Ergonomics

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Encyclopedia
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To assess the fit between a person and the used technology, ergonomists consider the job (activity) being done and the demands on the user; the equipment used (its size, shape, and how appropriate it is for the task), and the information used (how it is presented, accessed, and changed). Ergonomics draws on many disciplines in its study of humans and their environments, including anthropometry, biomechanics, mechanical engineering, industrial engineering, industrial design, kinesiology, physiology and psychology.

Typically, an ergonomist will have a BA or BS in Psychology, Industrial/Mechanical Engineering or Industrial Design or Health Sciences, and usually an MA, MS or PhD in a related discipline. Many universities offer Master of Science degrees in Ergonomics, while some offer Master of Ergonomics or Master of Human Factors degrees. In the 2000s, occupational therapists have been moving into the field of ergonomics and the field has been heralded as one of the top ten emerging practice areas.

- Physical ergonomics: is concerned with human anatomical, and some of the anthropometric, physiological and bio mechanical characteristics as they relate to physical activity.
- Cognitive ergonomics: is concerned with mental processes, such as perception, memory, reasoning, and motor response, as they affect interactions among humans and other elements of a system. (Relevant topics include mental workload, decision-making, skilled performance, human-computer interaction, human reliability, work stress and training as these may relate to human-system and Human-Computer Interaction design.)
- Organizational ergonomics: is concerned with the optimization of socio technical systems, including their organizational structures, policies, and processes. (Relevant topics include communication, crew resource management, work design, design of working times, teamwork, participatory design, community ergonomics, cooperative work, new work programs, virtual organizations, telework, and quality management.)
History and etymology

The foundations of the science of ergonomics appear to have been laid within the context of the culture of Ancient Greece. A good deal of evidence indicates that Hellenic civilization in the 5th century BC used ergonomic principles in the design of their tools, jobs, and workplaces. One outstanding example of this can be found in the description Hippocrates gave of how a surgeon's workplace should be designed and how the tools he uses should be arranged (see Marmaras, Poulakakis and Papakostopoulos, 1999). It is also true that archaeological records of the early Egyptians Dynasties made tools, household equipment, among others that illustrated ergonomic principles. It is therefore questionable whether the claim by Marmaras, et al., regarding the origin of ergonomics, can be justified (I G Okorji, 2009).

The term ergonomics is derived from the Greek words ergon [work] and nomos [natural laws] and first entered the modern lexicon when Wojciech Jastrzębowski used the word in his 1857 article Rys ergonomii czyli nauki o pracy, opartej na prawdach poczerpiętych z Nauki Przyrody (The Outline of Ergonomics, i.e. Science of Work, Based on the Truths Taken from the Natural Science).

Later, in the 19th century, Frederick Winslow Taylor pioneered the "Scientific Management" method, which proposed a way to find the optimum method for carrying out a given task. Taylor found that he could, for example, triple the amount of coal that workers were shoveling by incrementally reducing the size and weight of coal shovels until the fastest shoveling rate was reached. Frank and Lillian Gilbreth expanded Taylor's methods in the early 1900s to develop "Time and Motion Studies". They aimed to improve efficiency by eliminating unnecessary steps and actions. By applying this approach, the Gilbreths reduced the number of motions in bricklaying from 18 to 4.5, allowing bricklayers to increase their productivity from 120 to 350 bricks per hour.

World War II marked the development of new and complex machines and weaponry, and these made new demands on operators' cognition. The decision-making, attention, situational awareness and hand-eye coordination of the machine's operator became key in the success or failure of a task. It was observed that fully functional aircraft, flown by the best-trained pilots, still crashed. In 1943, Alphonse Chapanis, a lieutenant in the U.S. Army, showed that this so-called "pilot error" could be greatly reduced when more logical and differentiable controls replaced confused designs in airplane cockpits.

In the decades since the war, ergonomics has continued to flourish and diversify. The Space Age created new human factors issues such as weightlessness and extreme g-forces. How far could environments in space be tolerated, and what effects would they have on the mind and body? The dawn of the Information Age has resulted in the new ergonomics field of human-computer interaction (HCI). Likewise, the growing demand for and competition among consumer goods and electronics has resulted in more companies including human factors in product design.

The coining of the term Ergonomics, however, is now widely attributed to British psychologist Hywel Murrell, at the 1949 meeting at the UK's Admiralty, which led to the foundation of The Ergonomics Society. He used it to encompass the studies in which he had been engaged during and after the Second World War.

Applications

More than twenty technical subgroups within the Human Factors and Ergonomics Society (HFES) indicate the range of applications for ergonomics. Human factors engineering continues to be successfully applied in the fields of aerospace, aging, health care, IT, product design, transportation, training, nuclear and virtual environments, among others. Kim Vicente, a University of Toronto Professor of Ergonomics, argues that the nuclear disaster in Chernobyl is attributable to plant designers not paying enough attention to human factors. "The operators were trained but the complexity of the reactor and the control panels nevertheless outstripped their ability to grasp what they were seeing [during the prelude to the disaster]."

Physical ergonomics is important in the medical field, particularly to those diagnosed with physiological ailments or disorders such as arthritis (both chronic and temporary) or carpal tunnel syndrome. Pressure that is insignificant or imperceptible to those unaffected by these disorders may be very painful, or render a device unusable, for those who are. Many ergonomically designed products are also used or recommended to treat or prevent such disorders, and to treat pressure-related chronic pain.

Human factors issues arise in simple systems and consumer products as well. Some examples include cellular telephones and other hand held devices that continue to shrink yet grow more complex (a
phenomenon referred to as "creeping featurism"), millions of VCRs blinking "12:00" across the world because very few people can figure out how to program them, or alarm clocks that allow sleepy users to inadvertently turn off the alarm when they mean to hit 'snooze'. A user-centered design (UCD), also known as a systems approach or the usability engineering life cycle aims to improve the user-system.

Design of ergonomics experiments

There is a specific series of steps that should be used in order to properly design an ergonomics experiment. First, one should select a problem that has practical impact. The problem should support or test a current theory. The user should select one or a few dependent variable(s) which usually measures safety, health, and/or physiological performance. Independent variable(s) should also be chosen at different levels. Normally, this involves paid participants, the existing environment, equipment, and/or software. When testing the users, one should give careful instructions describing the method or task and then get voluntary consent. The user should recognize all the possible combination's and interactions to notice the many differences that could occur. Multiple observations and trials should be conducted and compared to maximize the best results. Once completed, redesigning within and between subjects should be done to vary the data. It is often that permission is needed from the Institutional Review Board before an experiment can be done. A mathematical model should be used so that the data will be clear once the experiment is completed.

The experiment starts with a pilot test. Make sure in advance that the subjects understand the test, the equipment works, and that the test is able to be finished within the given time. When the experiment actually begins, the subjects should be paid for their work. All times and other measurements should be carefully measured and recorded. Once all the data is compiled, it should be analyzed, reduced, and formatted in the right way. A report explaining the experiment should be written. It should often display statistics including an ANOVA table, plots, and means of central tendency. A final paper should be written and edited after numerous drafts to ensure an adequate report is the final product.

Ergonomics in the workplace

Outside of the discipline itself, the term 'ergonomics' is generally used to refer to physical ergonomics as it relates to the workplace (as in for example ergonomic chairs and keyboards). Ergonomics in the workplace has to do largely with the safety of employees, both long and short-term. Ergonomics can help reduce costs by improving safety. This would decrease the money paid out in workers’ compensation. For example, over five million workers sustain overextension injuries per year. Through ergonomics, workplaces can be designed so that workers do not have to overextend themselves and the manufacturing industry could save billions in workers’ compensation.

Workplaces may either take the reactive or proactive approach when applying ergonomics practices. Reactive ergonomics is when something needs to be fixed, and corrective action is taken. Proactive ergonomics is the process of seeking areas that could be improved and fixing the issues before they become a large problem. Problems may be fixed through equipment design, task design, or environmental design. Equipment design changes the actual, physical devices used by people. Task design changes what people do with the equipment. Environmental design changes the environment in which people work, but not the physical equipment they use.

Engineering psychology

*Engineering psychology* is an interdisciplinary part of ergonomics and studies the relationships of people to machines, with the intent of improving such relationships. This may involve redesigning equipment, changing the way people use machines, or changing the location in which the work takes place. Often, the work of an engineering psychologist is described as making the relationship more "user-friendly."

Engineering psychology is an applied field of psychology concerned with psychological factors in the design and use of equipment. *Human factors* is broader than engineering psychology, which is focused specifically on designing systems that accommodate the information-processing capabilities of the brain.

Macroergonomics

Macroergonomics is an approach to ergonomics that emphasizes a broad system view of design, examining
organizational environments, culture, history, and work goals. It deals with the physical design of tools and the environment. It is the study of the society/technology interface and their consequences for relationships, processes, and institutions. It also deals with the optimization of the designs of organizational and work systems through the consideration of personnel, technological, and environmental variables and their interactions. The goal of macroergonomics is a completely efficient work system at both the macro- and micro-ergonomic level which results in improved productivity, and employee satisfaction, health, safety, and commitment. It analyzes the whole system, finds how each element should be placed in the system, and considers all aspects for a fully efficient system. A misplaced element in the system can lead to total failure.

History
Macroergonomics, also known as organizational design and management factors, deals with the overall design of work systems. This domain did not begin to receive recognition as a sub-discipline of ergonomics until the beginning of the 1980s. The idea and current perspective of the discipline was the work of the U.S. Human Factors Society Select Committee on the Future of Human Factors, 1980-2000. This committee was formed to analyze trends in all aspects of life and to look at how they would impact ergonomics over the following 20 years. The developments they found include:

1. Breakthroughs in technology that would change the nature of work, such as the desktop computer,
2. The need for organizations to adapt to the expectations and needs of this more mature workforce,
3. Differences between the post-World War II generation and the older generation regarding their expectations the nature of the new workplace,
4. The inability of solely microergonomics to achieve reductions in lost-time accidents and injuries and increases in productivity,
5. Increasing workplace liability litigation based on safety design deficiencies.

These predictions have become and continue to become reality. The macroergonomic intervention in the workplace has been particularly effective in establishing a work culture that promotes and sustains performance and safety improvements.

Methods

• Cognitive Walk-through Method: This method is a usability inspection method in which the evaluators can apply user perspective to task scenarios to identify design problems. As applied to macroergonomics, evaluators are able to analyze the usability of work system designs to identify how well a work system is organized and how well the workflow is integrated.

• Kansei Method: This is a method that transforms consumer’s responses to new products into design specifications. As applied to macroergonomics, this method can translate employee’s responses to changes to a work system into design specifications.

• High Integration of Technology, Organization, and People (HITOP): This is a manual procedure done step-by-step to apply technological change to the workplace. It allows managers to be more aware of the human and organizational aspects of their technology plans, allowing them to efficiently integrate technology in these contexts.

• Top Modeler: This model helps manufacturing companies identify the organizational changes needed when new technologies are being considered for their process.
• Computer-integrated Manufacturing, Organization, and People System Design (CIMOP): This model allows for evaluating computer-integrated manufacturing, organization, and people system design based on knowledge of the system.

• Anthropotechnology: This method considers analysis and design modification of systems for the efficient transfer of technology from one culture to another.

• Systems Analysis Tool (SAT): This is a method to conduct systematic trade-off evaluations of work-system intervention alternatives.

• Macroergonomic Analysis of Structure (MAS): This method analyzes the structure of work systems according to their compatibility with unique sociotechnical aspects.

• Macroergonomic Analysis and Design (MEAD): This method assesses work-system processes by using a ten-step process.

Seating ergonomics

The best way to reduce pressure in the back is to be in a standing position. However, there are times when you need to sit. When sitting, the main part of the body weight is transferred to the seat. Some weight is also transferred to the floor, backrest, and armrests. Where the weight is transferred is the key to a good seat design. When the proper areas are not supported, sitting in a seat all day can put unwanted pressure on the back causing pain.

The lumbar (bottom five vertebrate in the spine) needs to be supported to decrease disc pressure. Providing both a seat back that inclines backwards and has a lumbar support is critical to prevent excessive low back pressures. The combination which minimizes pressure on the lower back is having a backrest inclination of 120 degrees and a lumbar support of 5 cm. The 120 degrees inclination means the angle between the seat and the backrest should be 120 degrees. The lumbar support of 5 cm means the chair backrest supports the lumbar by sticking out 5 cm in the lower back area. One drawback to creating an open body angle by moving the backrest backwards is that it takes one body away from the tasking position, which typically involves leaning inward towards a desk or table. One solution to this problem can be found in the kneeling chair. A proper kneeling chair creates the open body angle by lowering the angle of the lower body, keeping the spine in alignment and the sitter properly positioned to task. The benefit of this position is that if one leans inward, the body angle remains 90 degrees or wider. One misconception regarding kneeling chairs is that the body’s weight bears on the knees, and thus users with poor knees cannot use the chair. This misconception has led to a generation of kneeling chairs that attempt to correct this by providing a horizontal seating surface with an ancillary knee pad. This design wholly defeats the purpose of the chair. In a proper kneeling chair, some of the weight bears on the shins, not the knees, but the primary function of the shin rests (knee rests) are to keep one from falling forward out of the chair. Most of the weight remains on the buttocks. Another way to keep the body from falling forward is with a saddle seat. This type of seat is generally seen in some sit stand stools, which seek to emulate the riding or saddle position of a horseback rider, the first "job" involving extended periods of sitting.

Another key to reducing lumbar disc pressure is the use of armrests. They help by putting the force of your body not entirely on the seat and backrest, but putting some of this pressure on the armrests. Armrest needs to be adjustable in height to assure shoulders are not overstressed.
Organizations

The International Ergonomics Association http://www.iea.cc (IEA) is a federation of ergonomics and human factors societies from around the world. The mission of the IEA is to elaborate and advance ergonomics science and practice, and to improve the quality of life by expanding its scope of application and contribution to society. As of September 2008, the International Ergonomics Association has 46 federated societies and 2 affiliated societies.

The International Society of Automotive Engineers (SAE) is a professional organization for mobility engineering professionals in the aerospace, automotive, and commercial vehicle industries. The Society is a standards development organization for the engineering of powered vehicles of all kinds, including cars, trucks, boats, aircraft, and others. The Society of Automotive Engineers has established a number of standards used in the automotive industry and elsewhere. It encourages the design of vehicles in accordance with established Human Factors principles. It is one the most influential organizations with respect to Ergonomics work in Automotive design. This society regularly holds conferences which address topics spanning all aspects of Human Factors/Ergonomics.

In the UK the professional body for ergonomists is The Institute of Ergonomics and Human Factors and in the USA it is the Human Factors and Ergonomics Society http://www.hfes.org. In Europe professional certification is managed by the Centre for Registration of European Ergonomists http://www.eurerg.org (CREE). In the USA the Board of Certification in Professional Ergonomics http://www.bcpe.org performs this function. In Canada the professional body for ergonomists is the Association of Canadian Ergonomists (www.ace-ergocanada.ca)