

Applied Industrial Ergonomics (IE 665)

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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.**"

International Ergonomics Association (IEA) Executive Council 2000

Ergonomics: Foundations

- [Bernardino Ramazzini \(1633-1714\).](http://www.collegiumramazzini.org/messages/sld001.htm)
<http://www.collegiumramazzini.org/messages/sld001.htm>
- 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**.

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

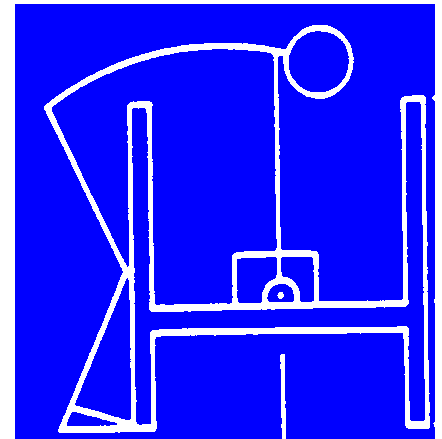
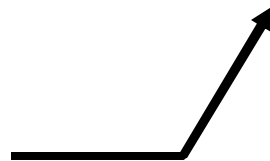
History of “Human Factors” in Design

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

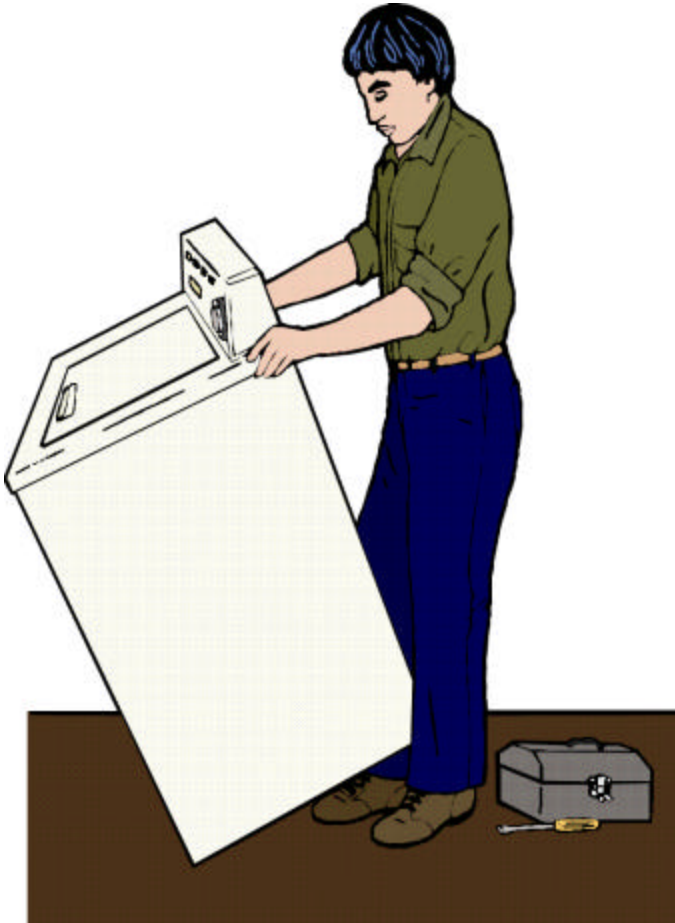
Optimal Procedure



History of “Human Factors” in Design

1900-1945: Workplace was “Task Oriented”

- people adapted to the task and equipment.
- tests were developed for better worker selection and training.
- “Efficiency gap” called for a paradigm shift by fitting job/tools to the person.



History of “Human Factors” in Design

1945-1960: “Human Factors”

Profession was born

- first engineering psychology labs were established in US & Britain
- first ‘Ergonomics Research Society’ was formed in Britain
- first scientific journal in 1957 – ‘Ergonomics’
- International Ergonomics Society launched in 1959



History of “Human Factors” in Design

1960-1980: Rapid Growth

- Initially human factors research was 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)



History of “Human Factors” in Design

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

Alternative Names of Ergonomics

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

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.

Occupational Ergonomics

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



What Ergonomics is NOT

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



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

Six Pillars (continued)

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”

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?

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?

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?

Ergonomics - Ambient conditions

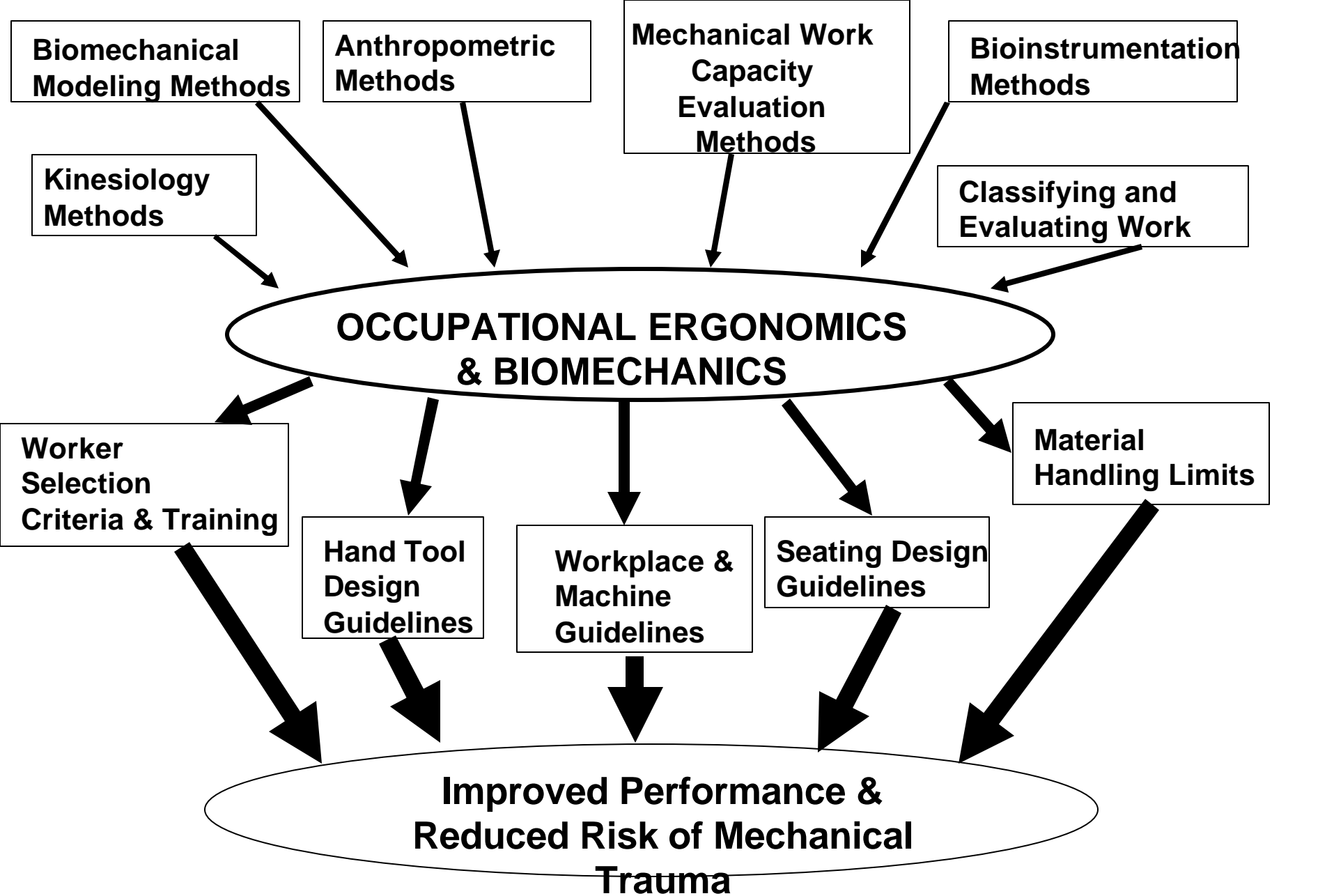
- Physical environment conditions at work
- What are the prevailing climate conditions that could effect the work (thermal, luminous, acoustic, vibration, air quality, electromagnetic field)
- What are the exposures?
- What protection is required?

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?

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?



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.

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

Need for Occupational Ergonomics

- 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%)

Need for Occupational Ergonomics (cont)

- “Social Justice” understanding of work and employment
- Trend in industrialized countries to accommodate individual workers regardless of physical capabilities, age, gender, or race
- Changing international standards for “work capacity” limits and “worker selection” tests
- Research reveals greater diversity of “performance” within age and gender groups than previously thought. For example, recommended weight-lifting standard in 1960s by International Standards Organization is illegal now in many countries because it “stereotypes” age/gender lifting limits

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

The Ergonomics Profession

Where do Ergonomics specialists Work? (1991)

Private Business/Industry	74 %
Government Agencies	15
Academics/University	10

Where do Human Factors specialists Work? (1991)

Large Organizations	57 %
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