BOARD OF CERTIFICATION IN PROFESSIONAL ERGONOMICS

THE PROFESSIONAL ERGONOMIST

The Newsletter of the BCPE

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ANALYSIS, DESIGN AND TESTING/EVALUATION IN ERGONOMICS

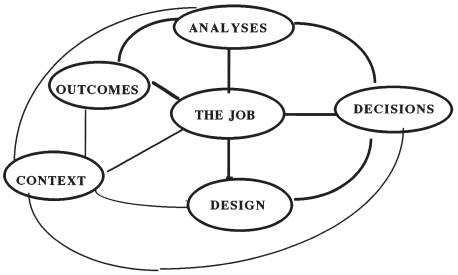
by Brian Peacock, Ph.D., PE, CPE and Dieter W. Jahns, M.S., CPE

According to Van Cott and Huey (1992, page 9), the most prevalent terms that are used for our profession include *human factors, human factors engineering, and ergonomic*s. Although these terms are often interchangeable, in the United States human factors tends to be the broadest category; human factors engineering tends to emphasize design; and ergonomics tends to be concerned with 'people at work' ." The issues with which we work arise in every domain in which humans interact with the products, processes and policies of a technological society. Yet, as individuals, all humans constantly live and work simultaneously in three worlds, eloquently described by Popper and Eccles (1985). One is the *Natural World (NW)* which exists and functions with, or without, human "interventions". A common purpose of engineering, technology and medicine is to harness or combat the forces of this natural world. For example we build shelters to protect ourselves from the elements and ever faster transportation to help us master space and time. Medicine attempts to offset the effects of biological battles, and time.

The second world is the Subjectively *Experiential World (EW)* which articulates how we respond to the external and internal milieu of stimuli and structures, emotions, and the mind. This mind is at the center of the world of the unique individual. While its locus has been identified by scientists and philosophers as being in the brain, the mind's structures and functions are subjects of intense debates and research, e.g. Eccles and Robinson (1985), Pinker (1997). It has been said that theories of the mind tend to be desparate analogies of the latest snazzy theory of something else, be it computing, chaos, quanta or complexity (e.g. see Howard, 1994).

The third world is the *Technological World (TW).* This is the observable world of human knowledge, characteristics and abilities as they interact with the Natural and Experiental worlds. This Technological World embraces the "techniques" of such fields as psychology, engineering, biomechanics, physiology, medicine, cognitive science, behavioral science, machine intelligence, computer science, sociology, education, political science, ethics, mathematics, economics, and philosophy which also form links with the Natural and Experiential worlds. Through such links and actions, all three worlds are changing in evolutionary fashion, as are the humans within these worlds. Our profession of Human Factors or Ergonomics feasts on these interactions, first to articulate the natural laws of "work", in the broadest sense, and then to develop the specific rules for the design of technology that will optimize human behavior, performance and satisfaction. "People at work" (that is people showing goal directed, purposive behavior requiring physical and mental effort) exhibit many common characteristics and behaviors while retaining their individual uniqueness.

To understand and change work systems, ergonomists use iterative processes of analysis and design to effect desirable outcomes of "work". These activities of ergonomists frequently interact with and are sometimes indistinguishable from the policy setting role of management and government. Of particular importance is the issue of "accommodation" which reflects the proportion of a defined population who are likely to interact successfully with a particular design and context. The conceptual model shown sets the scene for a discussion of the ergonomics process.



The "Job"

A job, process or situation involves purposive interactions among human, hardware, software, organizational and environmental "subsystems." This job may be real or a simulation, it may exist in the past, present or future. It may occur in the field or the laboratory. The context affects the validity of our investigations, predictions and interventions.

The "Outcomes"

The objectives, purposes or outcomes of "the job," process or simulation may be measured in terms of such things (dependent variables) as accuracy, quality, speed, productivity, injuries, illnesses, discomfort, satisfaction etc.

ANALYSIS CYCLES

Analysis (description) first seeks to describe the characteristics of "the job" and its elements (subsystems, independent variables) in terms of such things as space, time, mass, force, information, environmental factors, organizational factors, human factors and their combinations. These are simple or complex engineering (hardware, software, humanware or organizational design) quantities that are relevant to design. It should be noted that, eventually, (design) engineers will have to deal with univariate values and that complex interactions, indices or equations will have to be decomposed into their constituent elements before being applied to design.

Analysis (proper) is the process of measuring, or predicting, the relationships between these subsystem variables and process (job) outcomes. It is inevitable that

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such analysis will have a probabilistic basis because of human, situational and temporal variability, and the complexity of specific interactions.

DESIGN CYCLES

Design (or specification) consists of engineering (hardware, software, humanware, organization) statements that generally take the form of quantitative values. These design statements may consist of single values or ranges of adjustability (e.g. chair height, screen contrast, interface options etc.). Design also has a temporal context. Design statements or specifications may be made early (or late) in a project or in response to analysis of an existing "job". In the latter case it may be more appropriate to discuss "intervention" or "re-design".

Design Decisions

Where design is for an individual person or situation with well defined characteristics, it is usually possible to specify single ("tailored") values (e.g. shoe width, spectacle diopter, tall person.) More commonly, however a design decision has to accomodate a "population" of potential users, a range of conditions (normal and abnormal system function) and various temporal factors (fatigue, memory, learning) affecting human and system performance capability.

Usually design decisions will address issues of cost, risk, benefit; and these decisions are usually the domain of the manager, or the government, with help from their technical and political advisors. In many situations, design decisions are the result of negotiation between various factions given uncertain evidence.

Design Assumptions

It is usual, and indeed necessary, to make some assumptions about "the population" and the conditions or context. The population will be either formally or informally selected, trained and experienced. For example, the driver's workspace in vehicles do not usually address the characteristics of children; aircraft cockpits, process control rooms and legal briefs do not cater for the knowledge base of the untrained; the elderly may often be at a disadvantage in the use of modern "hi tech" devices; finally, professional sports activities exclude the unprepared. On the other hand, many consumer products, such as telephones or houses are designed for much broader populations.

Design Policy

Whether the population is broad or narrow, there will usually need to be a design decision to accomodate a certain portion of these expected (and unexpected) users. For example, in simple anthropometric based design it is common to discuss the 5th and 95th percentiles. In system safety specifications it is usual to offer protection at the 1 to 10,000 level or more. These design policy decisions are rarely the province of the human factors engineer or ergonomist. Rather, they are based on marketing opportunity, management inclination or government requirements. Commonly, these design decisions are related to "expected utility" or "cost benefit" evidence which relates the probabilistic nature of human accomodation to the value (or cost) of the outcome.

Design Implementation (Manufacturing)

Manufacturing is the process by which a design is implemented in a physical sense. Organizational "design" may be implemented by a "rollout" process or by decree. Humanware "design" is implemented through selection, training and assignment. Design implementation often gives rise to new knowledge and the need for new analysis and decisions in an iterative way.

Production

Production brings manufacturing from the single prototype into the real world context of volume, time constraints and other interactions between customers and suppliers of products or services. For example, an automobile assembly plant may have to produce 1000 vehicles a day; an airline booking process may have to deal with thousands of customers; and an emergency response service may be severly constrained by time and resource restrictions.

Use

Use has similar characteristics to production. One difference is that the human users of products or services may have a choice between alternative systems. On the other hand, employees of manufacturing or production processes commonly have less choice regarding the systems with which they interact.

TEST AND EVALUATION CYCLES

Test and evaluation are analyses that occur during the design, manufacturing, production or use processes. The purpose of test and evaluation is to measure, confirm or predict the outcomes of a process in order to initiate some (re)design intervention. The concepts of iterative design and "continuous improvement" are based on formal or informal test and evaluation. The challenge to human factors engineers/ergonomists is to separate the effects of levels (or changes) in independent variables through well designed processes under statistically controlled conditions.

SUMMARY

In summary, economists analyze the human, hardware, software and environmental ingredients of jobs (or simulations) as they affect one or more outcomes. The design, manufacturing and production processes integrate the results of these analyses with information regarding the cost, risk, utility or "importance" of the outcomes, with due regard to user population accommodation policy.

An Illustrative Example - Personal Ground Transportation.

The process of personal ground transportation involves the interaction between the driver, the vehicle, the roadway and various environmental conditions, including other traffic. The principal outcomes of this transportation process include speed (time of journey completion) and accuracy (safety). Other pertinent outcomes may include comfort, style and cost. These outcomes may be positively or negatively related to one another. "The job" will commonly be a journey or a particular "transaction", such as reading the temperature gauge, choosing a turn or avoiding an obstacle.

Analysis (system description) will include quantitative (or qualitative) measurement of such things as driver age, vehicle displays, traffic conditions and weather.

Analysis (proper) will involve the measurement of outcome variables as they are affected by changes in, and combinations of, the system variables. In the present case the analyses may be focused on the duration and accuracy of transactions involving a navigation system and their effect on performance of primary driving tasks such as steering and braking.

Design decisions may be confined to such simple things as display character height or symbol color, or more complex choices between operationally different navigation systems. These decisions (in the larger context of the design process) may be related to the cost of alternative systems and the probability of significant interference with primary task performance.

Design policy may include consideration of cost, roadway capacity and road safety. Many organizations aspire to have input to these issues, and there are many different agendas. The customer is concerned with such things as style, comfort, convenience, power, cost and reliability. The producer is concerned with profit, competition, avoidance of law suits and company image. The local authorities wish to move traffic through their limited—capacity road system efficiently. Various sectors of government may be concerned with vehicle, roadway, manufacturing system

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safety and protection of the environment. *Design policy* is clearly complex and the traditional ergonomics input may fade into the background.

Design implementation (including production, distribution, sales and support services) involves the employment of many people. The complexity of this real world informal test and evaluation is such that many and varied desirable and undesirable outcomes may result.

Formal test and evaluation may take many forms. Gross sales, traffic or accident statistics may be decomposed (analyzed) to influence future design policy. Specific broad surveys of new vehicle owners may be used to fine tune designs. Controlled road tests or crash tests may be used to influence more fundamental design issues. Finally, customer clinics, simulation and formal laboratory tests may be used to evaluate the outcomes of interactions between particular design entities.

For example, automobile, insurance and consumer organizations may be concerned with the use of emergency communication systems by older drivers. The practicing ergonomist will be expected to apply his/her skills and tools to the resolution of specific evaluation questions in the complex context of many, sometimes differing, views of "the design."

The ergonomics process outlined above can be formalized using some of the (modified) concepts of Quality Function Deployment. The main point that should be made in conclusion is that we should not treat analysis, design and test and evaluation in isolation. Rather we should communicate to students and professionals alike the contextual relevance of these separate aspects of our jobs as part of larger processes and the realities of a complex three-world view. The books by Chapanis (1997) and Meister (1997) provide a fundamental baseline on how to achieve that goal.

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THE CHANGING NATURE OF ERGONOMICS AROUND THE WORLD

by Martin Helander, Ph.D., CPE
Immediate Past President IEA
(Excerpted from "IEA International News and Information", February, 1996)

Human factors and ergonomics began in the Western world, and have proliferated around the world. In Europe ergonomics started with industrial applications in the 1950s, and used information from work physiology, biomechanics and anthropometry for design of workstations and industrial processes. The focus was on the well-being of workers and manufacturing productivity. In the USA, human factors engineering, human factors, or engineering psychology developed from military problems. Human factors has its origin in experimental psychology and systems engineering. The purpose is to enhance systems performance.

Ergonomics and human factors have spread since the 1950s to Asia, Africa, Latin America and Australia. In many industrially developing countries the emphasis in ergonomics has been on biomechanics, heat stress and work physiology. The economic conditions were different, and there was a greater tendency to use manual labor. As an example, Eriksson (1976) estimated 20 years ago that 200 workers at a road construction site could move as much dirt manually as one construction vehicle, and the costs were equivalent. Under such circumstances the national economy, as well as the workers' economy, will gain by using manual labor. Thus the interests and focus of ergonomics are specific to the needs of the country. However, with the introduction of computers in industrially developing countries, there has been a shift in interest; and the problems of usability of complex systems are now universal.

Results of the IEA survey

A survey among 25 IEA Federated Societies investigated the interests and activities of ergonomists around the world (Brown et al., 1995). Federated Societies were asked to estimate the proportion of eligible ergonomists who belonged to their Society. The average estimate was 61%. Since the number of members of IEA Federated Societies is about 16,000, the current world-wide population of ergonomists would be about 25,000. I personally believe that this is an underestimation. In the first place, there are many ergonomists working in countries that do not belong to IEA. In the second place, many ergonomists belong to other professional societies, and may not be considered in the estimate of 61%.

Table 1. The most important needs in 25 federated societies.

Specific needs	Frequency
Training and education	5
Diffusing ergonomics into industry	4
Marketing of ergonomics	4
Start-up and sustaining financial sources	3
Increased membership of society	3
Greater involvement with the European Societies and IEA	3
More members from different professions	3
Establishing more of a network interchange and support function	2
Recognize a multi-disciplinary approach to problem solving	2
Total	25

Of the current membership, 29% are academics, 27% practice in industry, 15% are researchers, 10% are private consultants, 8% work for the government, and 11% work in other occupations.

Despite the formal education of members in ergonomics, many societies claimed that the major problem facing the occupation was recognition by the government, industry and public. This was an issue of great concern both for professional societies and for individuals belonging to them. To improve this situation, societies seek new ways to enhance their profession. Certification and licensing of ergonomists is an important issue. It is also important that ergonomists can find ways of communicating among themselves.

The federated societies suggested many specific needs that societies must consider (Table 1).

Table 2 (on page 4) compares the current applications of ergonomics to the early applications (when a federated society was founded). Only the five most important areas are listed in the table. Of the early applications, anthropometry, work physiology and psychology were replaced by safety, workload assessment and human-computer interaction. This illustrates the current trend towards cognitive ergonomics.

Federated Societies indicated important emerging areas of ergonomics interest (table 3 on page 4). A new image of ergonomics is emerging from this survey. There has been a shift in interest over the last 20 years. The diffusion of computer technology and complex machinery has had a tremendous impact. Cognitive ergonomics, usability studies, human reliability, and human-computer interaction are new top priorities. Organizational design and the study of industrial change processes and continuous improvement are

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Table 2. The five most important early and current "contents" of ergonomics in 25 ergonomics societies.

Importance	Early applications	Current applications
1	Anthropometry	Safety
2	Work physiology	Industrial engineering
3	Industrial engineering	Biomechanics
4	Biomechanics	Workload
5	Psychology	Human-computer interaction

Table 3. Important emerging areas in ergonomics in 25 ergonomics societies around the world.

Topics	Frequency
Methodology to change work organization and design	7
Work-related musculoskeletal disorders	7
Usability testing for consumer electronic goods	6
Human-computer interface: software	6
Organizational design and psychosocial work organization	5
Ergonomic design of physical work environment	4
Control room design of nuclear power plants	3
Training ergonomists	3
Interface design with high technology	3
Human reliability research	3
Mental workload	3
Workforce cost calculation	3
Product liability	2
Road safety and car design	2
Transfer of technology to developing countries	2

also important. Biomechanics and work physiology are less dominating than they were in the past, except that there is a renewed interest in biomechanics owing to musculoskeletal disorders.

This trend was valid not only for industrialized countries but also for industrially developing countries. It behooves our profession to take note of this new emphasis. Since the beginning of ergonomics around 1950, society and technology have developed tremendously. Brian Shakel characterized the development as follows (Hendrick, 1993):

1950s - military ergonomics
1960s - industrial ergonomics
1970s - consumer products ergonomics
1980s - human-computer interaction and software ergonomics
1990s - cognitive ergonomics and organization ergonomics

Our profession is driven by design requirements from users, markets, industries, organizations and governments. Ergonomics must be able to quickly respond to the changing needs of society. Training programs in ergonomics must be able to incorporate new areas of interest. Certifications programs for ergonomists must be flexible enough to reconsider current needs, and teaching programs must incorporate new knowledge (Bullock, 1995).

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CERTIFICANT ROSTER FALL 1997

Twenty candidates sat for the BCPE Fall 1997 exam. Ten successfully passed the certification exam to earn the CPE/CHFP credential. Five candidates were successful in earning the AEP/AHFP credential.

Those successful in sitting for the Fall 1997 exam were:

Susan M. Boast MS AEP
David G. Curry PhD CPE
Roel R. Enriquez MSPH CPE
Victor S. Garrison BA CPE
Michelle Garner MSIE CPE
Stacy R. Johnson MS CPE
Gerard C. Jorna PhD CHFP
Dona M. Kambeyanda MS AHFP
Steven G. Kappes-Sum MS AEP
Ellen E. Meyer BS CPE
Gregory M. Rowell MBA CPE
Michael J. Welch MS CHFP
Syed A. Naqvi PhD CPE
Lisa A. Orr MSIE AEP
Tamara J. Smolar BA AEP

Dr. Jorna, who resides in the Netherlands, moved up from an AHFP to CHFP with the results of this exam and fulfillment of the four year work experience requirement.

Dennis Wylie BA CPE was certified in the new special category discussed in a previous issue of the newsletter.

Guido Romagnoli MSc AEP qualified for Associate certification by waiver of part one of the exam.

These certificants bring current totals of BCPE certificants to 725 CPE/CHFPs and 54 AEP/AHFPs.

Hugh Smith MA and David Gertman PhD are no longer active certificants.

A work session of the 1997 BCPE Annual Meeting in Albuquerque. Clockwise from bottom, left: Valerie Rice, President; Karel Jahns, Office Manager; Brian Peacock, Director; Dave Alexander, Treasurer; Hal Hendrick, Director; H. Harvey Cohen, Director; and Doug Harris, Vice-President.

Retiring BCPE Director Honored. Valerie Rice, President, thanked Colin Drury for his services as BCPE director and presented him with a plaque at the Albuquerque BCPE Reception.

BCPE 1998 Calendar of Events

March 10-11,1998	IIE's Applied Ergonomics Conference (BCPE co-sponsor) "Practitioners talking with Practitioners" Renaissance Atlanta Hotel in Atlanta GA
April 6, 1998	BCPE Exam – Various sites in the US and Canada Postmark Deadline for application: February 6, 1998
April 17-19, 1998	BCPE MidYear Business Meeting – Denver CO
May 3, 1998	BCPE Exam – Palo Alto CA at ErgoCon '98 Postmark Deadline for application: March 3, 1998
May 3- 6, 1998	ErgoCon '98 (BCPE co-sponsor) – Hyatt Ricky's in Palo Alto CA
October 4, 1998	BCPE Exam – Chicago IL (prior to the HFES 42nd Annual Meeting) Postmark Deadline for application: August 4, 1998
October 1998	BCPE 9th Annual Meeting – Chicago IL
October 4-8, 1998	HFES 42nd Annual Meeting

BCPE ACTIVITIES IN ALBUQUERQUE NM IN SEPTEMBER

The exam was given to 20 applicants on Sunday, September 21 on a downpour rainy day. A great day to take an exam but unlike what participants had expected from the sunny New Mexico's Land of Enchantment.

The BCPE reception and book fair held at the Double Tree in Albuquerque the evening of Thurs, September 25 was well attended and seemed to be enjoyed by all. President Valerie Rice, CPE, awarded Colin Drury, CPE a plaque of appreciation for service on the BCPE Board of Directors to develop professional practice criteria and standards. Authors Al Chapanis, CHFP; David Meister, CPE; and Hal Hendrick CPE signed their books which were purchased. Book sales were moderate, and a few CPE lapel pins were sold. Costs of the event far outweighed any income, but then that wasn't really our purpose. A good time was had by all who attended, and the annual BCPE reception tradition will be continued.

The Board of Directors and BCPE staff held the 8th Annual Meeting, Sept 26 -27 and addressed many issues facing BCPE. Highlights are:

1) Continued development of the new level of certification to encompass practitioners at a scope of practice of lesser dimensions than the current AEP/AHFP and CPE/CHFP certifications. Much time was spent by the Board in a work session on this project. A timetable was established for development of the exam of this certification with the goal of offering the first exam for applicants in October 1998.

2) Web Site development decisions were made (see related article).

3) Establishment of a "CPE/CHFP (retired)" status with a certification maintenance fee of $25.00 per year was approved. This status prohibits the practice of ergonomics. It is meant for those who no longer practice ergonomics and are on limited income. One must be current in certification maintenance fees and meet all criteria of the CPE/CHFP to qualify and use the designator CPE (retired)/CHFP (retired).

4) BCPE will co-sponsor (at no charge to us) the IIE Applied Ergonomics Conference in Atlanta in March 1998, in addition to ErgoCon '98 in May.

5) BCPE will formally respond to "IEA's Certification and Accreditation Guidelines".

6) Election of officers was conducted to keep the current slate of officers for another year. They are: President - Lt. Col. Valerie Rice, CPE; Vice President - Doug Harris , CPE; Treasurer - Dave Alexander, CPE; and Secretary - Robert Smillie, CPE

7) Various administrative motions were adopted for smoother procedures at headquarters.

It was a very productive session, and Albuquerque's southwest ambiance and sunshine were enjoyed by all.

CERTIFICANT PAGES ON THE BCPE WEB SITE

by Doug Harris, Ph.D., CPE

The BCPE Web Site at http://www.bcpe.org has been redesigned to provide more information about individual certificants and better access to that information. The decision to make these changes (and to expend the resources required to do so) was based on the assumption that a principal service that the BCPE can provide to its certificants is that of supplying this kind of information to potential employers and clients. Plans for these changes were discussed in the previous newsletter.

Format of Certificant Web Pages

At this time each individual certificant has his or her own Web Page on the BCPE Web Site. Each Web Page contains the following information, obtained from the certificant database maintained at BCPE headquarters.

Certificant Name and Certification
Name of Employer/Business
Address
Telephone Number
Fax Number
E-mail Address
Highest Degree/Institution

A visitor to the BCPE Web Site may now search certificants by Name or by Location. For example, a list of the names of all certificants located in Virginia may be obtained. From this list, the Web Page of an individual certificant may then be obtained by clicking on the name of the certificant.

Addition of Areas of Specialization

To increase the information provided about each certificant and to add new ways of getting to this information, certificant specialties will be added to the individual pages. Thus, a prospective employer or client who wishes to find a certificant specializing in, say, Computers or Materials Handling or Space Exploration, may obtain a list of those who have specified that specialty. Another click will take them to the page of any one of the certificants listed. In a similar manner, certificants may be searched on their Professional Expertise specialty, such as Decision Making or Forensics or Workload.

Since information about areas of specialization must come from the certificant (it is not available in the current certificant database), that information must now be obtained to implement this part of the Web Site. Certificants may provide their areas of specialization by completing the form that accompanies this newsletter and mailing it to BCPE headquarters, or by completing the same form on the internet at http://www.bcpe.org/update.htm. We prefer that the form be completed and submitted on the internet. Please note that for purposes of limiting access to the update form, the update page is not linked to the BCPE Web Site.

We recognize ahead of time that some certificants might prefer some other method of categorizing areas of specialization, and that others will have specializations that might not fit well with the categorizations employed. We have attempted to mitigate some of the inevitable criticism by using two types of specialization—systems/products and expertise, by matching these areas with categorizations employed elsewhere (including those used in ergonomics textbooks), and by testing the categories with a sample of certificants and making modifications before going to press.

Expansion of Web Pages and Linkages to Other Web Sites

We are providing the opportunity for certificants to expand the information on their Web Pages and to link their pages directly to another Web Site (such as their company's Web Site). An example of an expanded page is the one now provided for Douglas H. Harris. The page contains a photograph and additional information—career highlights, education, employment history, and references to a sample of publications, and is linked to the Anacapa Sciences, Inc. Web Site. An expanded page plus the link to one other Web Site is available for $100 per year. This package may be purchased at the Store on the BCPE Web Site, and information may be submitted for construction of the page by using the form provided at the Store.

As before, we welcome suggestions for improving the site and putting it to work for certificants. Please send them to dougharris@anacapasciences.com.

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The Newsletter of the BCPE

Fall 1997
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