EDUCATIONAL AND SKILL NEEDS OF NEW HUMAN FACTORS/ERGONOMICS PROFESSIONALS

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The Human Factors and Ergonomics Society's Education and Training Committee and the Early Career Committee identified the need to evaluate the effectiveness of graduate education in the field of human factors/ergonomics and identify areas requiring improvement. Consequently, a survey was constructed for this purpose. Fifty-two new professionals responded to the survey. While most of these individuals come from the traditional fields of psychology and engineering, many represented multiple disciplines including architecture, safety, IT, and kinesiology. New professionals made heavy use of online non-refereed sources as well as professional websites. While no particular topic in their college experience was deemed superfluous, they indicated a need for design experiences, exposure to the processes used in the "hard " engineering disciplines, how to communicate as a member of an interdisciplinary team. The most common academic areas that the respondents wished had been addressed in greater depth during their educational experience were research methods and statistics, application of knowledge learned, and various aspects of design. The survey also validated the Ergonomist Formation Model of the Board of Certification in Professional Ergonomics (BCPE).

INTRODUCTION

The Human Factors and Ergonomics Society (HFES) has a long history of involvement in the career development of its members. The HFES has established a year-round Career Center and it encourages career related publications in technical group newsletters, the HFES Bulletin, and the "Ergonomics in Design" journal. The Education Technical Group has encouraged presentations and panels on career development topics at the Society's annual meetings.

During the 1990s and early 2000s the HFES provided a paper-based guidebook related to career development. This resource guide was updated by Ron Shapiro in 2009, and is available in the Information for Students section on the HFES web site, under "Preparing for a Career in Human Factors/Ergonomics" (Shapiro, 2009). This online compilation has four sections, (1) articles by participants in a number of career related panels held during HFES annual meetings, (2) analyses of job postings at the Career Center, (3) reprints of career-related articles published by HFES, and (4) links to other HFES career related resources.

There have also been several surveys done under the auspices of the society. In 2004, Cooke and Gorman reported on a survey to identify the educational training needs of HFES members. The respondents were divided into three groups: academics, practitioners, and students. As would be expected, each group identified different needs. Students focused on job openings, career issues, and internships. Academics emphasized the need for student internships and improved facilities to attract undergraduates to the human factors/ergonomics (HF/E) discipline. Practitioners focused on the need for more specialists with practical HF/E experience, more practitioner training, and websites on specific topics; they also identified the need for a variety of education forums to allow members to remain current in different technical areas. Part of the Society's response to that request has been the development of a series of webinars.

A follow-up survey by Stone and Derby (2009) was done to determine if our member's needs had changed since 2004 and if their needs were being met by various HFES Education and Training Committee activities. The results showed that the training and education needs had indeed changed somewhat since the previous survey, but were still focused on cognition, display design, graphic user interfaces, signage, and human computer interaction. Like Cook and Gorman (2004), Stone and Derby determined that the perceived needs for educational training vary across the student, academic, and practitioner groups.

All society members were invited to participate in the 2004 and 2009 surveys. However, in 2010, the Education and Training Committee and the Early Career Committee identified the need to support individuals who had recently entered the human factors/ergonomics workforce. Consequently, a new survey was constructed to evaluate the effectiveness of graduate education in the field of HF/E and to identify areas requiring improvement, aimed directly at this demographic. We also included the revised ergonomist formation model (EFM; BCPE, 2009) in our survey

METHOD

Participants.

Members of the HFES who had completed their graduate degree between 2005 and 2010 were identified as potential respondents. They were distributed among three classes of membership, transitional associates, associates, and full members. Transitional associates (N=42) are students who have completed their academic requirements, and have less than two years of work experience. Associate members (N=48) are individuals who have at least two years of full-time, relevant experience and are active in the HF/E field. Full members (N=117) are individuals who have a master's degree from a regionally accredited university and five full-time years of applicable experience in human factors work. Appropriate academic degrees beyond the bachelor's degree may be substituted in part for work experience up to a total of four years. In addition, the survey was sent to five recent graduates from the Applied Experimental and Engineering Psychology MS program at Rochester Institute of Technology (RIT) who were employed as human factors professionals in different industries.

The Survey

Participants were surveyed about the knowledge and skills that they felt they needed (whether or not they had them) or would have been valuable to have when they first started in their new position. The survey had three distinct sections: (1) questions about participants and their education, (2) questions about their job experience, and (3) reflections about their job requirements relative to their education and skills. The last section specifically asked whether the objectives and points of reference of the revised EFM (BCPE, 2009) were relevant to the participants' jobs and how well their education had prepared them for the EFM competencies.

The survey consisted of a total of 38 questions. The question formats were a mix of multiple choice, short (one or two words) answers, Likert scale, and long answer open-ended questions. Responses were anonymous, but respondents completing the survey had the opportunity to enter their name into a drawing to receive a waiver of either annual HFES dues or an annual meeting registration via a separate email link to the HFES.

The survey was constructed with an online survey tool called "Clipboard" developed and hosted at RIT. Clipboard offers much flexibility in question and answer formats and recording and analyzing the responses. Potential respondents were emailed an invitation letter and a link to the survey, which had to be completed once it was started because there was no option to return to a partially completed survey.

Procedure

A draft survey with the characteristics described above was developed and, after two pilot studies, revised. The first pilot study was completed by respondents knowledgeable in this area; the second pilot study was completed by individuals randomly drawn from the sample of potential respondents. Altogether the survey went through 9 iterations before it was ready to be administered.

A preannouncement advising potential respondents about the intent of the survey and that they would shortly receive an e-mail with a web link to the survey. An e-mail with the web link to the survey was distributed two days later. Seven days later this was followed up with reminder to complete the survey. Seven days after that a "last chance to participate" e-mail was sent to non-respondents. The incentive was mentioned in all e-mailings, and all of the emails were signed by the current president of the HFES.

The survey results were analyzed depending on the question type. Multiple-choice questions were analyzed by a simple count while the numerical values of the likert-scale questions were averaged. Open-ended questions were analyzed by tallying similar reponses.

RESULTS

A total of 52 new professionals responded to the survey between January 20 and February 11, 2011. This represents a response rate of 25%. Due to the admittedly small sample, the results are not broken down by the respondents' membership status.

Demographics

The majority (86.79%) of our respondents were HF/E practitioners, with only 13.21% working in the academia; 8% had a BS degree, 45% had a MS or MA degree, and 47% had a Ph.D. (one respondent was ABD). All respondents had earned their highest degree since 2005, satisfying our criteria for new professionals.

The educational backgrounds of the respondents were very diverse. A rough classification into four main categories showed that 34% of respondents had earned their degree from psychology programs, 28% in engineering, 18% in science-related programs, and 20% in other programs. A little under 58% of the respondents had done an internship as a part of their college experience. However the majority of those who did have an internship reported that it was an essential part of their professional development.

All respondents also worked in HF/E related positions, with about half having "human factors" or "ergonomics" in their position title. Otherwise, the respondents' specific work domains and tasks were too diverse to allow for meaningful classification. Two major industry categories were defense (18%) and aviation/aerospace (16%), with rest of the respondents distributed among about 20 other specific industries or academic disciplines. See Table 1 for general fields of employment of our respondents.

Table 1
Areas of Employment of Survey Respondents.

Area of Employment	N	%
Practitioner, industry employee	18	34.62
Practitioner, contractor employee	8	15.38
Academia, research-oriented college or university	6	11.54
Practitioner, government employee	6	11.54
Practitioner, consultant to industry	6	11.54
Practitioner, consultant to the government	3	5.77
Other Responses	3	5.77
Academia, teaching-oriented college or university	1	1.92
Practitioner, private consultant	1	1.92

All respondents with a BS or MA or MS degrees worked as practitioners. Of the respondents with Ph.D. degree (N=25) only seven or 28% worked in the academia, the rest were practitioners. This means that also doctoral programs that are traditionally more theoretically oriented than Master's programs should not ignore applied research skills needed "in the wild" or outside a laboratory.

Relevance of Education

The participants were asked how frequently they use the skills and knowledge they had learned in college in their present jobs. The response alternatives and their corresponding numerical values (in parentheses), were daily (7), 2-3 times per week (6), once a week (5), 2-3 times per month (4), once a month (3), 2-6 times per year (2), and less than 2 times per year (1).

Table 2
*Mean Frequency of Use of Specific Skills in the Respondents' Current Jobs**

Skills/Knowledge	Freq.
Writing skills	6.16
Apply knowledge	5.84
Presentation skills	4.96
Literature research skills	4.88
Data analysis skills	4.31
Experimental design skills	4.12
Computer programming skills	2.96

*Ranging from max. 7 (Daily) to 1 (Less Than 2 Times/Year)

As can be seen in Table 2, with the exception of computer programming, all common skills and knowledge that are typically part of college curricula were highly relevant to our respondents' present jobs. Most skills were required on a weekly basis (> 4, or more than 2-3 times per month).

Table 3
*Mean Frequency of Use of Specific HF/E Resources in the Respondents' Current Jobs**

Resource	Freq.
Journal articles	4.38
Non-professional web resources	4.00
Online non-refereed sources	3.58
Professional websites	3.46
HF/E standards	3.44
HF/E textbooks	3.22
HF/E handbooks	3.06
Online social networks	2.98

*Ranging from max. 7 (Daily) to 1 (Less Than 2 Times/Year)

The survey also asked about the frequency the respondents accessed HF/E related resources to which they were introduced in college. Journal articles were the most often used resource, but non-professional web resources (e.g., Wikipedia) and non-refereed online sources (e.g., discussion forums, listservs, Google Groups) were also frequently utilized. On the other hand, HF/E handbooks were used only monthly, on the average, but that may simply indicate that the respondents knew the materials in these resources well enough to not need them as reference very frequently (Table 3).

Ergonomist Formation Model (EFM)

Results from the third part of the survey were analyzed by calculating the average rating for each of the EFM subdomains. The stem for these questions was "Please indicate how well your college education prepared you to meet the job requirements in the area of…" followed by a detailed description of the subdomain. The numerical values corresponding to the total of 7 response alternatives were 0-not applicable to my current position, 1-not at all, 2-very poorly, 3-inadequately, 4-adequately, 5-very well, and 6-extremely well. In addition, the relevance of the EFM subdomain was assessed by the percentage of respondents who indicated that the subdomain was applicable to their current position (that is, who did not choose the 0 alternative). See Table 4 for results.

Table 4.
*Mean Ratings of How Well the Respondents' College Education Prepared Them to Meet Their Job Requirements in the Revised EFM Subdomains, and the Relevance of the Subdomain in the Respondents' Current Jobs**

EFM Subdomain	M	%Rel
Physiology and Biomechanics (B.1.2.)	3.71	76
Basic Design Methods (C.3.)	3.74	92
Human–Env. Interaction Methods (D.2.1.)	3.76	76
Human–Env. Interaction Content (D.2.2.)	3.81	75
Human–Org. Interaction Methods (D.5.1.)	3.82	66
Anthropometry and Demography (B.1.1.)	3.88	86
Human–Org. Interaction Content (D.5.2.)	3.88	66
Human–Job Interaction Content (D.4.2.)	4.00	78
Professional Issues (F.)	4.04	96
Human–Job Interaction Methods (D.4.1.)	4.10	80
Human–Software Interaction Content (D.3.2.)	4.13	92
Design Concepts (A. 2.)	4.16	98
Human–Software Interaction Methods (D.3.1.)	4.19	94
Physical Environment (B.2.1.)	4.22	92
Basic Process Analysis (C.2.)	4.24	90
Basic Usability (c. 4.)	4.37	92
Application (E.)	4.37	96
Organizational Environment (B.2.3.)	4.39	80
Social Environment (B.2.2.)	4.42	84
Systems Concepts (A.1.)	4.44	90
Statistics and Design of Investigations (C.1.)	4.46	94
Human–Machine Interaction Methods (D.1.1.)	4.47	86
Human–Machine Interaction Content (D.1.2.)	4.47	86
Psychology (B.1.3.)	4.68	94

*Ranging from max. 6 (Extremely Well) to 1 (Not at All),

All of the EFM subdomains were relevant to over two-thirds of respondents. The lowest relevance scores were for human-organization interaction methods and content, at 66%. It is also noteworthy that cognitive aspects of human factors were more relevant to our respondents than physical ergonomics. This finding cannot be attributed to the background of the respondents, who came from a wide variety of academic programs.

Most importantly, however, in no subdomain did the respondents report that they felt more than adequately (4) prepared for the demands in the workplace. A particular subdomain very salient in the results is basic design methods. The participants ranked this area very relevant (92%) but felt that they were inadequately prepared in it (mean rating of 3.74). The results from this section of the survey were also mirrored in responses to the next, open-ended, long answer, questions of the survey.

Open-Ended Questions

There were five broad open-ended questions in the end of the survey. Asked to identify three different academic areas in which the respondents felt they were deficient produced very varied responses, ranging from cognitive psychology and perception to biomechanics and anthropometry. We thought that these responses would reflect the relative strengths and weaknesses of the particular academic programs of the respondents, so that engineers felt deficient in psychological areas and those who had graduated from liberal arts programs wished they had more technical skills, but this was not the case. The subject areas our respondents felt deficient were about equally distributed between academic disciplines so that those graduated from engineering programs also wished to have been exposed to HF/E engineering, biomechanics, computer programming, and data visualization, and those graduated from psychology programs called for more coursework in cognitive HF/E, visual perception, learning and training, and physiological psychology. The most common academic areas that the respondents wished had been addressed in greater depth in their educational experience across all programs were research methods and statistics, application of knowledge learned, and various aspects of design.

Another question asked the respondents to name three different skills they wish they had learned before they started working. Although the responses varied, several respondents came up with same or very similar topics. Design skills were most common on this "wish list" (21%); the closely related topic of writing specifications was cited by 10% of the respondents. Computer programming skills were mentioned by 15% of the respondents, despite the fact that it was an infrequently needed skill (see Table 2). More statistics, including statistical software use, was called for by 12% of the respondents. Other topics cited by several respondents were skills in project management, writing of grant proposals and preparing material for publication, skills to deal with the transition from academia to jobs in the industry, and skills to manage interpersonal relationships and group dynamics in the workplace. Also a variety of research methods topics were cited, including task analysis, function analysis, and cognitive work analysis techniques. Finally, skills necessary in searching and getting a job were very still much in the minds of our respondents.

When asked to identify one critical area in which most HF/E professionals are deficient and which should be addressed as part of their formal education, a particular theme emerged quite clearly. It seems that a major deficit in the educational experience of HF/E professionals is the understanding of the processes used in the "hard" engineering disciplines. The respondents clearly saw a need to be effective team members in multidisciplinary settings, making convincing arguments to engineers for contributions of HF/E in design, and writing specifications for products and systems so that they would be understood by the entire development team.

To rectify the aforementioned deficits, the respondents suggested several college courses, topics, or experiences to be added to the educational experience of new hires to do the respondents' jobs. Various design topics (e.g., CAD) were mentioned. One respondent stated that it would be more important to be able to express ideas visually than in writing in APA (American Psychological Association) style. Effective communication in oral presentations, writing, and by visual means were deemed important. Coursework in basic engineering topics to allow for understanding of the systems to which HF/E professionals contribute were suggested by several respondents.

Finally, the respondents were asked to identify courses in their educational experience that were of little use for them in their current jobs. This question produced mostly negative results. Most respondents could not name any courses they could do without, and some suggested topics that they considered important but had not included in their previous responses.

DISCUSSION

The key finding of this survey can be summarized by one word, "heterogeneity". The respondents had a mix of academic backgrounds, they worked in over 20 different industries, and the deficiencies they perceived in their preparation for their current jobs spanned a wide assortment of different topics. The diversity of academic backgrounds may indicate a trend away from the traditional HF/E disciplines of psychology and industrial engineering and emergence of variety of other programs that train HF/E professionals, such as information technology, computer science, other engineering disciplines (e.g., mechanical engineering), architecture, and business and management.

Academics can take heart from the result that no particular topics in the respondents' college experience were deemed superfluous. However, the results contain a clear message that the traditional "ivory tower" mentality of academia does little to help graduates hit the ground running in their jobs. Instead, the majority of respondents wished they had had experience in practical application of the knowledge they learned in college. In particular, practice in the design of things emerged as the most important issue lacking from their educational experience.

There also seemed to be a call for more—and perhaps more rigorous—coursework in the areas of research methods and statistics. These are seldom among anyone's favorite courses in college, but it appears clear that skills in experimental design and field methods, data visualization and analysis, and effective communication of the results are in high demand in many areas in which new HF/E professionals work. Working in interdisciplinary groups could also be easily practiced in the college environment, but it would require continual breaking down of interdepartmental boundaries and effective coordination between different academic programs.

Finally, our survey results validate the EFM. Of the 24 specific subdomains of the model, all but two were deemed relevant to over 75% of our respondents. The EFM also provides clear operational definitions (objectives) for each domain and subdomain, along with extensive lists of specific example topics (points of reference). Thus the model is eminently usable as a template for development, assessment, and revision of academic programs that aim to produce the future HF/E workforce.

This research complements previous results from Cooke and Gorman (2004) and Stone and Derby (2009) and provides an additional data point for the continual assessment of the changing job market for HF/E professionals. Our survey also introduced some new elements to this line of research. The survey was administered to a specific subpopulation of HF/E professionals, those members of the HFES who had earned their highest degree since 2005 and thus would be considered new professionals. This improves the accuracy of our results and makes them very current. We hope to repeat this survey after 2–3 years or after a sufficient number of new HF/E professionals have again entered into the workforce to provide for a reasonably large sample. Our survey also included elements from the EFM, which turned out to provide a very useful framework for assessing the educational preparedness of new HF/E professionals. Conversely, the EFM would also serve as a worthwhile template in developing HF/E programs and curricula across many academic disciplines.

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