academic objectives that must be met through the submission

Received: September 28, 2023. Accepted: February 19, 2024.

of program documentation and, in some cases, a site visit to the campus. Accrediting organizations are comprised of experts in their respective fields who define the standards for accreditation.

The Australian Occupational Health and Safety Education Accreditation Board defines the standards and accredits occupational health and safety academic programs in Australia. The Board accreditation criteria are based on the Occupational Health and Safety (OHS) Body of Knowledge, a conceptual framework that defines what OHS professionals should know to be successful OHS practitioners. Specifically for institutions seeking accreditation, the Body of Knowledge provides learning objectives to inform academic curricula and describe what newly graduated occupational hygienists should be able to do upon graduation. For example, in the category of biomechanical hazards, an OHS graduate should be able to "Develop criteria for design or modification of equipment to minimise biomechanical hazards and MSDs [musculoskeletal disorders]." The OHS Body of Knowledge project was initially funded by WorkSafe Victoria and was developed by the Australian Institute of Health and Safety. To meet the Australian Accreditation Board criteria, an academic program must demonstrate that (i) at least 50% of academic credits meet the OHS Body of Knowledge (with one year of full-time study), (ii) the academic program includes objectives and learning experiences that meet the OHS Body of Knowledge student learning outcomes, and (iii) that an ongoing process is in place for industry consultation (Australian Occupational Health and Safety Education Accreditation Board, n.d.).

The British Occupational Health Society Faculty of Occupational Hygiene (BOHS FOH) is the accrediting body for occupational hygiene academic programs in the United Kingdom. The BOHS FOH defines the learning outcomes for academic programs in 5 major categories: technical knowledge and skills, management, work environment and processes, science, and ethics. Each of the learning objective categories specifies demonstrable learning outcomes that the student should be able to demonstrate, and it is the responsibility of the academic program to demonstrate how program learning objectives meet the BOHS FOH learning objectives. For example, in the technical knowledge and skills category, the subcategory of measurement of hazardous substances, an academic program would have to demonstrate that it meets the learning objective of "Select appropriate equipment to measure specific airborne contaminants and devise a suitable sampling strategy." Depending on the degree level (e.g. Bachelor of Science or Master of Science), an academic program is required to meet specified learning objectives. In addition to the learning objectives, the BOHS FOH specifies faculty qualifications, facility and equipment requirements, and learning assessment requirements (British Occupational Hygiene Society Faculty of Occupational Hygiene 2019).

An additional accrediting board, ABET (formerly the Accreditation Board for Engineering and Technology—since 2005, the organization uses only the acronym), has defined core competencies (with guidance from the American Industrial Hygiene Association) for academic programs to train future IH professionals, and accredits academic programs internationally. Unlike the Australian Occupational Health and Safety Education Accreditation Board and the UK's BOHS FOH accreditation requirements that specify occupational hygiene topics that must be addressed in an academic curriculum, ABET accreditation program criteria are defined broader. ABET requires a multi-tiered model of defined criteria/objectives, including general criteria, program criteria, educational objectives, and student outcomes.

All ABET general criteria must be met for accreditation consideration and include specifications for student performance monitoring and admission, program educational objectives, specified student outcomes, continuous improvement, general curricular requirements, faculty qualifications, and institutional support. The student outcomes specified in the general criteria are relatively broad and describe what trainees are expected to be able to do upon graduation, for example, they must have "An ability to identify, formulate, and solve broadly defined technical or scientific problems by applying knowledge of mathematics and science and/or technical topics to areas relevant to the discipline." More specifically, at the academic program level, specified program criteria must be satisfied in the curriculum to include knowlege, such as, "anticipation, recognition, evaluation, and control of potentially hazardous agents, conditions, and practices." It is the responsibility of the academic program to indicate where the program criteria are met in the academic curriculum (ABET 2021).

If an academic OHS curriculum meets the United States-based Board of Certified Safety Professionals' (BCSP) OHS criteria, the program may be designated as a Qualified Academic Program (QAP). Graduates from a QAP-designated program may apply for the Graduate Safety Practitioner® designation upon graduation, which exempts the graduate from taking the BCSP's Associate Safety Professional® examination and applying for the Certified Safety Professional® examination when field experience requirements are met. To become a QAP, an OHS academic program must demonstrate that the curriculum meets at least 70% of the knowledge topics defined in the Associate Safety Professional® examination blueprint (Golding 2022). The examination blueprint includes 9 "domains" which specify required knowledge in specific topic areas. For example, Domain 2, Safety Management Systems, lists knowledge of machine guarding, confined space, and fall protection (BCSP 2019).

In addition to meeting specified student outcomes ABET requires accredited academic IH programs to demonstrate continuous improvement of their curricula to ensure that they are adjusting to the perpetually evolving needs of IH professionals in industry (ABET 2021). One common method of continuous improvement is to perform a training needs assessment to verify the skills currently addressed in an academic program and identify additional skills that need to be enhanced or added into the curriculum. There is a paucity of published literature that provides research on the needed and/or expected skills of IH program graduates and early career IH/EHS generalist professionals. In all of the existing publications, the ability to effectively communicate was identified as a crucial but often underdeveloped skill (Oestenstadet al. 1994; Brosseau 1995; Brosseau et al.2005; Brosseau and Fredrickson 2009; American Industrial Hygiene Association 2019). Other necessary skills identified in this literature included problem-solving skills, business skills, and technical skills in ventilation, hazard recognition and control, and risk assessment.

While there have been a few published studies where researchers assessed the skills needed to be a successful IH professional (Oestenstad et al. 1994; Brosseau et al. 2005; Brosseau and Fredrickson 2009; American Industrial Hygiene Association 2019), only two conducted interviews and performed a qualitative analysis to identify these skills (Brosseau and Fredrickson 2009; American Industrial Hygiene Association 2019). Given the lack of industry-based IH skills assessment data, there is a need to perform current interview-based research with industry professionals that use robust qualitative analysis methods to identify and clearly define essential skill needs (also known as "soft" or "professional" skills), in addition to technical skill needs. Additionally, no published research has included data that were collected for (i) examining existing curriculum content to meet industry needs and (ii) comparison to accreditation criteria for a specific academic program; this is a necessary component of a needs analysis that aims to make improvements to a program.

The aim of this study was to identify the training gaps that existed between industry needs and the Colorado State University (CSU) ABET-accredited, BSCP-qualified Industrial Hygiene Master's Program (i.e. CSU IH Program). It is important to note that this research was not intended to identify emerging issues in occupational health, rather the required underlying skills needed to effectively address current and emerging issues. Newly graduated industrial hygienists must be prepared to address not only traditional occupational health hazards such as chemical and biological hazards, but also emerging issues such as those identified by Ramos et al. (2022), including teleworking, health emergencies and dynamic decision making (e.g. COVID-19 pandemic), artificial intelligence, nanotechnology, and robotics. The researchers in the current study examined quantitative data from a curriculum map to verify that accreditation criteria were met and qualitative data from small group interviews and alumni surveys to perform a comprehensive training needs assessment. The methodology used in this research can be applied to other occupational health accredited programs that want to ensure their graduates are well-prepared to meet both the technical and the essential skill expectations of the professional world.

Methods

This research was conducted in two phases utilizing a model for a systematic approach to training needs assessment (US Department of Energy 1994). The needs assessment approach in the current study included the identification of "regulatory requirements" (i.e. program accredition requirements) and (ii) the identification of performance problems that may be addressed through training. In Phase 1, the researchers performed a curriculum crosswalk between the IH Program goals, which included (i) ABET accreditation criteria (i.e. student outcomes) and (ii) BCSP Associate Safety Professional® examination blueprint objectives (i.e. specific compentency areas); and the objectives and learning assessments for every core course in the current IH Program curriculum to identify any existing training gaps (Fig. 1).

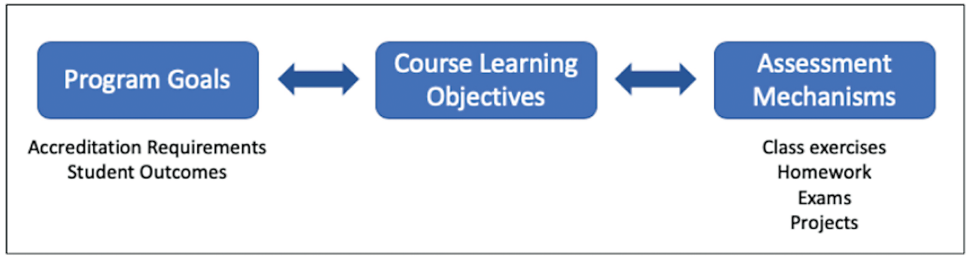

Fig. 1. Visual representation of the curriculum crosswalk.

In Phase 2, on which this paper will focus, the researchers facilitated a series of virtual focus group interviews with the members of the CSU IH Program Advisory Board and gathered the results from several recent alumni surveys to identify program needs from the perspectives of alumni and EHS professionals. The Phase 2 data were qualitatively analyzed to identify themes and recommend additional training for the IH curriculum. All aspects of this research were performed in accordance with the approved CSU Institutional Review Board protocol.

Interview data collection

Virtual group interviews were performed with members of the CSU IH Program Advisory Board to solicit input on the expected performance of IH graduates. This population was selected for convenience as well as participant familiarity with the IH Program and its goals. A total of 12 board members participated in the group interviews; of these members, 5 worked in government or industry, 4 worked as IH/ESH consultants, and 3 were academic professors, two of which actively taught IH courses at CSU. In addition, two of these participants were also recent graduates (<5 years) of the IH Program.

Based on the evidence presented by the American Industrial Hygiene Association (AIHA) (2019), the research team developed an interview protocol with the intent to encourage semi-structured discussion and capture a broad range of potential training needs and gaps. Participants were asked one primary question: *What performance problems (technical and non-technical) have you seen in recent CSU IH Program graduates?*

To balance perspectives and ensure that enough context and details were captured in the discussion, follow-up questions were phrased more positively and included (but were not limited to):

- What do these skills *look like* in your place of work?
- What should graduates be able to *do* or *execute* if they have these skills?
- What specifically needs work?

All 3 researchers/facilitators presented the discussion questions above to the IH Advisory Board members and were provided with an interview guide that contained the questions and space for recording notes during the interviews.

Alumni survey data collection

Qualitative data were also collected from 4 CSU IH Program alumni surveys conducted between 2015 and 2021 (Table 1). These surveys are typically e-mailed to program alumni regularly to solicit feedback on the strengths and weaknesses of the program and to understand the current challenges alumni face in the workplace. For the purpose of this research, all responses to the following questions were used in the analysis:

1] What are the biggest challenges you face in your current job?
2] Thinking about your current position, were there any gaps in your education that the Mountain and Plains Education and Research Center could have better addressed?
3] What did you like about the CSU IH program?
4] What suggestions do you have to improve the CSU IH program?
5] What were the strengths of the Industrial Hygiene training program?

Table 1. Alumni survey responses

Year	# of alumni surveyed	# of responses
2015	13	12
2018	32	25
2019	15	10
2021	30	21

There are likely multiple responses from "repeat" individuals over the 4 surveys; the magnitude of this issue is unknown since the survey responses were deidentified when received.

Interview and alumni survey data analysis

Verbal transcripts were generated from the group interview recordings, and meeting notes were taken where verbal transcripts were not generated. The transcripts were manually reviewed for accuracy and de-identified. The de-identified alumni survey responses were also included for analysis. The research team performed a content and thematic analysis to identify and analyze patterns within the data, using methods described by Braun and Clarke (2006).

A content analysis was performed on all transcripts and survey responses to identify skill gaps and categorize them into two deductively identified themes: technical skills and essential skills (i.e. non-technical skills necessary to execute technical skills and require humans' emotional side) (Kyllonen 2013; Tulgan 2015; Succi and Canovi 2020). Supporting contextual evidence for each skill gap was placed within each theme. For the technical skills theme, a semantic approach was used to identify several specific technical skills. A latent approach was used to iteratively review the essential skills subset of data to inductively derive and refine specific essential workplace skills (Braun and Clarke 2006). The two researchers performing the qualitative

analysis coded the transcripts independently and then reviewed and compiled the data together to reach consensus. After the initial data analysis, the researchers developed a third theme, *applied skills*, that accounted for skills that required both technical and essential skills elements. The final themes derived from the data were technical skills, applied skills, and essential skills.

Results

Group interviews and alumni surveys

The research team identified many skills that the interview participants and alumni thought were necessary for new graduates to perform well in a variety of workplace contexts. The data were coded into 3 themes that encompassed the skills needed to be a successful IH/EHS professional: technical skills, applied skills, and essential skills. A complete list of the skills identified in the data is found in Table 2.

Technical skills

Three technical skill categories were identified (i.e. fundamental areas of knowledge specific to industrial hygiene and occupational safety) (AIHA 2018). Interview participants recommended that aerosol science and ventilation be required as core curriculum courses (rather than elective courses) and indicated an increased need for these skills with the COVID-19 pandemic. In addition, both interview participants and alumni surveys strongly indicated a need for graduates to be aware of regulations beyond those of the Occupational Safety and Health Administration (OSHA), such as those from the National Fire Protection Association (NFPA), Department of Energy (DOE), and the Environmental Protection Agency (EPA). A number of "special" topics were noted in the alumni surveys, including electrical safety, radiation safety and health physics, worker's compensation, lean six sigma, hazardous waste, and how to respond to accidents.

Applied skills

There were 4 applied skills that were identified: business skills, critical thinking and problem solving, real-world application, and adult education and training. The business skills included building a business case, project management, and communication. The ability to build a business case for EHS initiatives that clearly shows the benefits (especially costs and savings) to the company, employees, and community was identified as essential for gaining buy-in from management. Project and resource management were identified as important in managing change and dealing with constrained budgets and resources. Further, both written and verbal communications were noted as vital skills to be successful in the workplace, and communicating verbally was suggested as possibly more important.

The critical thinking and problem-solving skills that were identified included (i) modeling of IH data and understanding limitations, (ii) resource awareness, and (iii) data quality and analysis. Interviewees recommended that IH students to be introduced to modeling software, such as AIHA's IH-MOD 2.0. In addition, it was suggested to teach students about the limitations of models as well as the importance of considering those limitations when determining and presenting solutions. Study participants agreed that being aware of various resources and tools was a crucial skill for assessing and solving unfamiliar problems in the workplace. Interviewees further agreed that it would be impossible to teach students every resource and tool but having a general idea of where to find the necessary information is an important skill.

Table 2. Themes from CSU IH Program Advisory Board Interview Data

Technical skills	Applied skills	Essential skills
Aerosol science	Business skills • Building a business case for safety and health • Project management • Communication	Communication and Interpersonal skills • Conflict management and dealing with resistance • Collaboration and negotiation • Building relationships and rapport
Ventilation	Critical thinking and problem solving • Modelling and understanding limitations • Resource awareness • Data analysis and quality	Self-directed learning and management
Non-OSHA standards and regulations	Real-world application	Leadership
Special topics	Adult education and training	Diversity, equity, and inclusion

Related to critical thinking and problem solving, the need for mature skills in data analysis was recommended by the interviewees. Understanding how to determine the appropriate number of samples to collect, which methods to use, working with limited data sets, and drawing conclusions require a solid technical background and the ability to think critically.

For real-world application of IH concepts, the interviewees and alumni suggested shadowing professionals, participating in internships, and practicing how to implement a variety of safety regulations. Interviewees also recommended introducing students to the myriad of professional responsibilities they may be assigned in the role as a professional IH.

Interview participants and the alumni surveys identified teaching and training adults as an important part of their professional roles. Participants also noted that IH/EHS training happens in a variety of contexts, from one-on-one teaching to classroom or lecture-style teaching for larger audiences.

Essential skills

Interview participants and the alumni survey results identified a variety of non-technical skills that were vital to success in the workplace, including communication and interpersonal skills; self-directed learning and management; leadership; and diversity, equity, and inclusion. It was recognized that these skills may be difficult to teach in a classroom setting, but they are essential for executing the technical skills and accomplishing tasks in a business environment. Further, interviewees and alumni surveys noted that being a successful IH/EHS professional requires highly developed interpersonal skills, including conflict management and dealing with resistance to change, collaboration and negotiation, and building relationships.

Self-directed learning and time management were identified as necessary skills by interviewees and in the alumni surveys. Alumni survey respondents noted that much of what they do is self-taught, and they had to learn on the job in a rapid manner. This kind of self-directed learning was highlighted during the pandemic-induced need to work remotely and in an autonomous environment. In addition, interviewees identified a strong need for effective time management skills. They recognized that IH/EHS professionals are often inundated with relatively large workloads and e-mails that can be difficult and overwhelming with which to keep up and recommended providing students with tips on time and self-management prior to entering the workplace.

The interview participants thought that leadership was an important skill for IH graduates, even in their first few years in the workplace. They noted that displaying leadership skills did not necessarily require an official position but could include peer mentorship, influencing others to obtain resources or achieve EHS goals, and engaging in professional development both in and outside of the organization.

Last, the interview participants shared that foundational knowledge in diversity, equity, and inclusion (DEI) was identified as a growing need for IH/EHS professionals. Specific DEI topics identified by board members included gender, age, class, and culture.

Discussion

By using results from several alumni surveys, the research team in the current study was able to capture the experiences of IH program alumni at various points in time, which has the potential to account for the continually evolving needs of the IH/EHS profession. However, the research team recognized that using an established survey, the high probability of repeat individuals across the survey population, and the inability to follow up with respondents are limitations to using these survey data. Additionally, non-response bias was inherent to these data—those who responded to the survey were likely to have different opinions than those who did not respond, which makes the results less generalizable.

Using Zoom for the interviews in the current study enabled wider participation, which may not have been possible in person. In addition, posing a broad, open-ended question enabled participants to share any skill they thought of and allowed the discussions to cover topics that were unanticipated by the research team. However, there are some important topics that may not have been presented, and if a different group of IH professionals had been recruited, the data would have varied.

Technical skills

The AIHA and the current study identified ventilation as a technical core competency of IH professionals, and knowledge of ventilation principles consistently appears as crucial for IH/ESH professionals in published literature (Oestenstad et al. 1994; Brosseau et al. 2005; Brosseau and Fredrickson 2009; AIHA 2018). Several advisory board members in the current study noted that a solid understanding of ventilation and aerosol principles had become particularly important during the COVID-19 pandemic.

Knowledge of safety regulations (e.g. OSHA) are often listed among the most important technical skills for IH/EHS professionals in published needs assessment literature; they also appear in AIHA's core competencies for IH professionals (Oestenstad et al. 1994; Brosseau et al. 2005; Brosseau and Fredrickson 2009; AIHA 2018). Participants in the current study

identified that in addition to OSHA regulations, knowledge of regulations from the NFPA, DOE, and Mining Safety and Health Administration are important for an academic curriculum.

Applied skills

The 4 applied skills categories (business skills, critical thinking/ problem solving, real-world application, and adult education and training) identified in the current study were identified as necessary workplace skills that require continuous development. The need for project management skills such as budgeting, building a business case, and managing resources were deemed important in the current study. This need was echoed in Oestenstad, et al.'s (1994) survey of manager expectations of entry-level IHs and in AIHA's survey of new EHS generalists (American Industrial Hygiene Association 2019). While project management skills are largely developed in the workplace, there are many opportunities to prepare students in the classroom. For instance, IH programs could work with business or engineering colleges to provide students with foundational information on business concepts and economics, as well as create opportunities for applied practice through team-based projects, case studies, and simulations.

Clear communication of technical information was identified as a critical skill in the current study and in the needs assessment literature (Brosseau et al. 2009; American Industrial Hygiene Association 2019). Similar to written communication, verbal communication of technical and business data was identified as a crucial skill in both the current study and literature (Oestenstad, et al. (1994).

Thinking critically to solve novel IH/EHS problems in the workplace requires a robust technical background, an understanding of acceptable/reasonable results in a given context, and an ability to collaborate with other employees to define problems, gather relevant data, and develop feasible solutions. The participants in the current study identified specific critical thinking skills in understanding the limitations of data/models and being aware of resources; these are skills that can be added directly to an academic curriculum through the incorporation of assignments that use modeling software. Problem solving and critical thinking were defined more broadly in needs assessment literature but were nevertheless deemed as important applied skills as well (Brosseau et al. 2005; Vincent 2005; Brosseau and Fredrickson 2009).

One way to develop applied skills in academia is through real-world application and hands-on experiences, both of which were heavily discussed in the current study and appear in IH needs assessment literature (Vincent 2005). Wybo and Van Wassenhove's (2016) literature review on health, safety, and environmental (HSE) education includes recommendations for realistic case studies, professional conferences, and internships. The need for "real world" experience was also noted in the AIHA white paper; internships were a recommended solution to this need (AIHA 2019). In addition, case studies, as mentioned in Wybo and Van Wassenhove (2016), can be an excellent classroom-based tool for exploring novel problems, ethics, business considerations, and interpersonal/cultural issues in workplace contexts.

In addition to business communication, the ability to communicate effectively to train employees on EHS topics was identified as an important skill in the current study. This finding was mirrored in surveys on IH/EHS graduate/professional expectations published by AIHA (2019) and Oestenstad et al. (1994).

Essential skills

Essential skills, such as communication, teamwork, leadership, time management, and interpersonal skills, have become increasingly important considerations in the hire of new employees in most workplaces (Succi and Canovi 2020). This sentiment was echoed by participants in the current study, who highlighted several essential skills proficiencies required for IH professionals to be successful. Essential skills can be difficult to assess and are not often explicitly included in accreditation requirements or program goals; this leaves a large gap between educational program goals and employer expectations.

Day-to-day interpersonal communication is crucial to the success of IH professionals, who must interface with employees at all levels in a variety of situations. Effective communication for the IH professional is complex: as Brosseau and Fredrickson's (2009) survey of IH employers indicated, communication requires building a foundation of trust among employees, listening, being willing to negotiate or alter original plans, and harnessing one's charisma and sales capabilities in order to persuade others to achieve health and safety goals. Participants in the current study noted that EHS discussions can become tense and/or uncomfortable, and IH professionals must be prepared to handle this resistance while maintaining relationships and promoting a positive safety culture. Embedding communication training and other essential skills in the curriculum can better prepare student for this workplace expectation (Gunarathne et al. 2021).

Self-directed learning and time management were identified in the current study as important skills for early IH/EHS professionals, particularly in the context of the COVID-19 pandemic, which forced many professionals to work from home for several months. While neither skill was explicitly mentioned in existing

IH needs assessment literature, they do appear as "learning skills" and "life balance skills" in Succi and Canovi's (2020) study on assessing the importance of essential skills for young professionals in Europe. Future IH needs assessment studies should consider adding survey questions about essential skills because they are crucial to timely problem-solving and gaining independence as a professional. Additionally, time management and life balance skills are critical in a profession anecdotally known for high levels of stress and burnout.

To promote self-directed learning, academic programs should consider incorporating independent and/or open-ended projects that require students to research a chosen topic or work with companies to define and solve real occupational health issues in the workplace. Academic research required for the completion of student theses or professional papers also lends itself to self-directed learning; however, advising professors should be made aware of methods for promoting self-directed learning in this area in order to foster development of this skill, for example, by applying Grow's (1991) staged self-direction model. To stimulate the development of effective time-management and life balance skills, IH programs could invite industry professionals to share their work experiences and methods for prioritizing and managing workloads, e-mails, and competing priorities.

As identified in the current study, it is important for junior EHS professionals to pursue opportunities for the development of leadership skills. In an EHS/workplace context, developing leadership skills means taking on roles of increasing ownership, responsibility, and/or influence over programs and policies, processes, projects, or people (Vincent 2005; Wybo and Van Wassenhove 2016; Succi and Canovi 2020). One of the most common ways to promote leadership skills in academic curricula is through team-based projects; however, the leader position is often taken by the most assertive students, with minimal guidance on effective leadership and team/project management techniques. This can result in poor leadership and frustration on the part of many students. To provide better opportunities for leadership development, IH academic programs should consider designing opportunities for each student to be the subject matter expert for a topic in class, or structure team projects so all students can take a leading role on one piece of the project. The program could also consider providing training on effective team and project management methods and encourage students to pursue leadership roles in student and professional organizations.

Another skill that received significant discussion in the current study was diversity, equity, and inclusion (DEI), as topic of increasing importance in the American workplace. IH/EHS professionals are tasked with promoting a safe working environment, so having an understanding of DEI issues in the workplace can help achieve this goal. To promote the development of DEI skills, IH academic programs could include topics such as gender considerations when discussing certain types of personal protective equipment, workplace accommodations for different abilities and religious practices, and ensuring training is available in preferred languages and designed for a variety of learning abilities. It is also recommended that professors and students receive foundational DEI knowledge to provide a common language for classroom discussions.

By partnering with adult education professionals to perform a robust qualitative data analysis, the research team was able to uncover several additional essential skills from the interview discussions that do not appear in current IH needs analysis literature: self-directed learning, time management, and DEI. The identification of these crucial workplace skills is an important addition to the literature and should encourage other IH academic programs to add these skills to their curricula.

In addressing the findings and recommendations from this study, it is important to note that although the CSU IH curriculum is ABET accredited and a BCSP QAP, the results of the expert panel interviews and alumni surveys indicated that new graduates were not meeting critical industry needs. Therefore, the industrial hygiene faculty at CSU developed a comprehensive spreadsheet listing the suggested areas of improvement and suggested approaches to incorporate the improvements into the curriculum. This spreadsheet allows the faculty to choose one area of improvement to work on each semester. For example, an interactive emotional intelligence e-learning module was developed to address the identified essential-skills gaps of conflict management and dealing with resistance, collaboration and negotiation, and building relationships and rapport. The module was incorporated into an environmental, safety, and health management course. In addition, the identified applied skills gap of "modelling and understanding limitations" was addressed by the development of an industrial hygiene statistics module in the industrial hygiene laboratory course using free industrial hygiene statistics software through the American Industrial Hygiene Association. The applied skills gap of "adult training and education" was addressed in the curriculum's occupational safety course by the development of an e-learning module requiring the students to apply what they learned in giving a safety presentation.

The two skills gaps slated to be addressed next in the CSU IH Program curriculum include (i) non-OSHA regulatory standards through an e-learning module (technical skills gap) and (ii) making a business case for

environment, safety, and health through the application of the American Industrial Hygiene Association's free business case spreadsheet that will be used for classroom projects (applied skills gap). The benefit of performing a skills gap assessment as in the current study, is that the results will provide ample continual improvement opportunities for an accredited program for several years—and may be used to demonstrate continual improvement for re-accreditation of the program.

Conclusions

The aim of this study was to assess the gaps that exist between industry needs and an ABET/BCSP accredited/qualified industrial hygiene academic program and to use the results to recommend improvements to the curriculum. By performing a robust qualitative analysis on data collected from group interviews and alumni surveys, the research team identified several technical skills, applied skills, and essential skills that must be developed by IH graduate students in order to become successful IH/EHS professionals. These skill gaps can be incorporated into the curriculum to improve the training of IH students. Additionally, the qualitative analysis uncovered essential skills previously unidentified by IH needs assessments, including self-directed learning, time management, and DEI, providing valuable information for all IH graduate programs. It is recommended to conduct interviews with IH/EHS professionals regularly in order to gain feedback on curriculum changes and identify the need for any new skills.

Acknowledgments

The researchers thank the CSU Advisory Board for their participation in this important training needs analysis to demonstrate continual improvement in the CSU IH Program. In addition, the authors thank Thomas Walker, CSU Alum, for his support.

Conflict of interest

Student trainee support funding for this project was provided by the NIOSH Mountain and Plains Education and Research Center, Centers for Disease Control and Prevention, Grant T42OH009229. The authors declare no conflict of interest relating to the material presented in this article. Its contents, including any opinions and/or conclusions expressed, are solely those of the authors.

Data availability

The data underlying this article will be shared on reasonable request to the corresponding author.

References

ABET. 2021. Criteria for accrediting applied and natural science programs. [accessed December 1, 2024] Available at https://www.abet.org.

AIHA. 2018. Core competencies for the practice of industrial occupational hygiene. AIHA. [accessed 8 August 2022] Available at https://www.aiha.org/publications/core-competencies-for-the-practice-of-industrial-occupational-hygiene.

American Industrial Hygiene Association. 2019. Hiring recent EHS generalist graduates: Expectations from hiring managers, recent graduates and academics. White Paper. AIHA.

Australian Occupational Health and Safety Education Accreditation Board (n.d.). [accessed December 1, 2023] Available at https://www.ohseducationaccreditation.org.au.

BCSP. 2019. Examination blueprint (ASP10). [accessed December 1, 2023] Available at https://www.bcsp.org/wp-content/uploads/2021/12/ASP-Blueprint.pdf

Braun V, Clarke V. Using thematic analysis in psychology. Qualit Res Psychol 2006:3(2):77–101. https://doi.org/10.1191/1478088706qp063oa

British Occupational Hygiene Society (BOHS) Faculty of Occupational Hygiene. 2019. University Programmes Accreditation Handbook: A Guide to British Occupational Hygiene Society (BOHS) Faculty of Occupational Hygiene (FOH) Accreditation for Undergraduate and Postgraduate Degree Programmes, © British Occupational Hygiene Society 2019. [accessed December 1, 2024] Available at https://www.bohs.org/app/uploads/2022/12/University-Programmes-Accreditation-Handbook-version-1-October-2019.pdf.

Brosseau L. Results of a survey to assess curriculum needs for academic training-programs in hazardous substances. Am Ind Hyg Assoc J. 1995:56(9):905–910. https://doi.org/10.1080/15428119591016548

Brosseau L, Fredrickson A. Assessing outcomes of industrial hygiene graduate education. J Occup Environ Hyg. 2009:6(5):257–266. https://doi.org/10.1080/15459620902754372

Brosseau LM, Raynor PC, Lungu C. Employers' expectations of knowledge and skills of master's-trained industrial hygienists. J Occup Environ Hyg. 2005:2(1):1–77. https://doi.org/10.1080/15459620590894733

Golding K. 2022. QAP Graduation Folder from BCSP.

Grow G. Teaching learners to be self-directed: a staged approach. Adult Educ Quart 1991:41(3):125–149. https://doi.org/10.1177/0001848191041003001.

Gunarathne N, Senaratne S, Herath R. Addressing the expectation–performance gap of soft skills in management education: an integrated skill-development approach for accounting students. Int J Manag Educ 2021:19(3):100564. https://doi.org/10.1016/j.ijme.2021.100564

Kyllonen PC. Soft skills for the workplace. Change: The Mag Higher Learn 2013:45(6):16–23. https://doi.org/10.1080/00091383.2013.841516

Oestenstad R, Boggs R, Perkins J. An analysis of manager expectations for entry-level industrial hygienists. Am Ind Hyg Assoc J. 1994:55: 546–551. https://doi.org/10.1080/15428119491018826.

Ramos D, Cotrim T, Arezes P, Baptista J, Rodrigues M, Leitao J. Frontiers in Occupational Health and Safety Management.

Int J Environ Res Public Health. 2022:19(17): 10759. https://doi.org/10.3390/ijerph191710759

Succi C, Canovi M. Soft skills to enhance graduate employability: comparing students and employers' perceptions. Stud High Educ 2020:45: 1834–1847. https://doi.org/10.1080/03075079.2019.1585420.

Tulgan B. 2015. Bridging the soft skills gap: How to teach the missing basics in today's young talent. Hoboken, NJ, USA: Wiley.

US Department of Energy. 1994. DOE handbook. Training program handbook: a systematic approach to training. Washington, D.C: US Department of Energy.

Vincent JH. Graduate education in occupational hygiene: a rational framework. Ann Occup Hyg. 2005:49(8):649–659. https://doi.org/10.1093/annhyg/mei043

Wybo J-L, Van Wassenhove W. Preparing graduate students to be HSE professionals. Saf Sci. 2016:81: 25–34. https://doi.org/10.1016/j.ssci.2015.04.006