A FRAMEWORK FOR EVALUATION OF UNIVERSITY HUMAN FACTORS CURRICULA

Esa M. Rantanen and Peter M. Vlach
University of Illinois at Urbana-Champaign
Savoy, IL

Curriculum reviews are performed to provide grounds for adjustments necessary due to changes in student enrollment, teaching faculty, and goals and objectives of programs that have a substantial human factors component. This task is arguably quite difficult due to the very broad spectrum of the human factors discipline and lack of widely accepted standards or criteria for education in human factors. This paper describes a framework for review of undergraduate human factors curricula using the program at the University of Illinois as an example. The framework was implemented as a hierarchical relational database with a web interface. Populated with either existing curriculum or desired courses to be developed it allows for rapid analysis of overlap between individual courses, missing important human factors topics, and determination prerequisite knowledge for these, and a rigorous and formal way of keeping human factors curricula aligned with explicitly stated goals for the programs.

INTRODUCTION

Curriculum reviews are common and regular tasks in many universities. They are performed to provide grounds for adjustments necessary due to changes in student enrollment, faculty available to teach various courses in human factors, and higher level goals and objectives of programs that have a substantial human factors component. However, this task is arguably quite difficult due to the very broad spectrum of the human factors discipline and lack of widely accepted standards or criteria for education in human factors. This paper describes a framework for review of undergraduate human factors curricula using the program at the University of Illinois at Urbana-Champaign (UIUC) as an example. With minor modifications, the same framework can be used for evaluation of graduate programs.

The process of human factors curriculum review and revision should be done according to the following four steps:

(1) Determine the goals of the human factors program and/or minor(s);
(2) According to the goals in (1), define educational criteria for the program;
(3) According to the criteria in (2), evaluate existing courses in the curriculum;
(4) According to (2) and (3) above, revise the curriculum by adjusting existing courses and/or adding new courses, according to available resources and within local constraints.

Both definitions of curriculum requirements and subsequent review of its contents are subservient to the purpose and goals of human factors education in the university, which must be determined first. That both the structure and content of the human factors curricula should be goal-oriented is taken here to be undisputed. To appropriately determine the goals for a human factors curriculum, then, programs can be examined in a two-dimensional space as depicted in Figure 1.

In Figure 1, the horizontal axis represents domain-specificity of the human factors education; to the left general, to the right specific, or as is the case of the program at UIUC, to aviation. The vertical axis represents a general educational continuum, with liberal and technical education at its ends. Liberal education is here defined as 'The areas of learning that cultivate general intellectual ability rather than technical or professional skills' ('liberal arts', Houghton Mifflin Company, 2002). Technical education, in contrast, is meant to be synonymous with engineering, or 'profession devoted to designing, constructing, and operating the structures, machines, and other devices of industry and everyday life' (Columbia University Press, 2003). It is the task of a curriculum evaluator to determine an appropriate placement of a human factors program in this matrix.

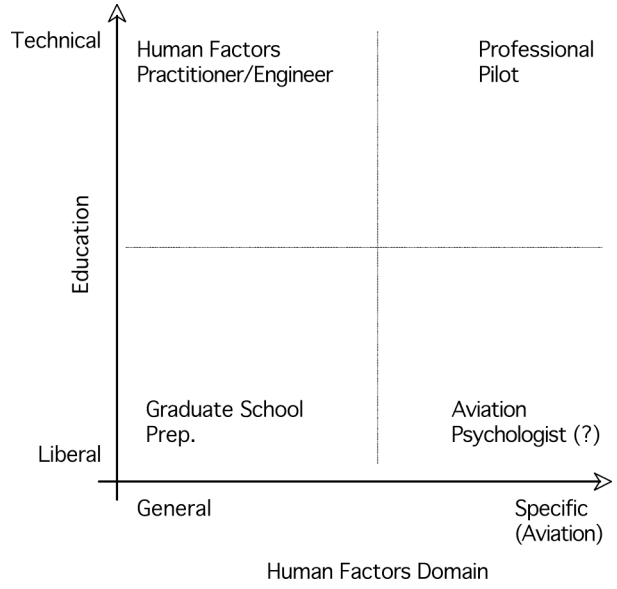

Figure 1. A matrix for defining goals of human factors curricula.

In the case of the UIUC, substantial aviation content (flight training up to instrument, multi-engine, flight instructor certifications) makes the program both highly technical and specialized, placing it at the upper right-hand corner of the matrix. Hence, changing the program's goals towards the hu-

man factors practitioner outcome would require adding more general human factors courses to the curriculum at the expense of some of the upper-level aviation courses. Emphasis on graduate study preparation would require adding liberal arts classes. All these adjustments are obviously constrained by the number of credit hours possible to fit in a four-year program.

EVALUATION CRITERIA OF HUMAN FACTORS CURRICULA

All evaluation activities are necessarily dependent on appropriate and applicable criteria. Herein lies one of the main problems with human factors: very few objective and widely accepted criteria exist within the discipline in general, and even fewer that might be applicable to human factors education. Furthermore, it is clear that the criteria will vary widely according to the goals of the programs, as illustrated by the matrix in Figure 1. There are, however, some sources that may be considered for guidelines for development of such criteria.

ABET, Inc. (http://www.abet.org/) is an accreditor for college and university programs in applied science, computing, engineering, and technology, which are closely related and even overlapping many human factors topics. ABET is also a federation of 28 professional and technical societies representing these fields and as such invites comparison with the Human Factors and Ergonomics Society (HFES). However, since ABET is an engineering organization, their accreditation criteria would have to be substantially modified to include psychological sciences before being applied to human factors.

The Board of Certification in Professional Ergonomics (BCPE; http://www.bcpe.org/) is an independent nonprofit organization that awards several kinds of professional certifications to individuals whose 'education and experience indicate broad expertise in the practice of human factors/ergonomics' The BCPE also adheres to the criteria and policies for competency assessment set by the National Organization for Competency Assurance (NOCA), and has been endorsed by the International Ergonomics Association (IEA) as an accredited ergonomics certifying body. It should be noted, however, that certification of HF professionals is a controversial issue within the profession and source of lively debates within the HFES. Also, a Certified Professional Ergonomist (CPE) is not by any means equivalent to a Professional Engineer (PE) certification and its meaningfulness is rightly questioned from time to time.

However, BCPE has adopted a detailed set of criteria for its certification activities in coordination with the Center for Registration of European Ergonomists (CREE) and in cooperation with the Education and Training Committee of the IEA, known as Ergonomist Formation Model (EFM), which defines professional competence in ergonomics. The EFM is based on the works of Bernotat and Hunt (1977), Jahns (1991), Rentzsch (1994), Rookmaaker, et al (1992), and Van Cott and Huey (1992), and thus represents an exhaustive review of literature on human factors curricula and competencies. It also corresponds to the curriculum criteria used by the HFES accreditation process for graduate programs in ergonomics/human factors (HFES, 2004), which offers a ready-made model for evaluation of also undergraduate curricula.

Finally, the IEA (http://www.iea.cc/) is the federation of 42 ergonomics and human factors societies from around the world. IEA also provides guidelines on standards for accreditation of ergonomics education programs at university level as well as lists Core Competencies in Ergonomics. These are a potential source for additional criteria.

IMPLEMENTATION OF CURRICULUM EVALUATION FRAMEWORK

The particular topics and areas to be covered in human factors curricula naturally depend on the goals set for the programs. However, there are a finite number of topics that fall within the human factors discipline and sub-disciplines, which will form a basis for all human factors curricula. The EFM offers an extensive listing of topics and subtopics and it was thus chosen in its entirety as a basis for human factors curriculum evaluation efforts at the UIUC. To implement this framework in a usable form for evaluation of existing curricula, it was brought into a relational database, dubbed the Human Factors Curriculum Review (HFCR) database (see Figure 2).

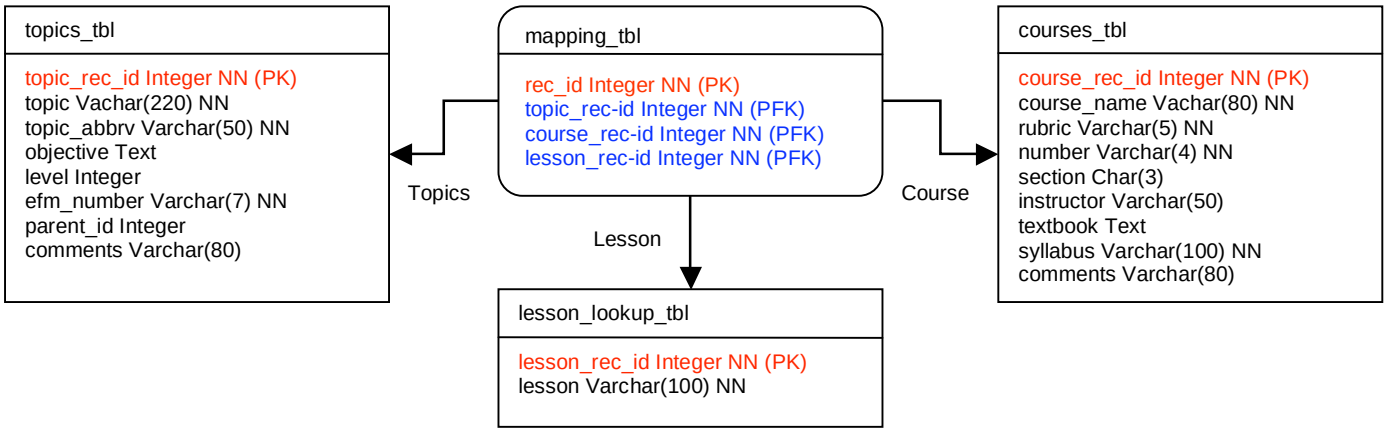

Figure 2. The structure for a relational database for development and evaluation of human factors curricula. The topics_tbl contains the EFM model, courses_tbl courses in the curriculum, and lesson_lookup_tbl individual lessons on various topics in the courses. The latter are then mapped into the EFM topics in the mapping_tbl.

Human Factors Curriculum Review Database

In the EFM model the major topics (e.g., Work Analysis and Measurement) are divided into subtopics (e.g. Statistics and Experimental Design) and sub-subtopics (e.g., Non-parametric statistics). The EFM also offers operational criteria for the first two levels. The EFM model was hence included in the HFCR database in the Topics table. Table topics_tbl includes a level column. This column is used to identify a topic level within a defined tree. It will be used later in queries to quickly separate topic levels for a better management of topic hierarchy and the easier user search interactivity. These levels are represented in a user interface in a form of pull-down menus. Column parent_id is used to link child topic to its parent topic within a defined structure. This eliminates a need for additional columns (e.g., level1, level2, level3…) and enables the user to have unlimited taxonomy structure. A direct implication of this design is that user can create any number of levels and cross-references within the topics structure.

The HFCR database is designed to link a set of topics to courses with a relevant focus on syllabus. The principle of this design is to allow administrative user to initially enter all topics and lessons independently from course information and the course information independently from topics and lessons. Each record in these tables can be uniquely identified by its corresponding record ID. When all tables are populated with data (i.e., desired human factors topics in the Topics table, courses in a program in the Courses table, and individual lessons within courses in the Lessons table), they can be linked via mapping table by simply matching topic_rec_id in the topic_tbl with lesson_rec_id in the lesson_lookup_tbl and course_rec_id in the course_tbl. The result of this link is a direct reference between a topic and its relevant lesson(s), and then between lesson(s) and the course(s) where the lesson(s) is/are being taught. Mapping table will prevent a need of having duplicate records in the course_tbl table and lesson_lookup_tbl table. It will also allow for easy querying in both directions.

A database populated with either existing curriculum or desired courses to be developed and with an appropriately designed interface allows for rapid analysis of overlap between individual courses, 'holes' in curricula that do not adequately address important human factors topics, and determination of appropriate order for the courses in the curriculum and prerequisite knowledge for these. Once the database has been populated, it can be easily changed according to changes in the program allowing for periodic re-evaluations to be performed quickly and easily.

Examples

The HFCR database can be queried in multiple ways. For curriculum evaluation purposes, the evaluator may select topics (from the topics_tbl, presently populated by the EFM model) that he or she deems both desirable (given the program's goals) and feasible (given available resources and constraints) for human factors curriculum in the university. The output will list all selected topics and all lessons from various courses associated with them. The evaluator will then be able to quickly determine whether the program has 'holes' in it, that is, desired topics that are not covered in any class in the curriculum, or unnecessary overlap between courses that cover the same topic. For example, a query on a topic 'Signal Detection' results in an output as depicted in Table 1:

Table 1
A sample output from the HFCR database to a query on a topic 'Signal Detection'.

4.	People and Technology Objective: To understand an area for application of ergonomics expertise, some models and concepts related to applying ergonomics, and at least one special form "ergonomic design" may take on in any area. 4.7. Information Design Objective: To investigate and design the major modes of information transfer to the human for effective and efficient performance of the system. 4.7.1. Signal detection;
1.	The Signal Detection Theory; AVI358/PSYC358/IE340; Rantanen
2.	ROC; Applications of SDT; AVI358/PSYC358/IE340; Rantanen
3.	Lab; Signal Detection; AVI358/PSYC358/IE340; Rantanen
4.	Signal Detection Theory; AVI456/PSYC456/IE445; Morrow
5.	SDT; Applications and Vigilance; AVI456/PSYC456/IE445; Morrow

From this example we can see that the signal detection theory is covered in two separate courses and in a total of five different lessons, which seems quite adequate. Rather, the evaluator may need to look closer into the lessons to determine that there is not too much overlap in coverage of this topic, particularly since both of the above courses are required in the university's curriculum. Furthermore, the evaluator (as well as instructors) may examine the lessons to see whether they fulfill the stated objectives of the parent topics and use this information to guide individual course development.

The database also allows for queries in the opposite direction: for example, the Topics table may be queried by certain lessons in the courses in the curriculum. This will help the evaluator as well as individual instructors to get the 'big picture' of where their lessons fit within the larger objective of human factors education. It may also be discovered that some lessons or courses that are deemed essential to the curriculum cannot be matched with existing topics in the Topics table. Such instances call for reexamination of the underlying model (e.g., the EFM) and its possible modification to better describe the expected competencies of students graduating with human factors degrees.

The HFCR database is by no means static but will, as it should, be constantly updated and modified according to changing goals of human factors programs in response to the development of the profession and demand for human factors professionals. The HFCR database allows for such updates to be made quickly and easily and programs to be periodically reevaluated by it whenever such changes take place.

DISCUSSION

There are two main goals that can be considered for undergraduate human factors programs. First, it is a widely held view in the human factors discipline that a minimum qualification for someone to become a human factors professional is a Master's degree in an applicable and relevant field. If this indeed is the case, then the goal of an undergraduate human factors program should be to prepare students for graduate study. On the other hand, undergraduate human factors education could be taught in the same way as engineering in general; a Bachelor's degree in engineering will prepare a student for a profession and allow a graduate to enter the workforce as a practicing engineer.

Within these two main options for human factors curricula discussed above, there are two other questions that should be answered in a clear and definitive manner: (1) do we want to teach skills or knowledge, or 'facts vs. tools', and (2) do we want to emphasize breadth or depth in our curriculum, or, in other words, educate generalists or specialists. As was stated earlier, all of these questions must be answered in the context of higher education in general and within specific constraints of credit hours and their meaningful allocation among competing educational areas.

These are difficult questions and there certainly are no 'automatic' answers to them. The curriculum evaluation framework and the HFCR database application presented here, however, offer a rigorous and formal way of seeking answers to them. It is also hoped that this approach will help keep human factors curricula aligned with explicitly stated goals for the programs, which should be vigorously debated and clearly stated for the benefit of both students and the profession.

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