
Ergonomics – the *human factor*

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Introduction to the module

You will come across different terms for *ergonomics* and *human factors* while exploring this topic. The term human factors refers to “designing for human use” (Sanders & McCormick, 1993), and is mainly used in the USA and in some other countries. The name *ergonomics* is derived from the greek *ergon* meaning work, and *nomos* meaning natural law. The term ergonomics is favoured in Europe and many other parts of the world (including Australia). These terms are synonymous for all practical purposes.

The most useful definition is offered by the International Ergonomics Association who defines ergonomics (or human factors) as:

the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimise human well-being and overall system performance. Ergonomists contribute to the design and evaluation of tasks, jobs, products, environments and systems in order to make them compatible with the need, abilities and limitations of people. (IEA 2000)

Other terms used to describe all or parts of this discipline are human engineering, work physiology, biomechanics, engineering psychology and engineering anthropometry.

During the last decade public awareness of ergonomics has developed. More and more we hear about “ergonomically sound”, “ergonomically safe”, “ergonomically tested” and “ergonomically designed”, chairs, cars, razors, keyboards, home appliances, beds, offices, tools and equipment. Very rarely do we hear about an ergonomically sound job design or an ergonomically tested task.

Although I believe the two terms to be synonymous, ergonomics tends to be most widely understood by the general public as being concerned only with the physiological aspects of work. This course is concerned with all factors which are relative to optimising the work environment and considers both physiological and psychological factors. The title “Human Factors” reflects more closely the subject matter which will be covered.

Objective

Upon successful completion of this module you should have gained an overview of the discipline sufficient to provide the practical context for the “beginning practitioner”.

The best fit

Ergonomics or human factors is about finding the best fit between a person’s capabilities (physical, psychological and social) and the demands created by the job, equipment and environment.

The following example illustrates the range of factors, which are involved in performing a simple task.

Example 1–1

Let's begin with a simple task of turning on a cold tap.

1. Identify:
 - see the tap
 - recognise it as a tap
 - recognise the cold tap.
 2. Decide:
 - what direction to turn
 - where to grip the tap.
 3. Grip the tap.
 4. Turn.
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There are factors which influence how well the task is performed. For example:

- light—can we see the tap?
- appliance—can we recognise the tap?
- colour—can we expect the blue or green tap to be cold?
- direction—can we expect to turn a tap to the left, to turn it on?
- location—can we reach the tap and is the cold tap on the left?
- temperature—is the tap too hot or cold to grip?
- wetness—is the tap too slippery to grip?
- stiffness—is the tap too stiff or too loose?

You can see that the above factors are a combination of:

- sensory factors—(e.g. ability to see)
- cognitive factors—(e.g. ability to understand and interpret what we see)
- physical factors—(e.g. ability to grip and turn).

Ergonomics or Human Factors is about the design required to make tasks as easy and safe to perform as possible. In this design, the sensory, cognitive and physical aspects of a task must all be considered.

As you can see from the “Turning on a Tap” example, even a very simple activity is made up of a number of steps.

To analyse the demands of a job or task we must first define the job or task. A job can be described as the group of activities or tasks assigned to a position, e.g. “Storeman”.

Each job can be broken down into a group of tasks performed.

Basically a task is a set of human actions that contribute to a specific functional objective and ultimately the output goal of a system (Salvendy 1987, p. 373). Task analysis is the process of identifying and describing those actions. The process of identifying and describing units of work, and analysis the resources necessary for skilful work performance (Salvendy 1987, p. 375). Resources include worker and work environment.

Task analysis is this process of breaking jobs and tasks down to define what is actually done, tools used, etc. For example:

Example 1–2

Receiving goods

- unloading trucks using a forklift
- imputing receipts into computer
- inspecting goods.

Shelving goods

- unloading pallets
- pricing goods.

Each task can then be broken into sub-tasks or steps.

Unloading trucks

- open truck doors
- put down ramp
- drive forklift from store to truck
- put pallet on forklift prongs
- remove pallet from truck
- place pallet on shelf in store.

Each step could be broken into smaller components or movements if so desired.

From a physical ergonomics perspective, task analysis is important to identify critical steps or sub-tasks which need to be performed to complete the task. The design considerations can then be addressed.

Task analysis will be discussed in more detail later in the course; however, the table on the following page is an example.

Example 1–3

Task	Steps	Visual demands	Auditory demands	Manual demands
Move pallet	Reach handle Grip handle Pull 2m × force 30N Release handle	See pallet	Nil	Pull pallet jack and pallet
Enter data onto computer		Read screen	Nil	Keying

Posture	Tools or equipment	Visual environ	Auditory environ	Physical environ
Standing upright	Pallet jack	Illumine 160 lux	60 dBA	Flat even floor
Sitting upright	Keyboard Screen	Illumine 300 lux	55 dBA	Keyboard and screen height

As you can imagine task analysis when all the sensory, physical and cognitive components are included, is extremely complicated.

Ergonomics may focus on a number of goals: safety, efficiency, ease of operating, productivity, quality, job satisfaction, error minimisation etc. Ergonomists may come from various backgrounds: engineering, therapies, architecture, industrial design, psychology etc.

The best approach to ergonomics is a “transdisciplinary” approach. When a transdisciplinary approach is taken engineers, ergonomists, users, decision makers and all other stakeholders will be involved in the application of ergonomics. This creates two important conditions:

1. Ensuring the context of “actual use” is considered and is authentic.
2. An awareness of the discipline of ergonomics is grown which ensures that other team members are more likely to consider the principles early in system design.

This is especially important with regard to engineering as the earlier ergonomics principles are considered the more likely it is that there will be a reduction in design-induced end operator error, that is, a reduction in latent sources of error being built into the system.

The classic of all design deficiencies which have come to our attention was a combination safety shower and eyewash constructed at a northern missile site. In order to operate the eyewash, it was necessary for a man, who might already be blinded by acid, to put his head in the eyewash bowl and then turn on the water valve with his right foot. The only problem was that the foot-operated valve was about four feet to his rear and higher than his waist. As an additional feature, if a man did happen to hit the valve, he got a full shower from overhead as well as getting his eye washed out. However, the whole problem became academic in winter because the whole system froze up

Anonymous, 1959

Activity 1–1

The above scenario probably made you giggle but what is the real problem in the system design?

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How many examples of poor system design have you come across in either your work or home environment? List these below.

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How many of these were poor because end user had been forgotten in the development? So often the design process is centred on technical problem solving with the result that the user is not included in the problem definition and/or the design specification. Revisit the list above and add suggestions for how the designer might have included consideration for the end user.

Even when the human user is considered in the design process, the result is not satisfactory. Why is this so?

Pheasant (1986), offers an explanation as to why things don't work properly, he notes five fundamental fallacies assumed by designers:

This design is satisfactory for me—it will therefore, be satisfactory for everybody else.

This design is satisfactory for the average user—it will therefore, be satisfactory for everybody else.

The variability of human beings is so great that it cannot possibly be catered for in any design—but since people are wonderfully adaptable it doesn't matter anyway.

Ergonomics is expensive and since products are purchased on appearance and styling, ergonomic considerations may conveniently be ignored.

Ergonomics is an excellent idea. I always design things with ergonomics in mind—but I do it intuitively, and rely on my common sense so I don't need tables of data.

(Pheasant, 1986:8)

Do engineers have knowledge about the human component of their systems? The literature suggests that engineers have little understanding of the human component in their system development evidenced by the high rate of latent design error as a contributing factor to accidents. Who then does have the knowledge of the human component of engineering systems? The answer is another group of professionals known as ergonomists. What do they do?

Activity 1–2

Try defining the following terms:

- the engineering design process
- design objectives
- design specifications

- conceptual design
- discipline of human factors and ergonomics
- cognitive ergonomics
- physical ergonomics
- organisational ergonomics

Chances are that you were only able to draw on your own specific discipline knowledge, try this exercise again within someone from another discipline. It is likely that you found that language use is quite different in each discipline and you may have even found that the same words have different meanings.

Activity 1–3

Ponder for a moment on your previous experience and consider the question, is there any engineered system anywhere that does not impact on people and therefore does not need to consider people as integral part of the design of that system. Jot your thoughts below.

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If you think you have found one, please take time to let us know because we haven't yet found one.

Go back now and look at Pheasant's five fallacies of design. Do they mean anything different to you now then when you first met them? To improve designed systems we continually need to be innovative in the design process.

Research methods

There are many good texts on ergonomic research methods and quick search on the Internet will also provide many leads. The most important of these research methods is the Task Analysis. Completion of an effective task analysis is necessary as the foundation of all other ergonomic analysis. It is a fundamental skill required of ergonomists. The next section will revisit and expand on this important area.

Task analysis

Task analysis is used to highlight any mismatch between the demands of a particular task and the operator characteristics. Task analysis is important in system design and in analysis of present systems. It may be used for designing human-machine interfaces, instruction manuals, determining personnel requirements, developing training programs and the systems evaluation.

A “task” is often described as the smallest unit of a job and is described as a combination of a verb and a noun (for example, check alarm). The level of description will identify whether the task referred to is the whole process, one persons task or part of a job or jobs. Identification of any mismatch allows for the early recognition of potential problem areas or identification of problems that already exist.

The terms “task analysis”, “task description” and “job analysis” are often used interchangeably but normally (Pollock, 1990):

- **task analysis/description** focuses on the task (person and machines)
- **task description** gives a breakdown on the overall task
- **job analysis** focuses on the person.

The appropriate level of description required depends on the purpose of the description/analysis.

Information gathering

The information required to complete a task description and analysis will include what tasks are being performed; what information is used; and what are the consequences for the users (Pollock, 1990).

This is done by gathering information in relation to:

- **tasks**—observe and/or video tasks being performed, ask operators to describe task (during or after), read technical literature
- **users**—consult management, users and literature
- **problems**—consult users and management, accident reports, watch user operation, seek expert opinion, “field” test operation.

Task description methods



This link will help you develop a clear concept of task analysis and provide you with some guidelines for data collection and analysis.

Activity 1–4

Develop a Hierarchical Task Analysis (HTA) and describe how to cook your favourite dish (if you can't cook apply it to the washing up, mowing the lawn or having a bath!). Draw your HTA here.

You will have found that although the task you were describing above was very familiar to you, it can still be quite difficult to create a HTA. It is sometimes less difficult to apply these techniques to situations which are less familiar and allow you the luxury of impartial observation.



You should now do an Internet search for Operational Sequence Diagrams (OSD). The next activity will require development of an OSD.

Activity 1–5

Develop an OSD for the same task you described in the first activity. Draw it here.

Did you find that you were able to build from one technique to the other?

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Which technique was more suited to the type of task presented, and why?

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What types of data did you require to complete a HTA or OSD of this task?

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How did you go? You probably found that representing the task as a HTA was less difficult than describing the task as an OSD, some of you may have even preferred the OSD representation. Your individual professional judgement will support the decision for which type of description you will use.

Hopefully you will have found that it is getting easier to think in terms of systems, tasks and steps. The key to successful completion of these types of exercises is the quality of data collected. Good quality task analysis is an integral step to planning and evaluating the design of jobs, equipment and environment. If you are unsure of what is required to complete a task analysis you should reread this part of the module, consult a wide variety of texts in the area and consult with your colleagues until you are able to form a clear concept of what is required.

Summary

In this module we looked at the essence of ergonomics as a discipline. This is an extremely important module, which should inform your processes throughout the rest of your learning of this topic. Continue now into the nuts and bolts of physical, cognitive and organisational ergonomics. This module informed the process now the latter modules will inform the content.

References

International Ergonomics Society 2000, *International Ergonomics Association Homepage*, <http://www.iea.cc/>, [accessed 11/10/00].

Salvendy, G 1987, *Handbook of human factors*, John Wiley & Sons, New York.

Sanders, M & McCormick, E 1992, *Human factors in engineering and design*, 7th edn., McGraw-Hill International Editions, Singapore.

Review questions

Review question 1–1

For what applications could you use the information gained from a task description/analysis?

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Review question 1–2

How would you go about gathering the information required to assess tasks, users and problems?

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Review question 1–3

Describe comparatively the functions, which are better performed by human operators and machines.

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Review question 1–4

Apply one of the task description/analysis tools outlined and describe how to cook your favourite dish (if you can't cook apply it to the washing up, mowing the lawn or having a bath!).

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