

Defining Ergonomics/Human Factors

P. G. Dempsey*, M. S. Wogalter[†] and P. A. Hancock[‡]

*Liberty Mutual Research Institute for Safety, 71 Frankland Road, Hopkinton, MA 01748, USA

[†]Department of Psychology, North Carolina State University, Raleigh, NC 27695, USA

[‡]Department of Psychology, University of Central Florida, Orlando, FL 32816, USA

The title *International Encyclopedia of Ergonomics and Human Factors* suggests that ergonomics and human factors are possibly two separate subject areas which are being covered. The conjunctive “and” would support this interpretation. If ergonomics and human factors are synonymous, why not just use one name? Several years ago, the main professional organization of this area in the United States decided to change its name by adding the term “ergonomics.” They also decided to add the conjunctive “and,” as opposed to separating the names by a dash or a slash, forms that are more frequently used to connote synonymy. The society is now called the Human Factors and Ergonomics Society (HFES). If ergonomics and human factors are the same, then why not use a slash instead of the “and” and call it Human Factors/Ergonomics Society? And for that matter, why not call this encyclopedia, the *International Encyclopedia of Ergonomics/Human Factors*? It is difficult to pronounce a slash (in speech, it is omitted). Thus, persons unfamiliar with the field would probably find the slash version rather odd sounding, hearing a string of three words and not knowing if the second word is an adjective. Conjoining both ergonomics and human factors in a name sounds better. In fact, there is a journal that uses “and,” *Human Factors and Ergonomics in Manufacturing*. This journal is edited by the same editor as this encyclopedia (Professor W. Karwowski).

Many professionals, although not everyone, consider the terms ergonomics and human factors synonymous. To some, ergonomics traditionally involves the physical aspects of work, while human factors involves perception and cognition. Ergonomics evolved from studying the interactions between humans and their surrounding work environment (with environment defined broadly to include machines, tools, the ambient environment, tasks, etc.). Use of the term “human factors” tends to be a North American phenomenon used by individuals who do work (research, teach, practice) with “above the neck” mental processes. Most of the rest of the world more frequently uses the term ergonomics to include “above the neck” and “below the neck” processes. In the latter, the areas of biomechanics and physical workplace design are emphasized. The use of the term ergonomics in the United States has typically implied “below the neck” activities, but it has become more in line

with other parts of the world, increasingly so as the term ergonomics is used and heard more often.

More recently in the US, ergonomics has been added to the label human factors as ergonomics became better known (through mass market public media, such as advertising for cars and chairs). Also, the superordinate organization, a level over the national and culture-specific organizations of the field, is called the International Ergonomics Association (IEA). Further, all of the worldwide societies use a form of the word ergonomics, only the US includes ‘human factors’ in the title.

Since ergonomics has been more closely allied with the physical aspects of the field, to better distinguish it from the more mental/cognitive part, there has been increasingly greater use of the labels “cognitive ergonomics” and “industrial or occupational ergonomics.” Indeed, there are technical groups of the HFES that use these distinctions. We expect to see greater use of the term ergonomics in the US, but we also continue to expect to see people distinguishing between the physical and cognitive sides of the field, including journal titles.

There appears to be a growing consensus that human factors and ergonomics (HF/E) refer essentially to a common body of knowledge. Despite this confluence, the discipline still suffers from a lack of name recognition. Most persons of the lay public, business, government, and academics generally do not have much of an idea what the field is all about. Most individuals have little problem understanding established areas like physics, chemistry, mathematics, and astronomy, probably because they have a basis in school curricula. The relatively new field of psychology, which is about 100 years old, has become so well recognized that many high schools now offer courses in it. HF/E has not reached this level of exposure. In fact, exposure to the field is rather scant even in colleges and universities. Martin and Wogalter (1997) examined the availability of HF/E courses to college students in the United States. Fifty schools were selected randomly from each of four categories of universities and colleges (research, doctoral, masters, and baccalaureate/liberal arts) from a listing of four-year colleges and universities in the United States. Only 2% (one school) in the sample of

liberal arts colleges and only 10% of the master's universities had a course in HF/E. Of the doctoral institutions, 62% had not a single HF/E course, and 44% of the research institutions had no HF/E courses. Other than a brief mention in a back chapter of an introductory psychology text book or of an industrial/organizational psychology text book, most college students have virtually no (or at best, scant) opportunity to learn about the field. This is particularly true if the university does not have an Industrial/Systems Engineering Department. Although Industrial Engineering Departments are the primary source of ergonomics research and teaching in the occupational ergonomics subspecialty, and the cognitive ergonomics subspecialty in some departments, not all Industrial Engineering Departments in the US have an ergonomics curriculum. This is one of the problems of not being considered a unique field by colleges and universities — the role of education and research is left to other departments that may or may not have a vested interest.

One obvious and crucial problem lies in the two predominant names that we have talked about above. Human factors is a general, indistinct term; one cannot deduce from this name the content of the knowledge domain. A lay person might guess that the field deals with human beings, but they probably would not recognize that it deals with (among other things) people interfacing with technology. Rather, the lay person might expect that a human factors psychologist deals with some special form of therapy, or perhaps, person to person interaction (and interestingly, this is one of the few domains that human factors does not address). This problem not only occurs with psychologists, but an engineer who says their area is human factors will also have problems eliciting much understanding by lay persons as well.

With the term ergonomics, the problems are different. One is that, unfortunately, the word ergonomics is very close to economics: the two can easily be confused by listeners and readers. But considering this differently, this resemblance can be turned into an advantage as Hendrick (1996a) did in his influential publication entitled "Good Ergonomics is Good Economics."

The "ergo" of ergonomics means work. The breadth of the field could be considered constrained by this prefix. Thus, how "work" is defined is critical. Many people may limit "work" to mean activities associated with employment. This frame of reference would not, for example, include leisure pursuits, an area certainly covered by the field's intent. Work can, however, be interpreted broadly, in that it involves the general physical expenditure of energy to accomplish a goal. Thus, most of what of humans do (and their bodily processes) could be justifiably considered to be work, and thereby, ergo related.

But what, besides work and the involvement of humans, defines the field? Whatever the actual name, one should ask

how the area is bound, what is its unique knowledge content, what are its central theses, and how do we provide a concise, succinct statement that characterizes the area? Here, we address the definition question, not simply as another exercise in polemics, but rather as a fundamental evaluation of where our area stands in the early years of the 21st century and to distill a way to advance our enterprise to a higher level of societal recognition and value.

One way to examine how an area embraces its domain is to see how it is being represented in various definitions. Definitions reflect how people specify some topic or concept using available language. Terms most frequently used to describe an area's scope can be a significant source of insight. In the present work, we extracted concise phrases describing HF/E from previous work (Dempsey *et al.* 2000; Wogalter *et al.* 1998) that involved analysis of numerous definitions.

Previously, we took the language from a set of 134 definitions from 78 sources compiled by Licht *et al.* (1990), and supplemented them with another 56 definitions from 35 sources of various kinds including HF/E textbooks and brochures, World Wide Web sites, introductory psychology, industrial/organizational psychology and safety engineering textbooks (Wogalter *et al.* 1998). Definitions selected were intended to describe the field circumscribed by one or more of the following names: ergonomics, human factors, human factors engineering, and engineering psychology. Some were short, dictionary type definitions (e.g. "the study of work" and "human-machine interface"); others were much longer accounts giving the contents and goals of the field. Example definitions are given in Table 1.

In the process of limiting the final list to the most frequently mentioned content words, Wogalter *et al.* (1998) first stripped the original set of definitions of certain elements, such as connecting words (e.g. the, and, to, which) that were unlikely to reveal meaningful interpretation. Additionally, the basic names designating the field were deleted, e.g. the term "ergonomics" was deleted if it appeared as part of the definition. The terms "human factors," "human factors engineering," and "engineering psychology" were also deleted when they co-occurred in these specific sequences, but the terms themselves were retained if they occurred in other word contexts and sequences. The remaining terms were then sorted alphabetically. Words with identical prefix roots were combined when the ending/suffix did not change the basic meaning of the word. Words with high frequencies were then used to create definitions of moderate length that express the field of HF/E.

Wogalter *et al.* (1998) argued that the content words with the highest frequency of mention across the included 134 definitions suggests that they are meaningful components describing the field. By combining these high frequency terms, basic or core definitions of the field can be formed. Moderate frequency terms can be used to refine the definitions with terms that elaborate the methods,

TABLE 1
Example Definitions

Brown, O. and Hendrick, H.W. (1986)	... the relations between man and his occupation, equipment, and the environment in the widest sense, including work, play, leisure, home, and travel situations
Chapanis, A. (1995)	... is a body of knowledge about human abilities, human limitations and other human characteristics that are relevant to design
Hancock, P. A. (1997)	... is that branch of science which seeks to turn human-machine antagonism into human-machine synergy
Mark, L.S. and Warm, J.S. (1987)	... attempts to optimize the fit between people and their environment
Howell, W. and Dipboye, R. (1986)	Person-machine system design
Meister, D. (1989)	... the application of behavioral principles to the design, development, testing and operation of equipment and systems
Clark, T.S. and Corlett, E.N. (1984)	... study of human abilities and characteristics which affect the design of equipment, systems, and jobs and its aims are to improve efficiency, safety, and well being
Sanders, M.S. and McCormick, E.G. (1993)	... designing for human use
Wickens, C.D. (1992)	... is to apply knowledge in designing systems that work, accommodating the limits of human performance and exploiting the advantages of the human operator in the process

goals, and other details. One example of a definition derived in this manner is: HF/E involves the application of engineering design to the study and production of safe and efficient human-machine systems. Using the same analysis approach, Dempsey *et al.* (2000) suggested the following definition: Ergonomics is "the design and engineering of human-machine systems for the purpose of enhancing human performance." Human performance includes health, safety and productivity. A few additional examples of moderate length appear in Table 2.

In Table 3, we have categorized the set of terms in another way. Here there is a small set of categories under the headings who, what, how, when/where, and goal. A quick study of this categorization undoubtedly inspires a well-suited definition or two. The table also provides a concise set of reference terms for describing our field to others.

Across the entire set of definitions examined in this exercise, the statements reflect a diversity in detail and purpose, varying in how much is given on the field's content, methods, and goals. Under different criteria, some statements would not be considered to be a true definition, but rather a description of methods or goals.

In August 2000, the International Ergonomics Association Executive Council adopted the following

definition (<http://www.iea.cc/ergonomics/>): "Ergonomics (or human factors) is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance." Although the IEA definition is fairly lengthy, it conveys many of the diverse ideas regarding what the field of ergonomics is about.

A survey and a series of focus groups in the United States (Hendrick 1996b) revealed that one of the primary complaints of HFES members was that untold numbers of people outside the field know little, if anything, about our field. As discussed at the outset, part of the problem has been our name, but also some of the problem may be that our definitions are not user-friendly. Most definitions have not been produced considering the varied population groups to whom they may be proffered. Using the word list study results mentioned earlier, a different set of definitions could be formed to target different recipient groups (e.g. lay persons vs. engineering/science experts). In fact, definitions could be tailored to a specific audience with whom you are speaking or working.

Technology is a powerful single force that is shaping human behavior. Too often, technology is "mindless" with respect to the individuals who either use it or are affected by it. A relatively small but growing group of HF/E professionals seek to mediate between growing technical systems and their human users. As technology becomes complex, there need to be even greater efforts in HF/E to enable synergistic relationships. Such efforts will be crucial to the path of true technological progress in the coming years. In order to attain its goal more effectively, the field needs a clear, concise, unequivocal and usable term to describe our efforts. We suspect that the term ergonomics will take that role, along with adjectives of physical and cognitive.

TABLE 2
Moderate-Length Definitions Formed from the Most Frequent Terms

- Designing and engineering human-machine systems
- Applying science to people performing in working environments
- Studying man's limited capabilities related to safe job operation
- Improving knowledge on the fit between users and tasks
- The interface between people and machines in systems

TABLE 3
A Short List of Terms Assigned to a Simple Category
Structure Describing Human Factors/Ergonomics

Who	What	How	When/Where	Goal
Human	System	Engineering	Environment	Safety
People	Machine	Designing	Work	Comfort
Users	Equipment	Applying	Life	Efficiency
Person	Product technology	Studying optimizing		

REFERENCES

- BROWN, O. and HENDRICK, H.W., 1986, *Human Factors in Organizational Design and Management – II* (Amsterdam: North-Holland).
- CHAPANIS, A., 1995, Ergonomics in product development: a personal view. *Ergonomics*, 38, 1625–38.
- CLARK, T.S. and CORLETT, E.N., 1984, *The Ergonomics of Workspaces and Machines: A Design Manual* (London: Taylor & Francis).
- DEMPSEY, P.G., WOGALTER, M.S. and HANCOCK, P.A., 2000, What's in a name? Using terms from definitions to examine the fundamental foundation of human factors and ergonomics science. *Theoretical Issues in Ergonomics Science*, 1(1), 3–10.
- HANCOCK, P.A., 1997, *Essays on the Future of Human Machine Systems* (Minneapolis, MN: Banta).
- HENDRICK, H.W., 1996a, Good ergonomics is good economics. *Ergonomics in Design* (Santa Monica, CA: Human Factors and Ergonomics Society).
- HENDRICK, H.W., 1996b, Road map to the future: revised strategic plan. *HFES Bulletin*, 35(10), 1, 5.
- HOWELL, W. and DIPBOYE, R., 1986, *Essentials of Industrial and Organizational Psychology* (3rd ed.) (Pacific Grove, CA: Brooks/Cole).
- LICHT, D.M., POLZELLA, D.J. and BOFF, K.R., 1990, *Human factors, ergonomic, and human factors engineering: an analysis of definitions*. Paper presented at the American Psychological Association (APA), New York (manuscript copy available from CSERIAC, Dayton, OH).
- MARK, L.S. and WARM, J.S., 1987, Editors' introduction. *Ergonomics and Human Factors* (New York: Springer-Verlag).
- MARTIN, D.W. and WOGALTER, M.S., 1997, The exposure of undergraduate students to human factors/ergonomics instruction. *Proceedings of the Human Factors and Ergonomics Society*, 41, 470–3.
- MEISTER, D., 1989, *Conceptual Aspects of Human Factors* (Baltimore, MD: Johns Hopkins University Press).
- SANDERS, M.S. and McCORMICK, E.J., 1993, *Human Factors in Engineering and Design* (7th ed.) (New York: McGraw-Hill).
- WICKENS, C.D., 1992, *Engineering Psychology and Human Performance* (2nd ed.) (New York: Harper Collins).
- WOGALTER, M.S., HANCOCK, P.A. and DEMPSEY, P.G., 1998, On the description and definition of human factors/ergonomics. In *Proceedings of the Human Factors and Ergonomics Society 42nd Annual Meeting*, Santa Monica, CA, pp. 671–4.