

# Comment

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## Guidelines for Education and Training in Engineering Psychology

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These guidelines have been written primarily to aid faculty and curriculum planners in the design of graduate programs in engineering psychology at both the master's and doctoral level. Because they deal chiefly with the content of such programs, they address indirectly the question of what material might be incorporated in single graduate or undergraduate courses as well.

In view of the declining job market for basic research psychologists, many institutions are seeking ways to incorporate more "applied" content into their curricula. The present guidelines should be useful in that effort, whether it extends to a full graduate curriculum or to just one undergraduate course. It is important to recognize, however, that engineering psychology has an identifiable content and, like any specialty area, requires concentrated study in this content as well as in various related content and skill areas. One should not expect to convert a traditional experimental psychology program, for example, into a viable engi-

neering psychology program through the cosmetic addition of a single course. On the other hand, viable programs can be (and often have been) constructed without a huge investment in new courses simply by integrating, in nontraditional ways, offerings that presently exist in other psychology and nonpsychology programs. What is essential is that the student have meaningful, organized, intensive exposure to the field's content and that he or she develop the requisite skills. There are probably as many ways to accomplish this purpose as there are universities.

### Definitions

*Engineering psychology* is that branch of psychology concerned broadly with the application of scientific knowledge about human beings to the design of machines, systems, and environments. It grew out of experimental psychology and still shares many of the same values in its research activities; however, it has a broader methodological base and a more "practical" orientation. For this reason, some have preferred labels such as *applied experimental* or *human performance* to the label engineering psychology. It shares a philosophy and integrating concept with the interdisciplinary field of *human factors* or *ergonomics*: Good design is achieved through effective synthesis of human and nonhuman elements into a coherent entity called a *system*. Whether, in fact, any distinction at all should be drawn among these various terms is the subject of continuing debate. Those who do favor a distinction see the engineering psychology (applied experimental, human performance) orientation as emphasizing the content of psychology (e.g., human capacities, limitations, and tendencies in processing information). Those who do not feel that the emphasis in all cases must be interdisciplinary: The field must truly integrate the psychological and design perspectives.

Because applications often occur within the context of larger organizations, engineering psychology intersects at several points with the field of industrial/organizational (I/O) psychology, and, indeed,

is so recognized in the I/O guidelines on education and training (Society for Industrial and Organizational Psychology, 1982). Notable examples include the areas of selection, training, stress, workspace design, the physical environment, and work description. The main difference is that I/O is concerned principally with the behavior of individuals and groups in the workplace; system design factors constitute only a small fraction of the variables that influence such behavior. Conversely, the workplace represents but one of the many contexts in which system design issues are important.

### Basis and Guiding Philosophy

Four recent documents constituted the principal basis on which these guidelines were developed. The first, "*A Survey of Graduate Education in Human Factors/Engineering Psychology*," was the product of an earlier Division 21 (Applied Experimental and Engineering Psychologists) Education and Training Committee effort chaired by Christopher Koch (1980). The second, a similar activity carried out by the Human Factors Society under the direction of Mark Sanders, was reported in the November 1982 issue of the *Human Factors Society Bulletin*. The third was a survey of recent human factors graduates reported by L. H. Geyer in the March 1983 issue of the *Human Factors Society Bulletin*. Together, these reports provided both a summary of the status quo in existing U.S. programs and a look at what features appear most functional in view of anticipated changes in market conditions and requisite competencies.

The fourth document was a set of E & T Guidelines in I/O psychology promulgated by Division 14 (Society for Industrial and Organizational Psychology) in 1982 under the direction of Richard Klimoski. We have shamelessly copied ideas, format, and even wording, on occasion, from this excellent model. Rather than give specific citations, we shall simply acknowledge Division 14's overall contribution to the present effort with an appropriate expression of gratitude.

The general philosophy that guided

the present effort was that the desired "product" of any engineering psychology program can best be characterized as a scientist-practitioner, one capable both of generating and applying scientific knowledge within the person-machine-environment context. As such, he or she can be expected to be competent in both research skills and domains of application. Thus, a training program should include direct experience with both domains. Because the goal of graduate training is to develop these competencies, and it is clear from the heterogeneity of programs now in existence (as well as the backgrounds of highly successful members of Division 21) that this goal can be accomplished in many ways, we have followed Division 14's lead in stressing goals or outcomes of training rather than means. Consequently, these guidelines are expressed in terms of skills, behaviors, and capabilities necessary to function as a new member of the profession and not in terms of courses, hours, and specific experiences.

### Competencies

It is possible to distinguish four domains of competency, all of which should be represented to one degree or another in the graduated individual's inventory of qualifications. These domains, together with the recommended level of representation, are described as follows:

#### 1. Core Skills

These skills constitute the principal "tools of the trade" and should be represented comprehensively and in considerable depth. The individual should have a solid grasp of these techniques both conceptually and in their proper application to research or design problems. The individual should have experience using the skills by conducting research, analyzing data, and so on, in course laboratories, independent research, and dissertation research.

a. *Research skills.* These include design of experiments, practical research implementation, and systematic and programmatic exploration of a problem.

b. *Statistics and quantitative methods.* Such methods involve statistical analysis (including the general linear model, nonparametrics, and multivariate techniques); measurement (including psychophysics, psychometrics, survey techniques, and basic measurement issues); and mathematical models and modeling.

c. *Computer techniques and instrumentation.* These techniques include laboratory and process control, data processing and programming, and peripheral components and other devices.

d. *Communication skills.* These include verbal skills (teaching, briefing, presenting in various contexts) and writing skills (different forms for different purposes).

#### 2. Core Content Areas: Psychological Knowledge Base

These areas constitute the major bodies of empirical and theoretical knowledge in psychology that are presently most applicable to design problems. This domain should be the least stable over time; consequently it should require the most frequent updating in future guidelines and in the practicing individual (e.g., through continuing education). Although the entire domain should be represented, the individual may exhibit real depth in only one or two major categories.

a. *Human information processing, perception, and decision making.* This area covers visual perception and psychophysics; psychoacoustics and speech perception; human cognition—learning and memory; and human cognition—decision making.

b. *Human-machine integration and design.* This area includes display and interface design principles; feedback, control principles, and automation; and workspace design.

c. *Environmental factors.* These include ambient conditions; macro- and microenvironments; and stress, workload, health, and safety.

d. *Biological bases of behavior.* These are basic neurophysiology and physiology and basic anthropometry.

e. *Simulation and training.* This area includes skill acquisition and transfer, fidelity issues and training effectiveness, and instructional system development.

#### 3. Other Psychological Knowledge

This domain includes content areas that are normally covered adequately at the undergraduate level in reputable major programs. Because applicants to graduate programs in engineering psychology do not necessarily present typical undergraduate psychology "profiles," it is important that deficiencies be rectified up to at least a normal undergraduate proficiency in these areas. The principal justification for these minimal competencies in a broad range of psychological areas is that no single area of research or application is isolated from all others. A knowledge of a broad range of psychology will give students a better perspective from which to decide which problems are important, and to make application decisions in the face of less than definitive data. This background knowledge also will help the student interface with other areas of psy-

chology, such as industrial/organizational psychology. For those who might be interested, this broader range of psychological knowledge, together with the core knowledge base, could satisfy a typical provision of certification or licensing laws. Such core knowledge should include (a) history and systems of psychology, (b) social psychology, (c) personality theory and individual differences, and (d) comparative psychology, animal learning, and motivation.

#### 4. Complementary Fields Outside of Psychology

It is highly desirable that individuals trained in engineering psychology have some formal exposure to the design disciplines, or at least to human factors perspectives other than those normally found in psychology departments. The depth and content of such exposure may vary considerably, and therefore no specific recommendation can be given. Examples of fields that might provide appropriate exposure include (a) biomedical, electrical, or industrial engineering; (b) biomechanics; (c) computer science; (d) systems engineering, operations research, and modeling; (e) architecture and urban design; (f) organizational design; and (g) mathematics and statistics. In addition to the four competency domains, the engineering psychologist should be familiar with the ethical, legal, and professional principles that govern the practice of psychology (e.g., the various APA and federal guidelines). It should be duly impressed on the student that, whether its purpose is research or application, the focus of her or his activities is usually people; individual rights must be recognized and observed. The consequences of one's research for society must be considered. Subhuman species must also be accorded humane and proper treatment.

#### Supervised Experience

As indicated at the outset, the focus of these guidelines is on ends (competencies) rather than means. Nevertheless, two broad "means" issues must be addressed: (a) what constitutes adequate research experience, and (b) what constitutes adequate practical experience. Naturally, formal coursework constitutes the principal vehicle by which competencies are established initially in both domains. However, this formal training must be reinforced and extended by supervised research and supervised practical application experience.

In the research domain, opportunities for participation with faculty members in research projects should be provided throughout the student's graduate career.

The nature of this experience should, in essence, constitute an apprenticeship—an individualized progression from heavily supervised, to shared responsibility, to independent and original research. Adequate demonstration of a capability for independent research is afforded by a publicly defended PhD dissertation on a topic consistent with the content of engineering psychology. In some cases it is also evidenced in an appropriate master's thesis; however, unless the final product (thesis or dissertation) is a clear demonstration of independent and original research, the supervised experiences is not sufficient to satisfy the scientist aspect of the scientist-practitioner model.

In the applications (practitioner) domain, the nature and amount of supervised experience can vary considerably. Hence, recommendations are presented in terms of typical "models" rather than rigid prescriptions. In general, a full semester of intensive work experience or its equivalent spread over a longer time period is regarded as the absolute minimum for such exposure to be meaningful. Typical formats are as follows:

#### **1. Contract Research/Development Projects Within the University Itself**

The student typically works as a research assistant in a university laboratory supported by government or private research grants and contracts under the general supervision of a principal investigator (PI). The PI is generally a faculty member; often the student's own advisor.

(a) The content area of the project should be consistent with the major competency domains outlined above.

(b) Care should be taken to ensure that the student is given a meaningful role in all phases of the work and that his or her participation is monitored and evaluated.

#### **2. Formalized Practicum/Internship Arrangements**

Here the student completes a fairly structured period of activity in the actual work setting of a sponsoring organization. This is usually arranged fairly late in the student's training, often on a competitive basis, typically at full salary, and under the supervision of the host organization's professional staff. The programs at IBM and Honeywell serve as good illustrations of this model. The key feature of this approach is that it is clearly designed as a training vehicle, albeit one in which the student can contribute to the organization's goals in one way or another.

#### **3. On-the-Job Experience**

In this case, the student is a regular employee of an organization that is engaged

in work relevant to the competency domains outlined previously. Supervision in this case is often split between the organization's professional staff and the student's academic advisor. In some cases (e.g., if the student is the organization's sole "human factors professional"), the academic supervisor must assume full responsibility for the training aspect of this experience, even though it is administratively under the employer's direction.

**4. Participation in Consulting Activities**  
Many individuals and groups of human factors professionals serve part- or full-time in a consulting mode. Participation in such activities can provide excellent (often broad-based) experience for the student.

(a) The same cautions cited under Section 1 above should be observed.

(b) The supervisor should recognize his or her ethical and legal responsibility to the client in providing adequate monitoring and supervision of the work performed by the student.

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This comment was prepared and modified by the Education and Training Committees of APA Division 21, Applied Experimental and Engineering Psychologists.

### **It's a Sin to Tell a Lie If You Don't Believe It Yourself**

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There are some peculiar philosophical assumptions implicit in Daniel L. Schacter's article "Amnesia and Crime" (March, 1986) that are never defended, or, for that matter, even identified. The most blatant

is that individuals who are capable of complete or nearly complete self-deception concerning their own criminal behaviors should be held less responsible for these actions than persons who fail to deceive themselves or are incapable of carrying out this feat. Thus, Schacter argued that if a person who commits a crime "genuinely" cannot remember doing it (I assume as a self-protective device), then he or she should not be held accountable for the crime. However, if the person only pretends not to remember, then he or she should feel the full force of the law and forthcoming punishment. It is a curious philosophical assumption that I believe should have been argued by Schacter, who, instead, seemed to take for granted that it did not merit discussion.

A second point, quite related to the first, is his use of the word *genuine*, which I assume refers to whether the individual is consciously aware of what he or she is doing, as opposed to having reached a state of self-deception without being aware of his or her own role in it. There also appears to have been some assumption on Schacter's part that hypnosis, sodium amytal, or polygraphs will give some insight into whether the self-deception is within awareness or outside of awareness. However, there seems to be ample evidence in the literature that such an assumption is false. Hilgard and Hilgard's (1975) research on pain appears to indicate that regardless of whether an individual states that he or she experiences pain, his or her blood pressure and other physiological responses will indicate that, at some level, he or she is in a state of discomfort. Sackeim, Nordlie, and Gur (1979), in a report on cases involving "functional" blindness, indicated that although an individual might claim that he or she cannot see, learning curves that he or she generates suggest otherwise. Recent studies by Sheehan and McConkey (1982) and Howard and Coe (1980) reveal that there appear to be differences in the styles by which hypnotic subjects are able to accomplish tasks, and that although some are able to achieve amnesia, for example, without being aware of even trying to do it (these persons would be called "genuine" by Schacter), others appear to have to work hard to accomplish the same hypnotic tasks. Coe (1978) has referred to the former as "happenings" and the latter as "doings."

Psychologists may be able to identify in various experiments some signs that might differentiate between those persons who are unable to deceive themselves but are actively trying to deceive the experimenter and those who are able to deceive