

Applied Industrial Ergonomics (IE 665)

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What is Ergonomics?

"Ergonomics (or human factors) is the scientific discipline concerned with the understanding of the interactions among human 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."

(IEA Executive Council 2000)

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Early History of "Human Factors"

1400s

- Leonardo da Vinci studies function of muscle and bone

1500s

- Galileo Galilei uses concept of constant period of oscillation to measure heart rates with a pendulum

1600s

- William Harvey postulates the existence of capillaries in connecting veins and arteries for proper circulation

1700s

- Stephen Hales measures arterial pressure & correlates it with hemorrhage & ventricular forces; shows how aorta's elastic properties convert pulsatile flow from heart into smooth flow

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Ergonomics: Foundations

- o Bernardino Ramazzini (1633-1714), Founder of occupational/ industrial medicine.
 - ✓ Studied occupational diseases and advocated workplace inspection a necessary tool for discovering causes of the diseases, for preventing diseases and preventing them.
 - ✓ Encouraged eventual passage of factory safety and workmen's compensation laws.
 - ✓ In 1700 he wrote *De morbis artificum diatriba* (Diseases of Workers) in Latin describing the health hazards of irritating chemicals, dust, metals, other abrasive agents and repetitive motions for workers in 52 occupations.

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Bernardino Ramazzini, 1700.

He recommended the starch makers to carryout their activities in the open spaces and to limit dust exposure... "I always advise these workmen to carryout this sort of work in a sunny and specious place, not in a confined quarter." **and to wash and dry corns to limit the possibility of inhaling dust ...** "... so that even when corn (wheat and barley) is in good condition, I consider it is worth the trouble to wash and dry it thoroughly, before taking it to the mill"



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Bernardino Ramazzini, 1700.

- "[I have seen] workers in whom certain morbid affections gradually arise from some particular posture of the limbs or unnatural movements of the body called for while they work."
- "Such are the workers who all day stand or sit, stoop or are bent double, who run or ride or exercise their bodies in all sorts of [excess] ways." ... " . . . the harvest of diseases reaped by certain workers . . . [from] irregular motions in unnatural postures of the body."

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Bernardino Ramazzini, 1700.

- Standing:
 - “Those who work standing ...carpenters, sawyers, carvers, blacksmiths, masons . . . are liable to varicose veins. . . [because] the strain on the muscles is such that the circulation of the blood is retarded.”
 - “Standing even for a short time proves exhausting compared with walking and running though it be for a long time. . . . Nature delights and is restored by alternating and varied actions.”

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Bernardino Ramazzini, 1700.

Sitting

- “Those who sit at their work suffer from their own particular diseases. [As noted back in Roman times by the learned slave] Plautus, ‘sitting hurts your loins, staring, your eyes.’ ”
- “All sedentary workers...suffer from the itch, are a bad color, and in poor condition... . For when the body is not kept moving the blood becomes tainted, its waste matter lodges in the skin, and the condition of the whole body deteriorates.”

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History of “Human Factors” in Design

Late 1800s / Early 1900s: The Industrial Revolution

- Frank and Lillian Gilbreth
 - study of human motion and workplace management
 - skilled performance, fatigue, workstations & equipment for physically disabled
 - **e.g. surgical teams study** - improved efficiency by suggesting new protocol: surgeons should call for instrument which is placed in extended hand by nurse
 - forerunners of “human factors” research

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History of “Human Factors” in Design

The Best Way to Lift Bricks

- Frank and Lillian Gilbreth: “...to lift 90 pounds of brick at a time is most advantageous physiologically as well as economically ...”

Bricks/Lift	1	18	24
Weight/Lift (lbs)	5	90	120
Work/Hour (kCal)	520	285	450
Bricks/Hour	250	600	300



Optimal Procedure →

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Recent History of “Human Factors” in Design



1900-1945: Workplace was “Task Oriented”

- people adapted to the job and equipment required
- tests developed for better worker selection and training
- BUT, still an “efficiency gap” that called for a paradigm shift by fitting job/tools to the person

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1945-1960: “Human Factors” Profession is Born

- ✓ first engineering psychology labs established in US & Britain
- ✓ first ‘Ergonomics Research Society’ formed in Britain
- ✓ first book on human factors in engineering design
- ✓ first scientific journal in 1957 – ‘Ergonomics’
- ✓ International Ergonomics Society launched in 1959



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1960-1980: Rapid Growth

- up to 1960, human factors research limited to military
- interest and need fed by “Race for Space”
- expansion beyond military and space research to industry and workplace (e.g. computers, automobiles, and other consumer products)



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1980-Today: Computers, Disasters, & Lawsuits

- **Computers** - desire for “people-oriented” technology grew through ergonomically designed computers, user-friendly software, and office design
- **Disasters** – Three Mile Island, Chernobyl, and various high-profile chemical plant explosions were linked to lack of attention to “human factor” considerations
- **Lawsuits** – courts came to recognize the need for experts in explaining human behaviour, responses, defective design, and effectiveness of workplace warnings and instructions

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What is Ergonomics?

Alternative Names

- Humans Factors Engineering
- Human Engineering
- Occupational Psychology
- Engineering Psychology
- Applied Experimental Psychology

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What is Ergonomics?

Ergonomics

- Ergonomics is the study and optimization of the interaction between people and their physical environment by considering their physical, physiological, and psychological characteristics.



Occupational/Industrial Ergonomics

- Concerns the application of ergonomics principles specifically to the workplace and related tasks.

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What is NOT Ergonomics?

1. NOT just applying “universal” checklists and guidelines blindly
2. NOT using oneself as the model for design since there is diversity and variation
3. NOT just using common sense since must be based on real data and information



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Six Pillars of Ergonomic Design

1. **User Orientation:** Design and application of tools, procedures, and systems must be user-oriented, rather than just “task” oriented
2. **Diversity:** Recognition of diversity in human capabilities and limitations, rather than “stereotyping” workers/users
3. **Effect on Humans:** Tools, procedures, and systems are not “inert”, but do influence human behaviour and well-being

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Six Pillars of Ergonomic Design

4. **Objective Data:** Empirical information and evaluation is key in design process, rather than just use of “common sense”
5. **Scientific Method:** test and retest hypothesis with real data, rather than “anecdotal” evidence or “good estimates”
6. **Systems:** object, procedures, environments, and people are interconnected, affect one another, and do not exist in “isolation”

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Ergonomics/Human Factors

- Ergonomics (European) and Human Factors (US) basically are the same disciplines.
- Ergonomics is the ‘science of work’, from ‘ergon’ or ‘ergos’ (Greek – work) and ‘nomos’ or ‘nomikos’ (Greek – laws).
- Ergonomics is multidisciplinary and uses multiple methods.
- Ergonomics is user focused
- If it doesn’t affect design in some way, it isn’t ergonomics.

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Ergonomics – Physical Design

- Who are the users?
- How does technology fit different user dimensions?
- How does technology fit user anatomy?
- How does technology fit user strength?
- How does technology fit different user abilities?
- How safe is the technology (health, comfort, performance)?
- How do users interact with technology?

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Ergonomics – Cognitive design

- How do users expect the technology to work?
- How is information displayed?
- How well are stereotypical expectations met?
- How complex is the interface?
- How much training is required?
- What user knowledge assumptions are met?
- How does information facilitate learning and memory?

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Ergonomics - Layout

- Are the work items optimally positioned in terms of comfort, convenience, and frequency of use?
- How well does the layout support the work flow?
- Who can be accommodated by the layout?
- How flexible is the layout when work content changes?

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Ergonomics - Ambient conditions

- Physical environment conditions at work
- What are the prevailing climate conditions that could effect the work (thermal, luminous, acoustic, vibration, air quality, electromagnetic field)
- What are the exposures?
- What protection is required?

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Ergonomics – Work content

- Job design selection and training
- What are the work patterns (shifts etc.)
- What are the work tasks?
- What are the required skills (Physical, Cognitive, Social)?
- What are the training needs?
- What can be simulated?

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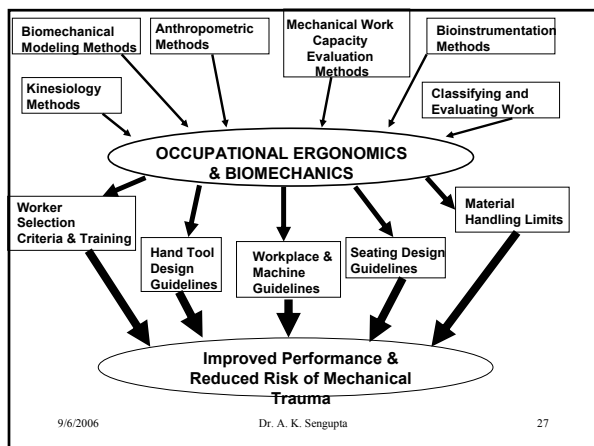
Macroergonomics

- Organizational design and management
- How should team work?
- What motivate users?
- How should functions be allocated?
- How should team be led?
- What are the opportunities for participatory ergonomics?

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Ergonomics

- Ergonomics is the scientific study of how people interact effectively with products, equipment, facilities, procedures and environments used at work and in everyday living.
- Ergonomics seeks to match the design of machines, jobs and workplaces with the capabilities, limitations and needs of people.
- Ergonomics seeks to maximize ease of use and optimize operator productivity, comfort and health.

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Ergonomic Considerations

- Physical factors - ambient conditions; objects (tools, furniture, etc.)
- Biological factors - body dimensions, body capabilities, physiological processes
- Psychological factors - mental workload, information processing, training, motivation
- Work factors - job demands (time, rate, etc.), job design
- Organizational factors - organization type/climate, management regimes

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The Need for Ergonomics

Evidence from Epidemiology

- Disabling work injuries in US (1990) = 1.8 million
- Permanent Impairment in US (1990) = 600,000
- Sprains/Strains account for 43% of work injuries
- Musculoskeletal conditions in US (1988) = \$126 Billion
- Reduction of worker's compensations costs by 36-91% by companies using Ergonomics in workplace
- Areas of Injury
 - 61%(back), 8%(knee), 7%(ankle), 6%(shoulder), 3.3%(wrist), 3%(neck)
- Causes of Injury
 - Overexertion (31%), impact (24%), and falling (17%), other (28%)

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The Ergonomics Profession

“Human Factors Society” Member Backgrounds (1991)

Psychology	45.1 %
Engineering	19.1 %
Ergonomics	7.7 %
Medicine/Life Sciences	3 %
Education	2.6 %
Industrial Design	2.4 %
Business	1.9 %
Computer Science	1.3 %
Other	8.3 %

The Ergonomics Profession

What Fields are Ergonomic specialists found in? (1991)

Computers	22 %
Aerospace	22
Industrial Processes	17
Health and Safety	9
Communications	8
Transportation	5
Other	17