Lecture 1:
Concepts of human factors: ergonomics

ENVD 5380 Human Factors in Environmental Design

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Ergonomics?

• Questions:
  – Engineering physiology?
  – Cognitive ergonomics?
  – Ergonomics and health aspects of work?
    • Working environment and Musculoskeletal disorders (MSD)?
  – Engineering, industrial design?
  – Ergonomics and computers?
  – What has to do with interior design?
Human factors (Ergonomics)

• Human factors
  – Ergonomics (synonymous)
  – Origins of ergonomics: Ergonomics is derived from Greek words.
    • Ergon/ergos (work)
    • Nomikos (adj.)/nomos (n.) (law-control and orderly assignment)
    • Ergonomics is the “Science of work”.
  – Engineering psychology
    • Psychologists
  – Human factors focuses on human beings and their interaction with products, equipment, facilities, procedures, and environments used in work and every day living.
    • Emphasis is on human beings and how the design of things influences people. Human factors seeks to change the things people use and the environments in which they use these things to better match the capabilities, limitations, and needs of people.
Human factors (Ergonomics)

• Objectives of Human factor:
  – To enhance the effectiveness and efficiency with which work and other activities are carried out.
    • Increasing convenience of use, reduced errors, increased productivity.
    • Only a subset of the objectives are generally of highest importance in a specific application.
  – To enhance certain desirable human values.
    • Including improved safety, reduced fatigue and stress, increasing comfort, greater user acceptance, increasing job satisfaction, and improving quality of life.
    • The objectives are usually correlated.
Human factors (Ergonomics)

• Approach of human factors:
  – It is the systematic application of relevant information about human capabilities, limitations, characteristics, behavior, and motivation to the design of things and procedures people use and the environment in which they use them.
  – Designing for human use and optimizing working and living conditions.
  – Human factors discovers and applies information about human behavior, abilities, limitations, and other characteristics to the design of tools, machines, systems, tasks, jobs, and environments for productive, safe, comfortable, and effective human use (Chapanis, 1985).
Ergonomic Design

• Ergonomics (Human factor) is not an inherent attribute of products.
  – Human factor is not just applying checklist and guidelines.
  – Human factors is not using oneself as the model for designing things.

• Ergonomics (Human factor) is more than “common sense”.
  – Example: knowing how long it will take pilots to respond to a warning light or buzzer is not just common sense. **Common sense is not very common.**

• To be “Ergonomic” a design must:
  – Fit the user
  – Be easy to use
  – Improve comfort
  – Improve performance (speed, accuracy, reliability)
  – Improve health and safety.
A history of Ergonomics (Human factors)

• Ergonomics: Foundation, Bernardino Ramazzini (1633-1714).
  – Founder of occupational/industrial medicine.
  – Studied occupational diseases and advocated of protective measures for workers.
  – Encouraged eventual passage of factor safety and workmen’s compensation laws.
  – In 1700, he wrote De morbis artificum diatriba (diseases of workers) describing the health hazards of irritating chemicals, dust, metals, other abrasive agents and repetitive motions for workers in 52 occupations.
Bernanadino Ramazzini (1700)

• Standing:
  – “Standing even for a short time proves exhausting compared with walking and running though it be for a long time...”

• Sitting:
  – “Those who sit at their work suffer from their own particular diseases.”
  – “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.”

• Repetitive hand motions:
  – “I have noticed bakers with swelled hands, and painful.... The hands of all such workers become much thickened by the constant pressure of kneading the dough.”

• Office work:
  – “The maladies that affect the clerks arise from three causes: first, constant sitting; secondly, incessant movement of the hand and always in the same direction; and thirdly, the stain on the mind...”
Productivity-Motion study

• The development of human factors in U.S.:
  – Its beginning in the industrial revolution of the late 1800s and early 1900s.

• Frank & Lillian Gilbreth (from 1908)
  – Pioneers and prolific authors, on motion study, motion study for the handicapped, fatigue study, etc.
  – Their work included the study of skilled performance and fatigue and the design of work stations and equipment for the handicapped.
  – Their analysis of hospital surgical teams resulted in a procedure used today.
Ergonomics (1900~1930s)

• Ergonomics (1900~1930s)
  – Telephones revolutionized communication
  – Automobiles assembly lines revolutionized industrial production methods in the early 1900s.
  – Typewriter technology and “assembly line” work processes reshaped offices in the early 1900s.
  – Typewriter design (1930s):
    • Keyboard layout
    • Poor neck posture

• Ergonomics (1940s)
  – WWII issues: Radio, radar, airplanes, simulators.
The birth of a profession

• 1945 to 1960: the birth of a profession
  – 1949: The name “ergonomics” accepted in UK. Ergonomics Research Society formed in UK.
  – 1952: “Ergonomics Society” formed with members from psychology, biology, physiology, and design.
  • Note: 1992: Human Factor Society renamed “Human factors and Ergonomics Society”.

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• 1957: Journal “Ergonomics” started.
Rapid growth of ergonomics

• 1960 to 1980: Rapid growth.
  – Until the 1960s, human factors in the U.S. was concentrated in the military-industrial complex.
  – Expanded beyond military and space applications.
    • Including computers, automobiles, pharmaceuticals, and other consumer products.
  – Despite all the rapid growth and recognition within industry, human factors (ergonomics) was still relatively unknown to the average person in 1980.
Computers, disasters, and litigation

• 1980 to 1990: Computers, disasters, and litigation
  – Computer technology
    • The computer revolution propelled human factors into the public.
    • Ergonomically designed computer equipment, user friendly software, and human factors in the office, new control devices, etc.
  – Disasters
    • In 1984, a leak of methylisocyanate (MIC) at the union carbide pesticide plant in Bhopal, India
    • In 1986 explosion and fire at Chernobyl nuclear power station in the soviet Union.
    • In 1989, an explosion a Phillips Petroleum plastics plant in Texas.
    • Meshkati (1991) found that inadequate attention to human factors considerations played a significant role in contributing to these disasters.
  – Litigation
    • Forensics and product liability and personal injury litigations.
    • Courts have come to recognize the contribution of human factors expert witnesses for explaining human behavior and expectations, defining issues of defective design, and assessing the effectiveness of warning and instructions.
Human Factors Profession

• Graduate education in human factors
• Who are human factors people?
• Where do human factors specialists work?
• What do human factors people do?
• How do human factors people feel about their jobs?
• Human factors beyond the human factors society... (Sanders, p.12).
The case for human factors

• Work environment
  – Physical demands (e.g. lifting limits)
  – Skill demands (e.g. typing at 100 wpm)
  – Risk demands (e.g. driving on ice)
  – Time demands (e.g. deadline)

• Physical environment
  – Physical agents
  – Chemical agents
  – Biological agents
The case for human factors

• Technology
  – Product design (anthropometrics, biomechanics)
  – Hardware interface design
  – Software interface design

• Psychosocial environment
  – Social
  – Cultural
  – Lifestyle
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
Forensic Human factors

- Accident analysis
- Historical data
- Observational data
- Accident reconstruction
- Critical incident analysis
- Near misses
- Deliberate near failure
- Error analysis
- Overload
- Environment demands
- Cognitive failures
- Human reliability analysis
Systems
Systems (Concept)

• Thinking in terms of systems:
  – “For every complex problem there is always a simple solution and it is wrong.”-H.L. Mencken
  – “The world we have made as a result of the level of thinking we have done thus far creates problems that we cannot solve at the same level (of consciousness) at which we have created them... we shall require a substantially new manner of thinking if humankind is to survive.”-Albert Einstein.
  – Systems thinking involves ‘seeing’ inter-connections and relationships, the whole picture as well as the component parts.
  – Systems thinking provides key insights for the management of complexity.
Systems

• Systems
  – A central and fundamental concept in human factors is the “system”.
  – A system is an entity that exists to carry out some purpose (Bailey, 1982).
    • The concept of a system implies that we recognize a purpose;
    • we carefully analyze the purpose;
    • we understand what is required to achieve the purpose;
    • we design the system’s parts to accomplish the requirements, and we fashion a well-coordinated system that effectively meets our purpose. (Bailey, 1982).
  – A system is an organized or complex whole; a combination of things or parts forming a complex, unitary whole.
Systems

• System Goals
  – Mission-Oriented systems
    • Needs of personnel are subordinated to the goals of the system
      – Example: mission to the moon.
  – Service-Oriented systems
    • Needs of the clients/users are part of the goals of the system
      – Example: hotel
Types of systems

- Human-Machine systems
  - Combination of one or more human beings and one or more physical components interacting to bring about, from given inputs, some desired output.

- Types of systems
  - Manual system
    - Physical aids that are coupled to the operator
      - Example: hand tools
  - Mechanical system
    - Operator uses controls to directly determine machine function
      - Example: car
  - Automated system
    - Operator uses supervisory control to monitor system performance.
      - Example: robotic assembly line
Characteristics of Systems

• Systems are purposive
  – Every system has a purpose (objective, goal)
    • Example: University goals include education, socialization, skills, research, administration, recruitment, financial, employment
Characteristics of Systems

• Systems can be hierarchical
  – Subsystems are parts of larger systems.
  – Defining where system analysis starts and ends requires decisions on:
    • System boundaries- what is and isn’t part of the system (not necessarily any right or wrong answers). Decisions based on the identification of system functions.
    • Limit of resolution- how deep does the systems analysis need to be?
    • Components- the lowest level of analysis required for defining a system. A component in turn can be a subsystem.
Characteristics of Systems

• Systems operate in an environment.
  – The system environment is everything outside of the boundaries of the system.
  – Depending on how the system’s boundaries are drawn, the environment can range from the immediate environment through the intermediate to the general.
    • Immediate environment:
      – Proximate environment around the system (e.g. workstation, a lounge chair, or a typing desk).
      – Usually has a demonstrable impact on system performance, such as lighting, noise, ventilation.
    • Intermediate environment:
      – More distant conditions and settings that are directly experienced (e.g. home, an office, a school, car, or campus store).
    • The general environment:
      – Neighborhood, a community, a city, or a highway system.
Characteristics of Systems

- Systems operate in an environment (cont’d).
  - Some aspects of the physical environment are part of the natural environment and may not be amenable to modification (e.g. heat or cold).
  - The nature of people’s involvement with their physical environment is passive.
  - However, the environment tends to impose certain constraints on their behavior.
    • Example: Limiting the range of their movements or restricting their field or view.
  - The environment tends to predetermine certain aspects of behavior.
    • Example: Stooping down to look into a file cabinet, wandering through a labyrinth in a supermarket to find the bread, or trying to see the edge of the road on a rainy night.
Characteristics of Systems

• System components serve functions.
  – Every component serves at least one function that is related to achieving the system goals. Allocating functions between people and machines is a key area in ergonomics.
  – Components serve various functions in systems:
    • Sensing (information receiving)
    • Information storage
    • Information processing and decision
    • Action functions.
Characteristics of Systems

• Components interact.
  – Components work together to achieve system goals.
  – Each component has an effect.

• Systems, subsystems, and components have inputs and outputs.
  – A system receives inputs from the environment and makes outputs to the environment.
  – Inputs can be physical entities (e.g. materials and products), electric impulses, mechanical forces, or information.
    • Open loop systems: When activated, needs no further control.
    • Close loop systems: Requires continuous control.
System reliability

• Components in series:
  – The more components that are in a series the less reliable the system. If a system has 100 components each of which is 99% reliable, then the system is only 36.5% reliable (a two-in-three chance of error or failure).
  – If one component fails the whole system fails. (e.g. decorative lights).

• Components in parallel:
  – Systems with parallel components have built in backup or redundancy.
  – Adding components in parallel increases system reliability.
  – Adding components in parallel is expensive.
Why have people in systems?

• To Care
• To be compassionate
• To know context
• To cooperate
• To create
• To innovate
• To understand...
Related articles from Journals

• Professional Journals:
  – Applied ergonomics
  – Ergonomics
  – Ergonomics News
  – The ergonomic open journal
  – Human factors
  – Human factors and ergonomics in manufacturing
  – International journal of cognitive ergonomics
  – International journal of industrial ergonomics
  – Occupational ergonomics
  – Safety & Health practitioner ergonomics supplement
  – Theoretical issues in ergonomics science
Assignment # 1

• Assignment # 1 (Concepts)
  – Write about “Relation of human factors and environmental design”.
  – Format:
    • a single space, 5-6 pages, 12 fonts,
    • Include text citations and references (APA style).
    • Should incorporate at least 1~2 references from professional journals.
Assignment # 1

– Contents
  • Title and your name
  • Introduction
  • Objectives
  • Method
  • Findings
  • Conclusions/Discussions
  • References

– Presentation in Power point
Reading references

• Lectures from:

• Reading assignments:
  – Sanders (1993), Ch. 13.