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# Assessing Outcomes of Industrial Hygiene Graduate Education

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*To ensure that industrial hygiene professionals continue to be prepared for current and future trends, it is important to regularly assess the value of their education. Described here are the results of discussions with employers and a mailed survey of graduates. Comparisons are made with past mailed surveys of both groups. Two sets of discussions were held in late 2005 with employers of industrial hygienists and other health and safety professionals. Twenty-eight participants were asked to discuss current and future needs for professionals in their organization and economic sector, their expectations for knowledge and skills when hiring professionals, methods for finding and hiring, and the importance of ABET accreditation. At the same time, a survey was mailed to 71 industrial hygiene students graduating in the last 15 years. Respondents were asked to rank the value of and their proficiency in 42 competencies. Questions also assessed employment experience, certification, the importance of ABET accreditation, and demographic characteristics. There was a lot of agreement between the two stakeholder groups (employers and graduates) about the most important skill and knowledge areas. Most employers identified communicating effectively and exposure assessment among the most important skills, with designing and initiating research as among the least. Hazard recognition, exposure measurement principles, and personal protective equipment were the most highly ranked knowledge areas. Employers discussed the need for good “business skills” such as teamwork, communication, and project management, and the importance of problem-solving skills. Graduates reported that skills in the areas of recognition, evaluation, and control were most valuable in their first jobs and generally reported high levels of proficiency in these skill areas. There was a similar dichotomy in opinions about accreditation within each stakeholder group. The reputation of the academic program was important when making hiring decisions; accreditation became an important factor only when a program’s reputation was not known. Graduates strongly supported ongoing accreditation but did not apply or attend on the basis of accreditation.*

**Keywords** accreditation, education, outcome assessment

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## INTRODUCTION

The occupational health and safety professions have been profoundly affected by global economic, political, and cultural changes. To ensure that professionals continue to be prepared for current and future trends, it is important to regularly assess the ongoing value of their education. Since the adoption in 1998 of an outcomes-based approach to curriculum and educational design, a variety of methods have been used to evaluate the applicability of expected competencies among employers. These have included regular assessments of graduates’ and employers’ perceptions of value as well as students’ perceptions of proficiency at the time of graduation.

Focus or discussion groups can be a powerful tool for eliciting information that complements or informs data from surveys or interviews. Focus groups are considered qualitative research techniques. Qualitative approaches differ from physical science research methods because they do not seek to discover cause and effect, establish predictability, or identify laws of nature.<sup>(1–3)</sup>

Qualitative methods use systematic and validated approaches for measuring human experiences. Participant interactions can produce responses across the range of opinion. However, focus groups do not measure every respondent’s viewpoint. Therefore, terms such as “few,” “many,” and “most” are used to describe results. Quotes from participants are often used to illustrate key findings.

As described elsewhere, a core set of 29 competencies was designed to describe the knowledge and skills expected of all students in master’s-level occupational health and safety programs (industrial hygiene, occupational health nursing, occupational medicine, and occupational injury prevention) at a single university.<sup>(4)</sup> Competencies are grouped into six categories: recognition, evaluation, control, communication, behavior, and management. Curriculum, course design, and evaluation are all built on this set of competencies, ensuring adequate coverage and a range of opportunities for putting knowledge and skills into practice. Each of the four programs has adopted profession-specific competencies in addition to the core set of 29. In the case of industrial hygiene,

13 competencies were added, primarily in the areas of recognition, evaluation, and control.<sup>(5)</sup>

The overarching goal of this research is to ensure that the graduate program continues to produce professionals who are prepared in both knowledge and skills for the range of jobs they are likely to encounter both immediately after and 5 to 10 years following graduation. This paper assesses the applicability of the competency set for currently enrolled students and describes important trends that may affect future employment. The results of discussions held with local employers in 2005 are described and compared with a 2001 mailed national survey of employers and a 2006 mailed survey of program graduates.

## METHODS

### Discussions with Employers

Two sets of discussions were held with local employers of health and safety professionals. In the first set, up to 10 employers were recruited to one of three groups in different economic sectors (government, industry/manufacturing, and consulting). Participants in Set 1 were recruited by e-mail

and telephone from the mailing list of the local section of AIHA<sup>®</sup> (with permission; 200 members) and were eligible for participation if they met the following criteria:

1. Must have at least one industrial hygienist on staff
2. Must have hired and supervised bachelor's- or master's-trained industrial hygienists in their current organization.

A second set was recruited by telephone and e-mail from the mailing list of the local section of the American Society of Safety Engineers (with permission; 150 members) and 10 members of a small business advisory board. Only one discussion group was held, consisting of a mix of employers from small, medium, and large industrial businesses who were eligible if they met the following criteria:

1. Organization must have no industrial hygienists on staff
2. Organization must have occupational health and safety professionals or employees with occupational health and safety responsibility on staff

**TABLE I. Skills Used in Discussions with Employers**

Competency	Category <sup>A</sup>	Competency	Category <sup>A</sup>
Calculate, interpret, and apply epidemiologic principles and data	E7	Identify hazards of workplace processes	R2 and R5
Calculate, interpret, and apply statistics	E7	Identify health outcomes of exposures	R3
Communicate effectively with other health and safety professionals	Cm5	Interpret and apply scientific findings	E4
Communicate effectively with range of stakeholders	Cm1	Manage resources effectively	M2 and M4
Demonstrate commitment to professional development	B5	Measure and evaluate programs	E5
Demonstrate familiarity with and apply code of ethics	B6	Prioritize hazards, exposures, and controls	E10
Demonstrate importance of ethical behavior and practice	B2	Produce effective scientific and technical reports	Cm2
Describe physical and chemical hazards	R6	Recommend, design, and implement appropriate controls	C6 and C7
Design and deliver employee education	Cm4	Show awareness of diversity in social and cultural beliefs	B1
Design and implement exposure assessment strategy	E8	Understand and apply exposure guidelines	E6
Design and initiate research	E1	Understand basic principles of air sampling	E9
Develop and implement programs	M3	Understand how to assess exposures	E6
Display effective leadership	M5	Understand, interpret, and apply regulations	B3
Formulate and implement policies	M1	Validate effectiveness of selected controls	C8
Gather, manage and analyze data	E2		

<sup>A</sup>See Table III for key to category.

- Must have hired and supervised occupational health and safety professionals or people with this responsibility in their organization.

Participants were contacted and screened by telephone for eligibility. Discussions were held over a 2-hr noon period in November and December 2005, at a local library or government agency. Written consent was obtained from participants as they arrived. Discussions were tape recorded and transcribed. Analysis was conducted using the long-table approach<sup>(1)</sup> and supplemented by qualitative data analyses using NVivo 7 (QSR International, Melbourne, Australia).

Participants were asked to discuss current and future needs for occupational health and safety professionals in their organization and economic sector, their expectations for knowledge and skills when hiring health and safety professionals, methods for finding and hiring, availability of internships, and the importance of ABET accreditation.

Participants were also asked to rank the three most and three least important skills and knowledge areas from a list of 29 skills (Table I) and 27 knowledge areas (Table II). The skills were drawn from a set of 42 competencies adopted in 1998 by the occupational health and safety graduate programs. The knowledge areas were similar to those used in a 2001 survey of employers.<sup>(5)</sup>

### Survey of Graduates

In early 2006, a mailed survey was used to assess educational impact among 71 students from the industrial hygiene master's and doctoral programs at a single institution

**TABLE II. Knowledge Areas Used in Discussions with Employers**

Aerosols	Industrial Processes
Analytic Methods	Industrial Safety
Biologic Aerosols	Instrumentation
Biological Monitoring	Ionizing Radiation
Emergency Planning and Response	Noise
Environmental Regulations	Nonionizing Radiation
Epidemiology	Outdoor Air Pollution Control
Ergonomics	Personal Protective Equipment
Exposure Measurement Principles and Practice	Statistics
Gases and Vapors	Temperature Extremes
Hazard Recognition	Toxicology
Hazardous Materials and Waste Management	Ventilation Principles and Practice
Health and Safety Regulations	Walk-Through Experience
Indoor Air Quality	

who graduated between January 1, 1992, and December 31, 2005. Respondents ranked the value of (1 = not valuable; 2 = valuable; 3 = very valuable) and their proficiency in 41 competencies (1 = not very proficient; 2 = proficient; 3 = very proficient). Questions also assessed employment experience and settings, degrees, and certifications, the importance of program accreditation, and demographic characteristics.

Valid addresses were found for 70 of the 71 eligible graduates. A survey research organization managed all mailings and data entry. Four mailings were used: (1) a personalized invitation letter, survey, and self-addressed, stamped envelope sent to all potential participants; (2) a reminder postcard sent to all potential participants 1 week later; (3) a reminder letter, survey, and self-addressed, stamped envelope sent to those participants who had not yet responded 2 weeks after the reminder postcard; and (4) a second reminder postcard 1 week after the second survey mailing sent to those participants who had not yet responded. Received surveys were double-key entered and checked by hand when out-of-range responses occurred.

## RESULTS

### Discussions with Employers

Commitments to participate were obtained from 34 people; 28 were able to attend. Twenty-one employers participated in three discussion groups (manufacturing 10, consulting 5, and government agencies 6) in Set 1 (industrial hygienist on staff). Participants in the manufacturing group were from large national or multinational companies (1800 to 800,00 employees). The single Set 2 discussion group (no industrial hygienist on staff) consisted of seven employers from small (< 100 employees; 4 participants), medium (100–500 employees; 1 participant), and large industrial organizations (> 500 employees; 2 participants).

### Ranking Skills and Knowledge Areas

Most participants agreed that *communicating effectively with stakeholders* and *understanding how to assess exposures* were among the most important of the 29 skills (see Table I for the full list of skills).

In addition, participants from Set 1 listed as important skills *design and implement exposure assessment strategy* and *gather, manage, and analyze data*. Participants from the manufacturing and government sectors (Set 1) thought that *understanding, interpreting, and applying regulations* was important, whereas no one in the consulting group listed this as an important skill.

Those in consulting and government thought that *communication with health and safety professionals*; *describing physical and chemical hazards*; and *recommending, designing, and implementing controls* were important skills, whereas none in the manufacturing group listed these. Many participants in the consulting and government groups also listed *identify hazards of workplace processes* and *prioritize hazards, exposures, and controls* among their top-ranked skills. Understanding

workplace hazards and how to prioritize these hazards were also among the top-ranked skills of Set 2 participants.

Most participants from both sets thought that *designing and initiating research* was among the least important skills. Other low-ranked skills among all participants included *formulate and implement policies; calculate, interpret, and apply statistics; calculate, interpret, and apply epidemiologic principles and data; interpret and apply scientific findings; show awareness of diversity in social and cultural beliefs; and demonstrate familiarity with and apply code of ethics.*

Of the 27 knowledge areas (shown in Table II), *hazard recognition* was ranked among the top three by 70 to 80% of all participants. Other highly ranked knowledge areas included *exposure measurement principles and practice* and *personal protective equipment*.

In Set 1 (employers with an industrial hygienist on staff), knowledge of *health and safety regulations, toxicology, and ventilation principles and practice* were important to all participants. Almost everyone in the manufacturing group thought knowledge of *noise* and *environmental regulations* was important, whereas participants in the consulting and government groups did not list either of these. Consultants were the only Set 1 participants to list knowledge of *gases and vapors* and *industrial processes* as important knowledge areas. Those hiring safety professionals (Set 2) most frequently listed *industrial safety, ergonomics, and industrial processes* as important knowledge areas.

The least important knowledge areas for participants in both sets included *biological aerosols* and *outdoor air pollution control*. Many in the consulting sector (Set 1) listed *emergency planning and response* and *environmental regulations* among the least important knowledge areas. Other common unimportant knowledge areas for Set 1 participants included *temperature extremes* (government) and *epidemiology* (manufacturing). About half of the Set 2 participants also thought that *epidemiology* and *temperature extremes* were unimportant knowledge areas.

### ***Current and Future Needs for Health and Safety Professionals***

Questions about current and future needs prompted discussion in all groups about important economic and political changes in the United States that have led to changes in the work and employment of health and safety professionals. Participants described a number of important drivers, including globalization and international competition, litigation, regulations, and heightened employee concerns about exposures and outcomes. None of the participants indicated that the need for health and safety professionals was decreasing, and most agreed that need will continue and is likely to increase.

While hiring continues in all sectors, a large part of the need goes unfilled. Participants in the manufacturing group noted: "Our workload has probably increased 200% based on the number of projects we have . . . [but] the staff is pretty much the same;" and, "We can certainly use more [staff], but I don't think we're going to get them." One participant noted a recent trend

toward promoting technically competent individuals internally and providing them with additional training in health and safety.

Participants in the government sector noted that there would always be a need for industrial hygienists, as well as other health and safety professionals. In addition to economic pressures, they noted that there were problems with unrecognized needs: "There are a lot of industrial hygiene things to do and the need is there. Whether the . . . public sector recognizes that, I'm not quite sure."

Consultants also reported an ongoing need for health and safety professionals: "What we're doing is in demand, which indicates that . . . there is a marketplace out there and there is a need for more people." A few of the participants in this group were hiring, but most of these were looking for professionals with previous work experience and specific skills. Consultants noted that they fill an important need for specialized skills that most companies cannot afford: "I find that companies just don't have the time to do something specific and I can use my narrower expertise . . . to help satisfy some of their needs."

Manufacturing sector participants agreed that they were using more consultants, due to understaffing. They noted that consultants, in addition to performing specialized tasks, were often hired to free up internal staff by taking on recurring and less demanding tasks.

Discussions in the manufacturing and government groups focused on the best model for filling the need for health and safety expertise. In both groups, participants described a decentralized approach combining a small central staff and the use of internal or external consultants at local sites. A few participants worked for organizations that continue to employ the more traditional approach with a centralized staff and limited use of specialized, external consultants.

Participants in the manufacturing sector also talked about changes in expectations for health and safety brought on by the adoption of standards for best practice, accountability, and certification. Environmental regulations, increased security requirements in food and product safety, and globalization have led to greater demands for cross-functionality. Participants also talked about the pressure to be both generalists and specialists. Being a generalist was viewed as important by some: "There have been big cost cutbacks and people are wearing more hats, so health and safety staff have to become more generalists." Some also noted that while being a generalist is important for recognizing problems it can also limit one's ability to identify solutions ("Specialists solve a lot more problems."). Thus, generalists need to develop some specialized skills.

### ***Hiring Health and Safety Professionals***

When asked what they look for when hiring professionals, most participants in Set 1 preferred a master's degree, a background in science, and 3 to 5 years of work experience. Those in the government sector also preferred professional certification. Set 2 participants were more willing to hire individuals with a bachelor's degree in safety or industrial

hygiene. In addition to technical expertise, participants most frequently mentioned that new hires should have good business and problem-solving skills.

Business skills include the specific skills of teamwork, communication, and project management. As one participant noted, "I've had people right out of school who are amazed at what a small percentage of their job is truly technical. . . . They can be the best technical experts in the world but if they can't communicate and get people on their team and get something pushed forward, it doesn't mean anything."

Communication skills received a lot of attention in every discussion group. Written communication should be intelligible and presented in a clear, logical manner. Professionals need to know how to make recommendations and present them in a manner that will persuade managers to read and act on the information. "If you can't convey [your recommendations] to them in the first three or four sentences . . . I think you're out." Participants mentioned asking job applicants for writing samples in an effort to evaluate this skill.

Communication involves influence, negotiation, and persuasion with a broad range of audiences: "It takes charisma, it takes salesmanship." With employees it is important to be technically competent, persuasive, and able to listen. With production or facilities personnel, a willingness to "give a little" is important to bringing about workplace improvements. "I think it's a skill—persuading, convincing, selling, and communicating." "You need to be believed and trusted." One participant noted a requirement for a sample oral presentation as a means of evaluating job applicants.

Participants also talked about the need to understand the social and cultural context of their workplace. A number of participants noted a preference for hiring someone inexperienced who would be easier to train in the organization's customs rather than a more experienced person who may have to re-learn these customs.

Problem-solving requires a number of different aptitudes, including the abilities to take initiative, talk with a range of people, integrate information, and be creative in developing solutions. Communication skills are also important for problem-solving because people provide the information necessary for developing solutions. Several participants noted that problem-solving involved both "art and science." "You can teach anybody to run an instrument . . . You have to be able to talk to people and pull it all together, and that's the art of it. Once you know the science, then you add the art." Communication is also important because people must be persuaded to implement the solutions: "Problem-solving is being creative and balancing that with what can realistically be done."

When asked to discuss why *designing and initiating research* was listed among the least important skills, participants thought this skill applied to "research with a capital R," which involves testing a hypothesis or discovering a new disease. Many participants noted, however, that understanding research results and using research methods were important to their problem-solving skills: "Every time you gather air samples

and then figure out what you've done, you've done research after a fashion."

### *Methods for Hiring*

Participants in the manufacturing group (Set 1) described a number of methods for hiring health and safety professionals, including job boards on local and national professional websites and at national conferences, electronic listservs, newspaper advertisements, contacts at local university programs, general website job listings, their organization's website, and networking with colleagues. Most agreed that "word of mouth" was often the best method for identifying good job candidates: "It's really a small profession and small community. Word of mouth seems to be the most effective, especially because we're under a lot of pressure to find people who are going to be able to do it all."

Participants from government agencies described limitations in recruiting due to the cost of advertising and recruiting, as well as the lower pay scale compared to other sectors. They mentioned posting jobs on local and national professional websites, contacting university programs, and networking among colleagues as the most common methods. State-level jobs required application to a government website.

### *Internships*

Participants from the manufacturing and government sector were more likely than those from consulting to be positive about hiring students as interns in their organizations. Consultants noted problems with confidentiality of information, pressure to complete jobs with limited budget and time, time required for training, and lack of continuity due to the short-term nature of interns. Participants from government agencies noted problems with liability, particularly when conducting workplace inspections. Most of the latter had hired interns only for special, short-term research projects.

Participants described advantages of interns to include: (1) an opportunity to assess abilities before making a long-term hiring commitment and (2) useful for completing of short-term or uncomplicated projects. Disadvantages that prevent the hiring of interns in their organizations were: (1) no easy method for doing so, (2) too much time to train, and (3) lack of specialized skills.

### *Accreditation*

Manufacturing and consulting group participants in Set 1 thought that the reputation of an academic program was more important than accreditation. Accreditation mattered, however, if participants were not familiar with the program. Participants' track record with a program's graduates was also important; several mentioned hiring only graduates from one program. Most of the government sector participants were unaware of accreditation or indicated it was unimportant to their hiring decisions.

## Alumni Surveys

Of the 70 mailed surveys, 46 (66%) completed surveys were returned, 9 (13%) were returned undeliverable, and 15 (21%) did not respond. For respondents with a valid address, the response rate was 75%.

Twenty-four (52%) respondents were male; 39 listed race as White/Caucasian, 7 as Asian/Pacific Islander, and 1 as Hispanic/Latino/Chicano/Mexican (more than one response was possible).

Ten (22%) respondents listed a minor in hazardous substances in addition to their industrial hygiene major. Twenty-six respondents reported holding professional certification, with the majority in industrial hygiene (15) and safety (7). Immediately after graduation most were employed in corporate/industrial settings (18), government agencies (15), and consulting companies (8). At the time of survey, the most common employment settings were corporate/industrial (18) and government agencies (13). Only three reported working as consultants.

Seventy-two percent (33/46) reported familiarity with ABET accreditation. Of those responding (41), 90% (37) thought ABET accreditation was important or very important

for the industrial hygiene program and the same fraction thought accreditation should be continued. Of 40 responding, however, only 55% (22) indicated that ABET accreditation was important or very important to their decision to attend the program.

The most highly valued competencies (ranked as “very valuable” by more than 75% of respondents) were predominantly in the recognition and evaluation clusters (Figure 1):

- Identify hazards of work site processes (R2)
- Understand relationship between exposures and health outcomes (R3)
- Understand laws and regulations (R4)
- Identify hazards associated with sources and processes (R5)
- Describe physical, chemical and biological aspects of generation of hazards (R6)
- Gather, manage, and analyze data (E2)
- Interpret and apply scientific findings (E4)
- Assess aspects of exposure assessment, dose response, and risk characterization (E6)
- Understand basic principles of sampling and its use for evaluating exposures and controls (E9)

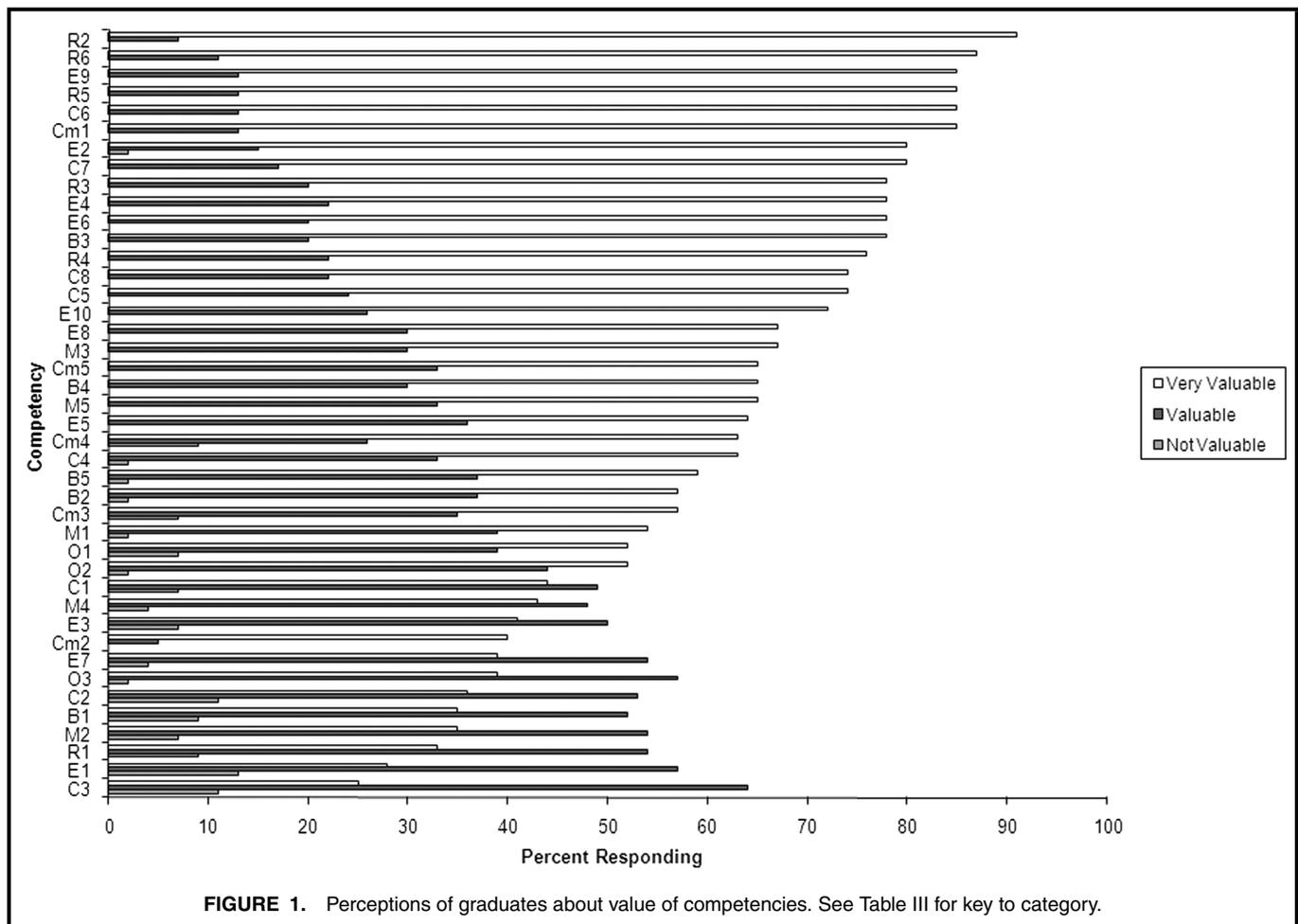


FIGURE 1. Perceptions of graduates about value of competencies. See Table III for key to category.

- Recommend, evaluate, and implement controls (C6)
- Select most appropriate control methods for given situation (C7)
- Communicate effectively with a variety of stakeholders (Cm1)
- Understand and apply relevant laws and regulations (B3).

The five least valued competencies (ranked as “not valuable” by more than 8% of respondents) were (Figure 1):

- Recognize influence of cultural and social factors (R1)
- Design and initiate research (E1)
- Design and implement screening programs (C2)
- Design and implement health promotion programs (C3)
- Manage financial resources effectively (M2).

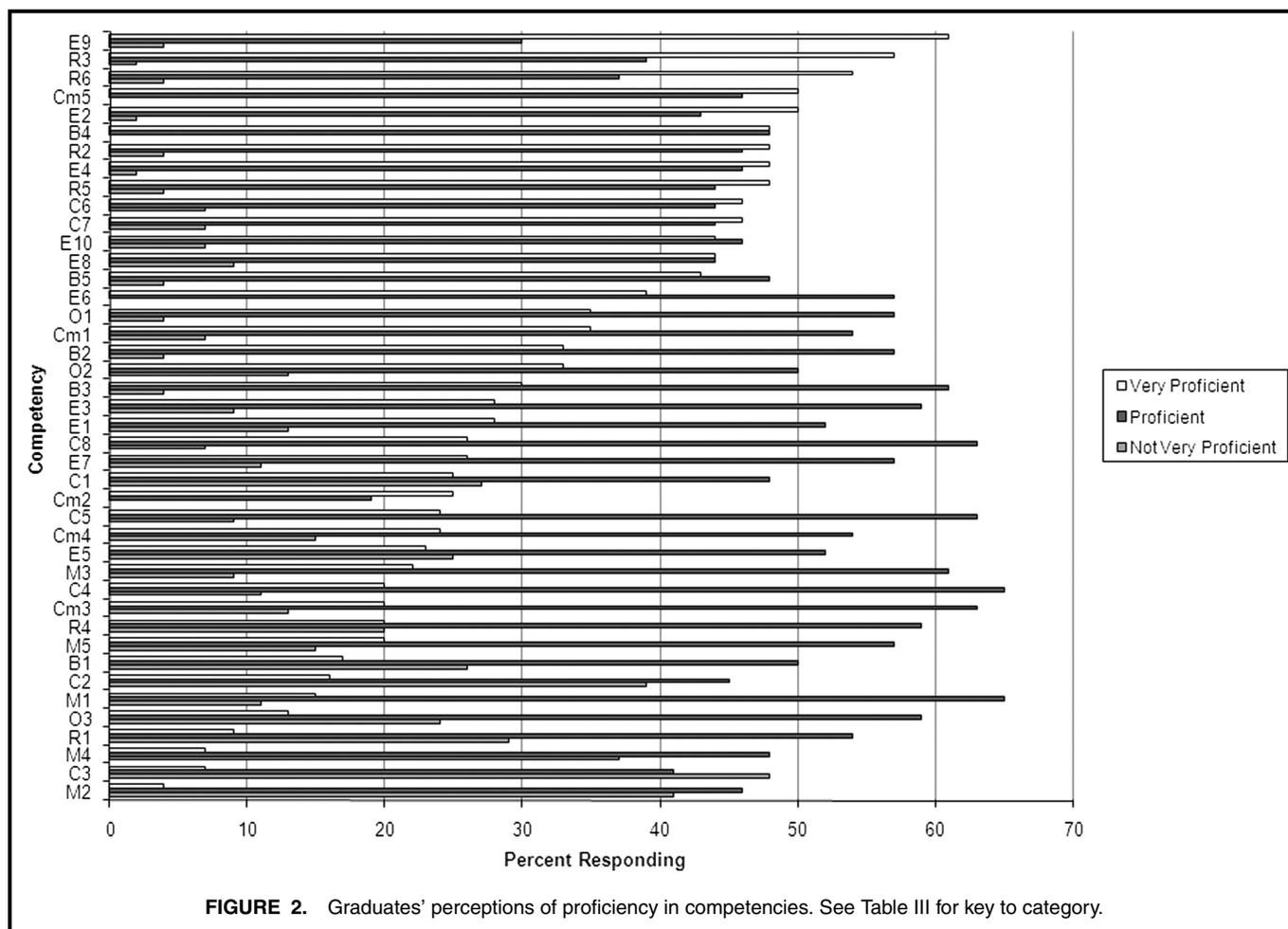
High levels of proficiency were reported by 50% or more of graduates in five competencies, again, found predominantly in the recognition and evaluation clusters (Figure 2):

- Understand relationship between exposures and health outcomes (R3)

- Describe physical, chemical, and biological aspects of hazard generation (R6)
- Gather, manage, and analyze data (E2)
- Understand basic principles of sampling and use for evaluating exposures and controls (E9)
- Communicate effectively with other safety and health professionals (Cm5).

There were eight highly valued competencies (mean  $\geq 2.5$ ) for which the mean value exceeded the mean proficiency by more than 0.5 (Table III):

- Know laws and regulations (R4)
- Measure and evaluate programs (E5)
- Design and implement changes in the work environment (C5)
- Validate effectiveness of selected control methods (C8)
- Develop and implement health and safety programs (M3)
- Manage staff and personnel effectively (M4)
- Display effective leadership (M5)
- Communicate effectively with variety of stakeholders (Cm1).



**TABLE III. Graduate Perceptions of Skills (Mean, Std Dev) (n = 45)**

Category	Skills	Value <sup>A</sup>	Proficiency <sup>A</sup>	Difference
Recognition				
R1	Recognize influence cultural and social factors	2.2 (0.6)	1.8 (0.6)	0.4
<b>R2</b>	<b>Identify hazards of worksite processes</b>	2.9 (0.2)	2.4 (0.6)	0.5
R3	Understand relationship between exposures and health outcomes	2.8 (0.4)	2.6 (0.5)	0.2
R4	Know laws and regulations	2.8 (0.4)	2.0 (0.6)	0.8
<b>R5</b>	<b>Identify hazards associated with specific sources and processes</b>	2.9 (0.3)	2.4 (0.6)	0.5
<b>R6</b>	<b>Describe physical, chemical, and biological aspects of the generation of hazards</b>	2.9 (0.3)	2.5 (0.6)	0.4
Evaluation				
E1	Design and initiate research	2.2 (0.6)	2.2 (0.6)	0
<b>E2</b>	<b>Gather, manage, and analyze data</b>	2.8 (0.4)	2.5 (0.6)	0.3
E3	Assess risks to population health	2.4 (0.6)	2.2 (0.6)	0.2
E4	Interpret and apply scientific findings	2.8 (0.4)	2.5 (0.5)	0.3
E5	Measure and evaluate programs	2.6 (0.5)	2.0 (0.7)	0.6
<b>E6</b>	<b>Assess aspects of exposure assessment, dose response, and risk characterization</b>	2.8 (0.4)	2.4 (0.5)	0.4
E7	Calculate, interpret, and apply statistical and epidemiological data	2.4 (0.6)	2.2 (0.6)	0.2
<b>E8</b>	<b>Design and implement an appropriate exposure assessment strategy</b>	2.7 (0.5)	2.4 (0.6)	0.3
E9	Understand basic principles of sampling and its use for evaluating exposures and controls	2.9 (0.3)	2.6 (0.6)	0.3
<b>E10</b>	<b>Prioritize hazards and exposures and the actions necessary for eliminating or controlling them</b>	2.7 (0.4)	2.4 (0.6)	0.3
Control				
C1	Design and implement surveillance systems	2.4 (0.6)	2.0 (0.7)	0.4
C2	Design and implement screening programs	2.2 (0.6)	1.8 (0.7)	0.4
C3	Design and implement health promotion programs	2.1 (0.6)	1.6 (0.6)	0.5
C4	Design and implement work process interventions	2.6 (0.5)	2.1 (0.6)	0.5
C5	Design and implement changes in the work environment	2.8 (0.4)	2.2 (0.6)	0.6
<b>C6</b>	<b>Recommend, evaluate and implement controls</b>	2.9 (0.3)	2.4 (0.6)	0.5
<b>C7</b>	<b>Select most appropriate control methods for given situation</b>	2.8 (0.4)	2.4 (0.6)	0.4
C8	Validate effectiveness of selected control methods	2.8 (0.4)	2.2 (0.6)	0.6
Communication				
<b>Cm1</b>	<b>Communicate effectively with a variety of stakeholders</b>	2.9 (0.3)	2.3 (0.6)	0.6
Cm2	Write well	2.9 (0.3)	2.6 (0.5)	0.3
Cm3	Interpret and disseminate policies	2.5 (0.6)	2.1 (0.6)	0.4
Cm4	Design and deliver adult education programs	2.6 (0.7)	2.1 (0.6)	0.5
<b>Cm5</b>	<b>Communicate effectively with other safety and health professionals</b>	2.7 (0.5)	2.5 (0.5)	0.2
Management				
M1	Formulate and implement guidelines and policies	2.5 (0.5)	2.0 (0.5)	0.5
M2	Manage financial resources effectively	2.3 (0.6)	1.6 (0.6)	0.6
M3	Develop and implement health and safety programs	2.7 (0.5)	2.1 (0.6)	0.6
M4	Manage staff and personnel resources effectively	2.5 (0.6)	1.7 (0.6)	0.8
M5	Display effective leadership	2.7 (0.5)	2.0 (0.6)	0.7

*(continued on next page)*

**TABLE III. Graduate Perceptions of Skills (Mean, Std Dev) (n = 45) (Continued)**

Category	Skills	Value <sup>A</sup>	Proficiency <sup>A</sup>	Difference
Behavior				
B1	Demonstrate awareness of diversity in social and cultural beliefs	2.3 (0.6)	1.9 (0.7)	0.4
B2	Identify ethical dilemmas and work in ethical manner	2.6 (0.5)	2.3 (0.6)	0.3
<b>B3</b>	<b>Understand and apply relevant laws and regulations</b>	2.8 (0.4)	2.3 (0.5)	0.5
B4	Function effectively on an interdisciplinary team	2.7 (0.5)	2.5 (0.5)	0.2
B5	Stay current in one's field of practice	2.6 (0.5)	2.4 (0.6)	0.2
Other				
O1	Familiarity with and able to use code of ethics	2.5 (0.6)	2.3 (0.6)	0.2
O2	Understand relationship of OH&S professionals with management and employees	2.5 (0.5)	2.2 (0.7)	0.3
O3	Manage hazardous materials and waste	2.4 (0.5)	1.9 (0.6)	0.5

Note: Skills shown in **bold** are those listed as valuable by employers (survey and discussion groups) and graduates (survey).

<sup>A</sup>Ranked on a 3-pt scale from 1 = not valuable or not very proficient to 3 = very valuable or very proficient.

## DISCUSSION

**T**welve skills listed among the top three by more than 20% of the participants in the employer discussion groups were also among those skills identified as essential or valuable by more than 50% of employers and graduates completing surveys (Figure 1; shown in **bold** in Table III). Ten of these skills fall within the areas of recognition, evaluation, and control (note that B3 should probably be considered an “evaluation” rather than “behavior” skill); the remaining two describe communication skills.

One additional evaluation skill (*understand basic principles of sampling and its use for evaluating exposures and control*, E9) was not listed among the top three by employers in the discussion groups but was identified as an essential or very valuable skill by more than 80% of respondents to both surveys. Ranking by mean, the top 10 more valuable skills identified by graduates shows that two additional skills from the recognition and communication clusters overlap with those identified as essential by more than 50% of employers: (1) *Write well* (Cm2), and (2) *Understand relationship between exposures and health outcomes* (R3).

While industrial hygienists need knowledge and skills in each of the six competency areas, these data suggest that competencies in the recognition and evaluation clusters are of paramount importance to their success. A survey of health and safety professionals in 48 countries supports this conclusion; more than 80% of respondents thought that industrial hygienists should have the following skills, most of which fall in the areas of recognition and evaluation:<sup>(6)</sup>

- Recognize harmful chemical, physical, and biological agents
- Identify hazardous work processes, products, and materials
- Conduct work site surveys

- Evaluate work practices to reduce or eliminate exposures
- Interpret sampling data
- Recommend control measures to reduce exposures
- Know occupational exposure limits
- Know health and safety regulations.

Writing well is also an important skill for employers of engineers, whose jobs may have similarities to those of industrial hygiene and safety professionals. In a review of ABET-accredited engineering programs, *communicating effectively* was ranked by employers as a highly important or essential learning outcome by 91% of respondents, followed closely by *engineering problem solving* (86% of respondents).<sup>(7)</sup> The importance of good communication skills was a common topic in all four discussion groups. Participants noted the importance of both written and oral communication in every phase of their work involving the recognition, evaluation, and control of workplace hazards. Without effective communication skills, health and safety professionals may be hampered in their ability to obtain information, sell their recommendations, persuade people to make changes, describe likely outcomes of exposure, make scientific or technical data understandable to nonscientists, and be succinct in presenting information and recommendations to a variety of audiences.

Participants also addressed the importance of organizational skills for developing effective written reports and oral presentations, managing projects, and working in teams, which were the key “business skills” expected of health and safety professionals.

There were no outstanding differences in the highly and least valued skills between the two sets of employers (those hiring industrial hygienists vs. those hiring other health and safety professionals). The biggest difference between the two sets was in the importance the latter group placed on knowledge of industrial safety and ergonomics vs. the importance

of toxicology and ventilation principles and practice in the former.

Accreditation of industrial hygiene programs has been a somewhat controversial subject, and some graduate programs have decided not to pursue this option. Survey and discussion group results also demonstrate a discordance in opinions about the value of accreditation. While graduates strongly supported ongoing accreditation, most did not apply or attend on the basis of accreditation. Employers also were mixed in their opinions, noting that accreditation was important more in principle than in practice.

Qualitative research does not seek to control but rather to observe and report perceptions of the target audience. Using systematic procedures for data collection and analysis ensures that results are dependable because they accurately reflect participants' opinions. These research results cannot necessarily be used to generalize to all industrial hygiene graduate programs. Other programs may have different goals for graduates and may differ in the types of employment sought by graduates. Some of the specific findings described here may be relevant only to this geographic area. It will be up to readers to determine the transferability of these results to their own circumstances.

This work illustrates the value of conducting both surveys and discussion groups, as each yields a different type of information. Regular surveys of graduates' and employers' opinions about educational outcomes allow for longitudinal comparisons and ensure that curricula remain responsive to employers' expectations. Discussion groups can delve more deeply into the reasons underlying participants' opinions and may lead to new or different perspectives. Results from discussion groups also ensure that surveys continue to assess things that are meaningful.

An effort was made to gain a broad picture of employers in the geographic area where the majority of graduating industrial hygiene students take jobs. The mix of economic sectors in the three discussion groups in Set 1 (manufacturing, consulting and government agencies) reflects the range of graduate employment locations. Again, transferability will depend on another program's similarity in employment across these sectors.

The results from Set 2 are offered only as preliminary comparison to those of Set 1 because the former consisted of only one discussion group. Set 2 was included as a pilot

effort to explore differences between employers' expectations of industrial hygiene and safety professionals, and its results should not be used to generalize about competencies or employment of safety professionals.

These assessments indicate that industrial hygienists continue to be a necessary part of doing business in the United States in both the private and public sectors. There appears to be no lessening of the need for industrial hygienists' knowledge and skills, although there are important economic, political, and social drivers that continue to affect how and where they work. While their primary skills reside in the areas of recognition and evaluation with a principal focus on airborne exposures, they are also expected to have excellent communication skills. In all sectors, there is pressure for knowledge and skills in related areas, such as safety and the environment, although there is concern that industrial hygienists may be sacrificing their ability to solve problems in the quest for breadth vs. depth of understanding.

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