EMPLOYERS' EXPECTATIONS FOR EDUCATION AND SKILLS OF NEW HUMAN FACTORS/ERGONOMICS PROFESSIONALS

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This paper reports the results from a survey administered to individuals in several companies whose responsibilities included either hiring or supervision of new human factors/ergonomics professionals. The survey asked about the knowledge and skills expected from new professionals entering the workplace. It was based on the survey previously administered to new professionals about their experiences in their first human factors jobs. The results both replicate and complement the findings of the previous survey. Many critical skills, such as communication skills, are not specific to the discipline. However, in over half of the Ergonomist Formation Model subdomains the respondents rated new professionals' preparedness as only adequate. The open-ended questions allowed for a review of specific challenges and the responses echoed those of the new professionals' responses last year. Application of the knowledge gained in college to practical design tasks was reported lacking in the new professionals' skill set. Skills to effectively interact in multi-disciplinary and cross-functional teams were found wanting in both surveys. Results from both surveys offer a useful and cross-validated review of the current demands new professionals are facing, and a mandate to educators to develop human factors curricula in response to them.

INTRODUCTION

Arguably one of the most critical issues that our professional society should grapple with is the education and training of the future human factors/ergonomics (HF/E) workforce. Only if people entering the profession have the knowledge and skills necessary to be employed by companies that design products or systems for human use or have human operators responsible for complex and safety-critical systems can they hope to make a difference in those settings and advance our profession. It follows, then, that educators of the future HF/E workforce should be closely tuned to industry needs and flexible in revising and updating academic curricula in response to changes in them.

The Human Factors and Ergonomics Society (HFES) has long sustained a keen interest in career issues. Much of this work is available online on the Information for Students—Resource Guide page on the HFES website (https://www.hfes.org//Web/Students/career.html). However, as workplace demands and the profession itself mutate, the task of evaluating educational programs against expectations in the labor market must evolve accordingly.

There have been periodic inquiries into the education and training needs of human factors/ergonomics (HF/E) professionals (Cooke & Gorman, 2004; Stone & Derby, 2009). Last year, Rantanen and Moroney (2011) reported results from a survey administered to new HF/E professionals, defined as individuals who had been working in the field for less than five years. The survey was fairly comprehensive, asking how frequently the participants used the skills and knowledge they had learned in college in their present jobs, as well as what HF/E resources they accessed in the course of their jobs. The survey also asked about the respondents' preparation in the domains and subdomains of the Ergonomist Formation Model (EFM) of the Board of Certification in Professional Ergonomics (BCPE, 2009).

The results of the Rantanen and Moroney (2011) survey were quite interesting. Both the educational backgrounds of the 52 respondents and the positions they held at the time of the survey were very diverse. Many respondents had educational backgrounds much different from the traditional psychology or engineering programs. The respondents' positions were too diverse for meaningful classification. However, the respondents were much more unified about the particular areas they felt they were insufficiently prepared for in the demands of their jobs. These areas included design experiences, exposure to the processes used in the "hard" engineering disciplines, and experience in communicating as members of interdisciplinary teams. 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 EFM as a relevant framework and a useful template for development, assessment, and revision of academic programs that aim to produce the future HF/E workforce.

In this paper we discuss results of a follow-up survey, conducted in the spring of 2012. The survey was administered to individuals in several companies whose responsibilities included either hiring or supervision of new HF/E professionals, who were defined in the same way as in Rantanen & Moroney (2011).

METHOD

Survey Development

The survey was developed using the "Clipboard" online survey tool of Rochester Institute of Technology (RIT). Clipboard offers great flexibility in constructing different types of questions and answer formats, accessing the survey via an URL link, and collection and analysis of responses.

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This survey was very similar to the one we ran last year (Rantanen & Moroney, 2011). It consisted of several questions about the respondents' work domain, their educational background, and their experience in hiring and/or supervising new HF/E professionals. The contents of a question about how frequently new HF/E professionals were expected to use specific skills and apply knowledge in the respondents' company were identical to the question in last year's new professionals' survey. The question addressing the frequency of use specific HF/E resources in last year's survey was replaced by an open-ended question about how the respondent's company expected new HF/E professionals to keep up with current research and conduct reviews of relevant literature.

This survey, too, included questions about the preparedness of new professionals in the EFM domains and subdomains. Apart from the wording of this question, this section was identical to last year's survey. The last six questions were open-ended. The respondents were asked to identify a particular, critical area in which they felt most HF/E professionals are deficient in and which should have been addressed as part of their formal education, up to three academic areas that should have been addressed in greater depth in the new professionals education, and up to three skills that new professionals should have learned before they started working. We also asked what skills the respondents expected new professionals to learn within the first year of their employment. Finally, we asked about "deal cinchers" and "deal breakers" in hiring of new HF/E professionals.

Sampling Procedures

A personal invitation to participate was emailed to people who worked in companies that employ HF/E professionals and who were personal acquaintances of at least one of the authors. The email included the URL link to the survey and a request of the recipient to forward the invitation to other personnel within their company who also were involved in hiring and/or supervising HF/E professionals or other managers among their professional acquaintances.

RESULTS

We received a total of 23 responses to the survey. Altogether 51 personal emails were sent, and although some recipients indeed did forward the survey invitation to other managers in their organizations or other acquaintances of theirs, our plan for "snowball sampling" clearly did not work. In fact, less than half of the people who received the direct personal invitation participated in the survey. Fortunately, those who did respond provided very thoughtful and valuable insights into the topics surveyed.

Demographics

The respondents were employed in diverse business areas. In fact, no two respondents reported working exactly in the same area. Due to the anonymity of the responses, we do not know the specific companies, but the business areas included aviation and aerospace, healthcare products and medical devices research, design and manufacturing, consulting, R&D, software and hardware design and development, contracting with the government, military, and other industries (e.g. power, oil and gas, mining) and design of consumer products. The areas where HF/E professionals were employed in the respondents' companies covered almost all HFES technical group designations.

Sixteen respondents had a doctoral degree, five a Master's degree, one a Bachelor's degree, and one was a medical doctor. They earned their degrees between 1969 and 2009; the median year was 1998. The degrees were mostly in traditional HF/E-related psychology (N=12) and engineering (N=7) disciplines; one respondent had a degree in education, two in human factors, and one in medicine.

The respondents were relatively experienced and well qualified to answer the questions in the survey. They had experience in hiring between 0 and over 100 HF/E professionals (Mdn=7) and in supervision between 2 and over 100 professionals (Mdn=5). Fifteen respondents reported to be very well able to evaluate the preparedness of new HF/E professionals for their jobs through daily interaction with and mentoring of them; eight respondents reported their ability as moderate through evaluation of the work, reports, and other deliverables of new professionals.

Skills and Knowledge Expectations

The respondents' expectations for specific skills and knowledge of new HF/E professionals are depicted in Table 1. These results are remarkably congruent with the new professionals' own experiences reported in last year's survey (Rantanen & Moroney, 2011).

Table 1
The Mean and Median Frequencies New HF/E Professionals Are Expected to Use Their Skills and Knowledge in their Jobs.*

Skills/Knowledge	Mean Freq.	Median Freq.
Apply knowledge	6.35	7
Writing skills	6.00	7
Presentation skills	4.35	4
Literature research skills:	4.13	4
Data analysis skills:	4.04	4
Experimental design skills:	3.65	3
Computer programming skills	3.13	2

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

Application of knowledge was expected on a daily basis. Similarly, writing skills were deemed very important and to be used daily. Note, however, that many technical skills, such as experimental design and data analysis skills were expected to be used much less frequently, about once a week, and computer programming skills were required very infrequently, a few times a year. Writing and presentation skills are also critical, and these can and should be practiced and honed during the

students' formal education. These results contain a clear message to educators. It is indeed important *what* students learn in their academic programs, as they are expected to have relevant, applicable knowledge when they enter the workforce.

We also asked how new HF/E professionals were expected to keep up with current research and conduct reviews of relevant literature. The responses varied and mostly this task was left to the worker's discretion. It was heartening to note that almost all respondents said that their companies actively encouraged participation in conferences and professional societies' meetings, however.

Ergonomist Formation Model

We repeated the question about new professionals' preparedness in the EFM subdomains from last year's survey. The mean and median ratings (ranging from 1-not at all prepared to 6-extremely well prepared) and the percentage of respondents who indicated that the subdomain was applicable to their company appear in Table 2.

These results parallel those of last year's new professionals' survey as well. There appears to be room for improvement in all subdomains, as the highest median score was 5 (very well) in only one subdomain, psychology, and in all other subdomains the new professionals' preparedness was rated to be merely adequate (4) or inadequate (3). The lowest scores were in the Design Concepts subdomain (M=3.32, Mdn=3), which the new professionals also indicated to be an area in which they felt least prepared upon entering the workforce.

Not all subdomains were equally relevant for the respondents' companies. The least relevant subdomains were human–organization interaction content (57%) and methods (59%), human–environment interaction content (68%) and methods (73%), and physiology and biomechanics (68%). On the other hand, application of HF/E, basic process analysis, systems concepts. and statistics and design of investigations were relevant to every respondent. Half of the 24 subdomains were relevant to over 90% of respondents.

Open-Ended Questions

The first of the six open-ended questions asked the respondents to identify one critical area in which most HF/E professionals are deficient in and that should be addressed as part of their formal education. The responses were similar and echoed a common theme. Specific issues included a lack of understanding of systems engineering processes and the ability to effectively integrate human factors processes within the systems engineering life cycle, the ability to flexibly deal with outside-the-textbook constraints within the systems engineering process, and lack of creativity in addressing the areas which yield the largest user benefit in design. Shortcomings in the ability to work with engineers and other team members who may have conflicting ideas was also brought up by several respondents.

Table 2
Mean and Median Ratings of How Well the Respondents thought New HF/E Professionals Were Prepared to Meet Their Job Requirements in the Revised EFM Subdomains, and the Relevance of the Subdomain in the Respondents' Companies (Percent Indicating Relevance)*

EFM Subdomain	M	Mdn	Rel.
Design Concepts (A. 2.)	3.32	3	95
Anthropometry and Demography (B.1.1.)	3.53	4	77
Human–Env. Interaction Content (D.2.2.)	3.60	4	68
Physiology and Biomechanics (B.1.2.)	3.67	4	68
Human–Org. Interaction Content (D.5.2.)	3.67	4	57
Organizational Environment (B.2.3.)	3.74	4	87
Human–Env. Interaction Meth. (D.2.1.)	3.75	4	73
Human–Org. Interaction Methods (D.5.1.)	3.77	4	59
Physical Environment (B.2.1.)	3.81	4	95
Basic Design Methods (C.3.)	3.86	4	95
Human–Job Interaction Content (D.4.2.)	3.94	4	76
Human–Job Interaction Methods (D.4.1.)	3.94	4	82
Application (E.)	4.00	4	100
Basic Process Analysis (C.2.)	4.05	4	100
Social Environment (B.2.2.)	4.05	4	95
Human–Machine Interact. Cont. (D.1.2.)	4.05	4	86
Professional Issues (F.)	4.06	4	77
Human–Machine Interact. Meth. (D.1.1.)	4.10	4	95
Systems Concepts (A.1.)	4.18	4	100
Statistics & Design of Investigations (C.1.)	4.27	4	100
Human–Software Interact. Meth. (D.3.1.)	4.29	4	95
Basic Usability (c. 4.)	4.30	4	95
Human–Software Interact. Cont. (D.3.2.)	4.40	4	91
Psychology (B.1.3.)	4.43	5	95

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

Specific skills new HF/E professionals were deemed lacking included risk management and familiarity with tools to identify and quantify errors in the design of systems and to link design controls to error risks, statistics and design of investigations, basic math and verifying the validity and reasonableness of the output of statistical programs, and project management skills. The inability to translate HF/E knowledge into actionable and comprehensible information to other team members was also cited as a specific deficiency.

Finally, applied design skills were deemed deficient. New professionals who have graduated from current HF/E programs have little experience in applying their knowledge in experimental techniques to the actual design of user interfaces, or lack understanding of the design process in organizations. General creativity in evaluation of product concepts and interfaces with users and participatory design were also mentioned as specific deficiencies. An interesting finding was that com-

panies often hire "general" psychologists to do HF/E work, but their HF/E-specific training is limited to a summer short course or the like.

Another open-ended question sought to identify specific academic areas and skills that should have been addressed in greater depth in the education of new HF/E professionals. The responses are a treasure trove for educators and those designing HF/E curricula. Several existing academic areas were mentioned, such as cognitive neuroscience, systems engineering, ethnographic methods, human-computer interaction, usability engineering, and in particular statistics and experimental design. In addition, the respondents brought up several topics that appear to be lacking in most academic programs but that warrant serious attention by educators. These topics included logical reasoning, business perspectives on the value of human factors, and multi-disciplinary team collaboration and working on cross-functional teams. It is unlikely that these topics would be a part of a formal syllabus in any regular course, but there is no reason why they could not be integrated into almost any course on any subject. Clearly, these are areas where graduates have manifested substantial deficiencies.

When asked to identify skills that new HF/E professionals may not have at the time of hire but would be expected to learn within the first year in the job, the respondents produced a list that was very similar to their responses in the previous questions. It seems reasonable to conclude that these responses are related, since areas in which new professional have been found to be deficient are also areas they need to pick up quickly upon being hired.

Finally, our last questions asked what the respondents were looking for when hiring new HF/E professionals, or "deal cinchers", as well as characteristics in applicants they would avoid, or "deal breakers". Desirable characteristics included excellent verbal and written communication skills, adaptability to different situations, and the abilities to operate in a wide variety of group settings, communicate clearly the need for HF in the product development process, take initiative and work independently, see "the big picture", and prioritize effectively. Depth of knowledge, integrity, and a strong work ethic were also prized.

The undesirables were the converse, and included inability to work well with others, too academically focused and narrow interest areas, poor communication skills, negativity ("cannot do" versus "can do!" attitude), inability to accept and respond to constructive criticism, individualistic rather than collectivist approach to work, extreme competitiveness, closed mindedness, extreme ego, bigotry, overselling of HF/E credentials, inability to apply knowledge to real problems, poor interpersonal skills, and lack of project (in school context) experience.

DISCUSSION

The results of this survey, which was designed for and administered to individuals who hire and supervise new HF/E professionals, both replicate and complement the findings of the previous survey, administered to new professionals. From these results a clear picture emerges of the demands for specific knowledge and skills of HF/E professionals, and a mandate for educators to supply them. Some skills in high demand are generic. Effective communication skills are not specific to HF/E discipline, but HF/E curricula should offer ample opportunities for their practice and perfection. Some other expectations, such as the ability to effectively advocate for HF/E principles and practices should be integral to HF/E education in any program, yet it was brought up as a specific deficiency in new professionals' preparation.

This survey again validated the EFM as a very useful and usable framework for assessing knowledge and skills of the HF/E graduates. It is also readily usable in curriculum development. Finally, the open-ended questions allowed for a review of specific challenges and the responses echoed those of the new professionals' responses last year. Again, application of the knowledge gained in college to practical design tasks was reported lacking in the new professionals' skill set; last year, this was on top of the list new professionals said they wished they had learned in college. Similarly, skills to effectively interact in multi-disciplinary and cross-functional teams were found wanting in both surveys.

Limitations

The well-known limitations of survey research were clear and present in this study as well. The low response rate and failure of snowball sampling were the most significant disappointments. This survey was admittedly quite long with 33 questions, many of which were open-ended, and this may have contributed to the low response rate. Furthermore, the 24 questions about the EFM subdomains, although requiring responses on a likert-scale, were associated with lengthy definitions the respondents had to read. On the other hand, the responses were very carefully considered and insightful and the EFM again proved to be a useful framework for assessment of HF/E professionals' preparedness and competencies. A simpler and shorter survey would undoubtedly have yielded less and poorer data.

The larger question our research attempted to address is how to create a conduit for information about changing needs and expectations from employers and managers of HF/E professional to the educators of the future HF/E workforce. Surveys are clearly not the optimal tool for this purpose for several reasons. The problems with low response rates have already been discussed. Surveys furthermore only provide snapshots in a given time and should be repeated frequently for a more continuous flow of information. Frequent surveys, however, may be impractical because of the time and effort they require to develop, administer, and analyze, and they would only exacerbate the problem of low response rates. Better methods are therefore needed to bridge the communications gap between the workplace and educational institutions.

CONCLUSION

This survey was the third in a series of surveys we conducted in 2011-2012. All surveys were in response to the HFES' concern for future workforce issues. The most basic purpose of our efforts has been the fostering of a meaningful dialogue between the educators of the future HF/E profession-

als (i.e., academics) and the people in the "sharp end", that is, who *do* human factors in the industry. Whether surveys are the best, or even an appropriate way, to achieve this purpose is certainly debatable, and such a debate is indeed warranted and should be encouraged. Nevertheless, we consider these findings a good starting point for describing the topic area and the critical issues that need to be addressed.

We have now surveyed new professionals in their first jobs after graduation (Rantanen & Moroney, 2011), students still in college anticipating their entry into the workforce (Moroney & Rantanen, this volume), and managers of new HF/E professionals. All three surveys paint the same picture, and taken together they thus have cumulative validity that compensates for the small *n* of each individual survey.

Both of the authors work in the academia, and our focus is on curriculum development in response to the changing demands in the workplace. We have received some criticism that HF/E education, particularly Ph.D. education, does not need to concern itself with practice of HF/E, but can, and indeed should, focus on theoretical aspects of the subject matter. We have two responses to this assertion. First, we certainly need to be concerned also about the education of the future *educators* of the future HF/E workforce. Secondly, all applications of HF/E should obviously be based on a sound theoretical foundation. However, as the last year's survey (Rantanen & Moroney, 2011) showed, a majority (72%) of the new professionals holding doctoral degrees in HF/E-related disciplines work in the industry, and that most of our respondents were employed in the industry rather than academia. Educators should therefore indeed be aware of the expectations new HF/E professionals face upon graduation.

The "take-home" message from the three surveys is quite clear: To better prepare new HF/E professionals for the demands of the workplace, their training should include practice in design, project management, working in interdisciplinary teams, and making persuasive arguments for human factors in all project phases. These are topics that could be incorporated into any college curricula on any topics, and we hope that educators hear this message loud and clear.

The big question about proper conduits between employers of HF/E professionals and the professors of HF/E students in colleges remains unanswered at this time. Although we plan to survey new professionals again after a few years (i.e., after sufficient number of new HF/E professionals have graduated and entered the workforce), it is apparent that the survey methodology is less than ideal for this purpose. We therefore encourage people working in the industry who recruit new HF/E professionals to think creatively of ways to effectively communicate their needs to academics in HF/E-related programs, and urge the academics to be open to the expressed needs from the industry.

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