the American Society of Safety Engineers
vol. 1, num 1
Spring 2004
THE JOURNAL OF SH&E RESEARCH

Feature Article One:

Safety Educators and Practitioners Identify the Competencies of an Occupational Safety and Environmental Health Doctoral Degree: An On Line Application of the Delphi Technique

By William DeLeo

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Safety Educators and Practitioners Identify the Competencies of an Occupational Safety and Environmental Health Doctoral Degree: An On Line Application of the Delphi Technique

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Abstract

Both conventional wisdom and a review of the literature reveal an ever-increasing need to produce safety, health and environmental (SHE) educators and SHE practitioners in this country in order to meet the challenges confronting the SHE profession in the 21st century.

Traditionally, as there have not been formal SHE doctoral programs, SHE educators derive from a variety of "related" professions, such as engineering, health education, psychology and management. Thus, interest, professional experience and doctoral training in a "SHE related field" has combined to produce the typical SHE academic. Whether to increase the number of SHE doctoral programs, and how best they may be delivered (e.g., traditional format or distance education) remain empirical questions. A four (4) round on line Delphi study addresses the question of what the curriculum of a SHE doctoral program might look like were one to be developed. This research was undertaken with the urging and encouragement of many professionals in the field who asked that it be done for the purpose of helping the Professional Education Standards Committee (PESC) of the American Society of Safety Engineers (ASSE) ascertain the competencies that would be achieved by doctoral students of an accredited SHE program. As the ASSE states on its web site, "In setting the standard, as members of the Accreditation Board for Engineering and Technology (ABET), the ASSE encourages the in-corporation of safety principles and courses into engineering program curricula nationwide and establishes curriculum standards for associate, baccalaureate, and master's degree programs" (www.asse.org). However, in order to establish the curriculum standards for a SHE doctoral program, the competencies for that program must first be established.

Introduction

Professionals in the field need to develop curricula leading to SHE doctoral degrees. The same professionals need to identify the outcomes, skills, and competencies that these programs will develop (Institute of Medicine, 1998). An email to this researcher from Dr. Paul D. Specht, CSP, PESC Chair Elect of ASSE and Related Accreditation Commission of the Accreditation Board for Engineering and Technology (ABET), expressed his support of the need for this study and urged this researcher to use the Master's Level Exit Outcomes and Competencies as a starting point, or baseline, for beginning the study. He states:

> I was very pleased to hear about your doctoral research topic. To the best of my knowledge, there is very little information on the competencies of graduates in safety doctoral programs. However, the Accreditation Board for Engineering and Technology (ABET) has identified competencies for Master's level graduates. I would strongly urge you to use those competencies as a starting point. The American Society of Safety Engineers (ASSE), the largest organization of safety professionals in the world, has designated ABET as the only body it recognizes for the accreditation of programs leading to Baccalaureate and Masters Degrees in Safety. ABET, with oversight from ASSE's Professional and Educational Standards Committee (PESC), sets the standards for safety degrees. In its Criteria for Accrediting Engineering-Related Programs 1999, ABET presents very clear outcomes-based criteria. These criteria should serve as a foundation for a doctoral program 's entrance requirements. (*Letters and Email from Safety Educators and Practitioners*, P.D. Specht, October 16, 2000).

The Master's in Safety exit outcomes/competencies were used as a baseline reference for the Experts' review in this study prior to their identifying the competencies for a doctoral program in Round 1 of the Four Round Delphi study. These same ABET outcomes would also be used between Rounds 2 and 3 by the Review Panel to "place" the highest rated competencies from Round 2 into ABET outcome categories as well before Ranking them in Round 3. A brief review of the history of the Delphi Technique will highlight the rationale for its use in this study.

The Delphi Technique was created by Olaf Helmer and Norman Dalkey in 1953, at the RAND corporation to address a future military issue and it became popular when applied a decade later to large scale technological forecasting and corporate planning (Helmer 1983). This was the first use of the Delphi process as a fundamental tool for forecasting technological areas for many technology-based corporations. Once it had been used successfully in forecasting, science and operations research areas, other areas like *environment health*, and transportation also used the evaluation model of the Delphi process to deal with subjective information (Sackman,1975). Thus began the use of Delphi process, or technique, as a way of using the consensus of experts to find information or solutions to problems.

Essentially, Delphi is the name given to a set of procedures for eliciting and refining the opinions of a group - usually a panel of experts (Dalkey 1967, Brown 1968). [NOTE: In this study , the Expert Panel consisted of Safety

Educators and Practitioners]. It is a way whereby a consensus and position of a group of experts is reached after eliciting their opinions on a defined issue, and it relies on the informed and intuitive opinions of specialists. This collective judgment of experts, although made up of subjective opinions, is considered to be more reliable than individual statements and is thus more objective in its outcomes (Helmer, 1983). Delphi, then, could be characterized as a method for structuring a group communication process so that the process is effective in allowing a group of individuals to deal with a complex problem (Linstone and Turoff , 1975). Volk, 1993, cited the following general steps of the Delphi technique that can be used in the curriculum development process [NOTE: *researcher's commentary italicized for clarity]:*

1. Group members, whose opinions are sought, are identified. These members, who are usually experts in the research topic(s), become the Delphi Expert Panelists [*Safety Educators and Practitioners in this study*].
2. A questionnaire is sent asking each panel member to generate a list of goals or issues [*Competencies of a SHE doctoral program*] towards which a consensus of opinions is sought. The list may also be generated by the researcher to expedite the process [*The list of Experts' perceived competencies was generated in Round 1*].
3. When the list is prepared, a second questionnaire is sent [*Posted on secure web site*] for each panel member to rank order the items [*Competencies Rated on Likert Scale from Very Important to Not Required in Round 2*].
4. The results of the second questionnaire are then presented in a third questionnaire. This questionnaire shows the preliminary level of group consensus (Mean) along with each member's earlier response [*Highest Rated competencies are grouped into ABET Categories of Masters in Safety outcomes per Dr. Paul Specht letter*]
5. Each Expert panel member ranks each item again [*Highest Rated competencies emerging from Round 2 are Ranked again in Round 3*] and, if desired, provides a brief explanation for any differing opinions.
6. The results are tabulated and presented in a final statement [*Round 4*] representing group consensus [*of the highest ranked competencies emerging from Round 3*].

Many competencies must be integrated to produce a new curriculum; no one person would possess all the expertise required, so experts from the field of education are needed to input data for the curriculum design decision makers according to Lewy, 1977. This Delphi study used

Safety Educators and Practitioners as the Panel of Experts (Experts) from the field of Occupational Safety and Health.

Method

This was a 4 round Delphi study done completely over the Internet. The data was gathered from questionnaires posted on a secure server and accessed only by the Expert Panel and the researcher. The procedures involved to identify the competencies of a SHE doctoral program were as follows:

1. Qualifying Experts
2. Round 1: Developing the List of Competencies
3. Filtering the List of Round 1 Competencies
4. Round 2: Rating the Competencies for Preliminary Consensus
5. Grouping Round 2 Competencies into 3 General Categories
6. Round 3: Ranking the Competencies
7. Round 4: Analyzing Consensus
8. Summarizing Findings

The results from each round were placed into an Excel spreadsheet and evaluated by the researcher and confirmed by the Review Panel.

Qualifying Experts

Qualifying potential expert respondents and data gathering for each round was accomplished using a secure Internet web site instead of mailing survey questionnaires. The first step in the Delphi was to identify the experts whose opinions were being sought and confirm their availability and qualifications to participate in this study. In addition, a Review Panel (Reviewers) consisting of a trio of East Carolina University professionals – an Industrial Technology Associate Professor, a Bio-Statistician Professor, and a Safety Manager - was selected to review and confirm results from each round. Each of the potential Expert members was contacted by telephone and/or email and invited to participate. Of the 30 members

recommended by the ASSE for the expert panel, 16 were both available and qualified to participate in the study. Their qualifications were confirmed by each member having submitted an on-line questionnaire to the researcher via an email attachment. The 10 Educators and 6 practitioners qualified as Expert panelists had over 460 years of practical, consulting, training and/or teaching experience. In addition, the 2 groups of educators and practitioners had authored over 500 books, articles, and training tapes.

Round 1: Developing the List of Competencies

After confirming the Experts' qualifications and availability to participate in the study, Round 1 - requesting their submittal of perceived competencies - was posted on the researcher's secure web site. In two weeks, each member of the two Groups, Safety Educators and Practitioners (Experts), submitted a total of 131 competencies. The Review Panel screened the list for any duplication and paired the list of competencies down to 58 competencies for Rating in Round 2. See Appendix 1 for a listing of the 58 initial competencies.

Round 2: Rating the Competencies for Preliminary Consensus

This list was again posted on the researcher's secure web site and pilot-tested by the Reviewers for any technical glitches and clarity of content. The Experts were then asked to rate each of the 58 competencies in Round 2 on the Likert Scale as follows: Most Important (4), Important (3), Not Important (2), Not Required (1) After 2 weeks, the results indicated the list of the 58 competencies posted in Round 2 was now down to the 30 rated highest by the Experts.

Grouping Round 2 Competencies into 3 General Categories

The Reviewers then "placed" these 30 competencies into 3 generic categories consisting of the exit outcomes of a Master's in Safety program according to ABET on the basis of relevance

to the outcomes in that generic category. This was done for simplicity and clarity in ranking them during the next round. The ABET Master's program exit outcomes were categorized as follows:

Category I:

1. An ability to function on multi-disciplinary teams
2. An understanding of ethical and professional responsibilities
3. Knowledge of contemporary issues within a global and societal context

Category II:

4. An ability to apply mathematics and science
5. An ability to analyze and interpret data

Category III:

6. An ability to anticipate, identify, and evaluate hazardous conditions and practices
7. An ability to develop hazard control designs, methods, procedures and programs

Of the 30 highest rated competencies being passed to Round 3, the Reviewers determined that 10 should be placed into Category I, 11 into Category II, and 9 into Category III. Each competency was grouped into a category according to it's ABET outcome similarity. By placing these competencies within the general categories of outcomes described above, the Experts could rank each competency within that general category from 1 to 10, 1 to 11, and 1 to 9, respectively with 1 being the Most Important and 9, 10, 11, respectively, being the Least Important. (See Appendix 2).

Round 3: Ranking the Competencies

After the Reviewers pilot-tested the site for clarity of direction and functionality, an email was sent to the Experts with a link to Round 3 and asked to Rank order the competencies. The results from Rank ordering them within each ABET category above meant that the highest ranked competencies were the ones that had a median less than 5.5 for Category I, less than 6.0 for Category II, and less than 5.0 for Category III, respectively (See Appendix 2). To further quantify consensus after completing Rounds 2 and 3, a Spearman's rank correlation was computed for each category of competencies (Runyon, 1997). For each of the 10) competencies in Category 1, an ordered pair of means, consisting of the mean rating from Round 2 and the mean ranking from Round 3, was obtained. However, prior to calculating the mean ranking from Round 3, the experts' rankings were transformed by the formula, "new ranking = 11 – old ranking". This was required so that higher scores (higher scores in Round 2 were kept as compared to lower scores kept in Round 3) would reflect a more favorable view of the competency in both the Round 2 ratings and the Round 3 rankings. From the 10 ordered pairs calculated in this way, a Spearman rank correlation was calculated to reflect the degree of consensus between Round 2 ratings and Round 3 rankings for the competencies in Category 1. This entire procedure was repeated for the 11 competencies in Category 2 and also for the 9 competencies in Category 3. The Spearman rank correlation coefficient provided a measure of the extent to which consensus was being achieved from Round 2 to Round 3 – a high correlation reflected a high degree of consensus (Volk, 1993).

Round 4: Analyzing Consensus and Summarizing Findings

After the Reviewers confirmed the results from Round 3, the web page for Round 4 was prepared and sent to them for critiquing. The goal was to present the highest ranked competencies in each of the Categories in Round 3 (those with mean ranks of less than 5.5 in Category I, less than 6.0 in Category II, and less than 5.0 in Category III) to affirm the Expert panel's collective decision in reaching consensus thus far. The Experts were then notified by email with a link to the site and directed to *Accept* or *Reject* each of the competencies presented (See Appendix 3). The null hypothesis in this instance was that the accept/reject responses from the Experts would be equi-probable and, if this were the case, then consensus was not attained. For each of the 15 Round 4 competencies, the number of

Accept and *Reject* responses was tabulated and the binomial test, or sign test, and the Chi-square were used to determine whether or not consensus had actually been achieved at the end of the study (Volk, 1993).

The null hypothesis for the binomial test is that the "accept" and "reject" responses are equi-probable, and the one-sided research hypothesis is that the "accept" response is more probable than the "reject" response. Failure to reject this null hypothesis would be consistent with no consensus among the experts, whereas rejecting the null would support the research hypothesis that a consensus among the Experts for the competencies of a SHE program had indeed been reached. The results indicated that the null hypothesis was indeed rejected, thereby affirming that consensus for the doctoral level competencies had been achieved. A p-value of .05 was used to determine whether a consensus had been reached on each competency. Those competencies with a p-value of .05 or less (all 15 of them) were kept in the final listing of validated information reflecting consensus. The final form was established for the listing of doctoral level competencies of a SHE PhD program and a final copy was emailed to each member of both the Expert and Review Panels. The final results were also posted on the researcher's web site and all Experts were notified by email of their availability for viewing.

Results

The primary the results of the on line Delphi study are found in Table I below.

Table I: Round 4 Final Competencies Ordered Highest to Lowest by % Accepted*

Competency	% agreemnt
Ability to effectively utilize the Safety Sciences Literature	100%
An ability to critically evaluate existing research literature in OS&H, and identify gaps in that Literature	100%
Development, Implementation, Management and Evaluation of Safety and Health Programs	100%
Evaluation of safety and health program performance and design of performance measures	100%
Ability to develop hazard control methods, procedures and programs to include integration of safety performance into the goals, operations, and productivity of organizations and their management	100%
Ability to estimate the economic impact of safety issues and practices on a firm's economic performance (Cost Modeling)	100%
Demonstrated in-depth knowledge of safety, health and environmental issues.	93%
Ability to stay current with the changing safety challenges in the workplace	93%
An ability to review, compile, analyze and interpret data from accident and loss event reports and other sources regarding injuries, illnesses, property damage, environmental effects or public impacts in order to identify causes, trends and relationships	93%
An ability to understand and articulate what is an appropriate safety and health management system for an organization in an industry with a specific culture at a certain point on the life cycle of a business	93%
Demonstrated in-depth knowledge of safety, health and environmental issues.	93%
Ability to design a meaningful occupational safety research project. This would include the identification of relevant research hypotheses, study factors and their levels, variables one should attempt to control for, and appropriate outcome measures.	86%
Ability to conduct a meaningful occupational safety research project, once the project has been designed. This would include identification of appropriate sources of data, a protocol for collecting the data, and the compilation of the study data into an appropriate database for analysis	86%
An in-depth understanding of all aspects of Risk Assessment, Communications and Management.	86%
A comprehension of major differing approaches to the safety profession including an understanding of how safety fits into appropriate institutional frameworks such as education, industry, government, and the military (Philosophy of Safety).	79%

* 100% = All experts (Educators & Practitioners combined) agreed.

Recommendations:

At the beginning of this study, the researcher had a number of telephone interviews with safety professionals in and out of academia from around the country. The purpose was to determine the need for this study as well as get a sense of what universities, if any, had any doctoral Safety programs. Personal contact with a number of these professionals was enlightening and even provocative. Conventional wisdom throughout the profession [and the researcher's review of the literature] says that although much has been written about safety in general in the last century, there's never been a historical study done on Occupational Safety. A study done on this subject at this time would establish a baseline from which future researchers could begin inquiry into the myriad of subject matter facing the OSEH profession in the 21st century.

In addition, these same educators and practitioners in this study were unanimous about the need for a Doctoral Degree in Occupational Safety and Environmental Health. Their claim that technology had changed the workplace and will continue to do so is undeniable. A study on the impact technology has had on the profession and/or the SHE professional, can help refine the competencies identified in this study and lead to newer ones in the future. By understanding this impact, land grant and/or co-op universities offering SHE doctoral degrees can continue to better meet the needs of the society in which they serve by changing the curriculum as the technology changes. The use of technology to gather data from experts in the field in a timely manner ought to translate into not only a more responsive curriculum design for doctoral programs, but also a more cost effective delivery mechanism for the universities as well. Given that, the SHE Doctoral Degree will continue to be a valuable and critical asset in the workplace. If the technology can be used to gather timely information about the ever-changing workplace, so too must researchers and university curriculum designers be mindful of appropriate opportunities to modify the competencies identified here while a consortium of universities are sharing in the costs. The concept of safety changing as the workplace changes is a given, especially since Sept 11, 2003. New training programs and techniques must be designed to meet the needs and challenges of the 21st century workplace. One of the resultant competencies exiting the final round of this study was, *An ability to stay current with the changing safety challenges in the workplace.*

What are the safety challenges in the 21st century workplace? How will the Occupational Safety profession and academia [those soon to be offering SHE doctoral degrees] respond to them? Isn't a historical review of Safety Education in the United States, with input from men like Walter, Hawkins, Grimaldi, Elkow, Mills, and Konzen in order at this time to create a foundation upon which the profession can meet the needs of the 21st century workplace? How can Technology Education better serve the profession in meeting the needs of the 21st century workplace? What impact can technology have in gathering information for both educators and practitioners to make the work place safer? Does the will exist to create on line Doctoral programs in Safety and Environmental Health among a consortium of universities sharing the technology, risks and costs or can public/private partnerships undertake such programs more effectively? How many doctoral programs and how soon can they be created utilizing existing technology and cost and risk sharing? Doesn't current technology as an on line delivery mechanism make the cost/benefit rationale very attractive for a consortium of universities as well as the working safety professionals? With technology, a SHE doctoral program at a consortium of universities doesn't need to develop critical mass first to justify a few students being enrolled around the country! These are but a few of the questions facing the profession that beg answers sooner rather than later. The first step to developing a SHE PhD program curriculum, has been accomplished in this study - the next step is designing the content that will generate these competencies…*yesterday!*

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Helpful Links

1. **Accreditation Board for Engineering and Technology. http://www.abet.org/accredited_programs/**
2. **American Society of Safety Engineers. http://www.asse.org/**
3. **Web/Internet Surveys. http://www.surveysystem.com/websurveys.htm page 33.**