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Human Factors Engineering (Ergonomics)

Book Chapter

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INTRODUCTION

The term "ergonomics" is derived from Greek words ergon (work) and nomos (natural laws) and first entered the modern lexicon when Wojciech Jastrzehowski used the word in his 1857 article (the outline of Ergonomics, that is, science of work, Based on the Truths Taken from the Natural Science). Since then, the term has been variously defined by different scholars.

International Ergonomics Association (2014) [1] defines ergonomics 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 optimize human well-being and overall system of performance. According to this definition, ergonomics is employed to fulfill the two goals of health and productivity. It is relevant in the design of such things as safe furniture and easy- to –use interfaces to machines. Proper ergonomic design is necessary to prevent repetitive strain injuries which can develop overtime and can lead to long term disability [2]. According to the International Ergonomics Association (2014) [1], ergonomics could be defined in three categorizations.

* Physical ergonomics: is concerned with human anatomical considerations, and some of the anthropometric, physiological and bio-mechanical characteristics as they relate to physical activity.

* Cognitive ergonomics: is concerned with internal processes, such as perception, memory, reasoning, and motor response, as they affect interactions among humans and other elements of a system. Relevant topical issues include internal 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 system, including their organizational structure, policies and processes. Relevant issues here include communication, crew resource management and work design, design of working times, team work, participatory design, community ergonomics, cooperative work, new work programs, virtual organizations, teleworks and quality management. The emerging field

of human factors in highway safety uses human factor principles to understand the actions and capabilities of road users-car and truck drivers, pedestrians, bicyclists, etc. and use this knowledge to design roads and streets to reduce traffic collision. Driver error is listed as a contributing factor in 44% of fatal collisions in the United States, so a topic of particular interest is how road users gather and process information about the road and its environment, and how to assist them to make the appropriate decision [3, 4].

Brookhuis, Hedge, Hendrick, and Salas-Stanton [5] define ergonomics as the science of fitting workplace conditions and job demands to the capabilities of the working population. According to them, effective and successful "fits" assure high productivity, avoidance of illness and injury risks and increased satisfaction among the workforce. Although the scope of ergonomics is much broader, the term here refers to assessing those work related factors that may pose a risk of musculo-skeletal disorders and recommendations to alleviate them. In all the different sheds of definition of ergonomics presented here, it is widely believed that the attention of ergonomics extends across work, leisure and other aspects of our lives. Hence, scholars generally agree that ergonomics, also known as human factors, is the scientific discipline that seeks to understand and improve human interactions with products, equipment, environments and systems. In this reasoning, therefore, drawing upon human biology, psychology, engineering and design, ergonomics aims to develop and apply knowledge and techniques to optimize system performance, whilst protecting the health, safety and well being of individuals involved.

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 B.C used ergonomic principles in the design of their tools, jobs and workplaces.

According to [6] one outstanding example of this can be found in the description Hippocrates gave of how a surgeon's work place should be designed and how the tools he uses should be arranged. They were also of the view that archeological records of the early Egyptians Dynasties made tools, household equipment, among others that illustrated ergonomic principles. However, it is therefore questionable whether the claim by [7] regarding the origin of ergonomics can be justified.

Later, in the 19th century, Fredrick Winslow Taylor pioneered the "Scientific Management" method, which proposed 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 of 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 bricklayers from 18 to 4.5, allowing bricklayers to increase their productivity from 120 to 350 brick per hour.

[8] reports that World War 11 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 co-ordination 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 differential controls replaced confusing 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 great forces.

[9] questions, how far could environments in space be tolerated, and what effects would they have on the mind and body? He adds that 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.

In summary, the Coining of the term ergonomics, however, is now widely attributed to a 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 engaged during and after the Second World War [10].

Applications of Ergonomics

[11] reports that more than twenty technical sub-groups within the Human Factors and Ergonomics Society (HFES) indicated the range of applications for ergonomics. Human factors engineering continues to be successfully applied in the fields of aerospace, aging, health care, product design, transportation, training, nuclear and virtual environments among others. [12] argue that the nuclear disaster in Chenobyl 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 arthritics (both Chronic and temporary) or carpal tunnel syndrome. Pressure that is in significant or imperceptible to those unaffected by these disorders may be very painful or render a device unusable. Many ergonomically designed products are also used or recommended to treat or prevent such disorders, and treat pressure-related chronic pain. [13] reports that human factor issues arise in simple systems and consumer products as well. According to them, 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 in advertently turn off the alarm when they mean to hit "Snooze". A user-centred design (UCD), also known as a systems approach or the usability engineering life cycle aims to improve the user-system.

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 work place (as in for example ergonomic chairs and key boards). 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 over-extension 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 [14].

[15] suggests, that 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, while environmental design changes the environment in which people work, but not the physical equipment they use.

Design of Ergonomic Experiments

There is a specific sense of steps that should be used in order to properly design an ergonomics experiment. [16] advises that first one should select a problem that has a 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 combinations and interactions to notice the many differences that could occur. [17] also admits that 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 Industrial 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.

In the words of [18] the experiment should start with a pilot study. 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 appreciated 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 in the final product.

Maximizing Job Performance and Efficiency

There is no gainsaying that some ergonomists practice in the area of job design. These professionals help employers assess both the individual tasks necessary to perform a particular job and the skills needed to accomplish each. By grouping like tasks and skills, jobs can be redesigned to maximize efficiency [19]. An office telephone receptionist, for example, may perform a number of other tasks as varied as lifting, sorting mail, and bookkeeping. Grouping these responsibilities, which can all be performed in the vicinity of the office telephone system, make use of the receptionist's time when there are no telephone calls. Ergonomists help employers evaluate different ways of organizing work days to increase worker productivity, ensuring that workers have adequate breaks and rest periods, as well as well-defined set of tasks.

[20] opines that an ergonomist may use similar skill-analysis principles to help an employer identify the best candidate for a particular job. He further argues that by working with the employer to define the physical, mental and social skills needed to perform a job, ergonomists can determine the necessary qualifications and help employers with personnel selection. [21] report that job task and skill analysis is also used to determine the most effective ways to train employees. Training for astronauts and pilots, for example, may include simulations developed by ergonomists. Training simulations, such as computer virtual reality training, teach trainees how to deal with dangerous scenario such as accidents, without exposing them to the dangers of a real accident. Ergonomists also design virtual simulation for medical doctors, enabling them to practice diagnostic and surgical skills can computer-simulated patients, thereby not endangering the health of a live patient.

Consumer Product Design

Ergonomic design makes consumer products safer, easier to use, and more reliable. In many manufacturing industries, ergonomists work with designers to develop products that fit the bodies and meet the expectations of the people who will use them. For example, an ergonomically designed tooth brush has broad teeth, and a bristle head shaped for better tooth surface contact. In the same vein, the shaving razor has undergone a similar design revolution. The beak handled, easy-grip models popular today are more comfortable to use and have a better shaving performance than the straight-edged razors of days gone by. Ergonomic design has dramatically changed the interior appearance of automobiles. Today, cars are equipped with seatbelts and adjustable headrests that prevent the neck from snapping backward in the event of a collision. Modern automobiles are not only more comfortable, they are also safer. The principles of design affect other features of the automobile as well.

[22] reports that ergonomic improvement to computer hardware and software is ongoing. The mouse, a hand-shaped input device, enables users to give the computer commands with the click of a button. Many computer users already use verbal commands, the screen, or use pencil-like instruments to enter there a commands, rather than typing them on a keyboard or clicking with a mouse.

Psychology and Systems

[23] argues that people performing in systems have in common the fact that they are each somebody doing something some place. The activities range from a telephone installer connecting a cable high atop a pole in the middle of the winter, to a chauffeur driving an automobile on a curvey mountain road, or a craftsperson building a violin in a small

workshop on a sultry afternoon. According to [24] in each case, there is somebody doing something, some place. A human is performing some activity in some context.

However, it is possible that performance can easily be confused with behaviour. According to [25], performance is meeting your objective and result. The actions leading to this result are behaviour. [26] explain the relationship between performance and behaviour with an illustration. Consider someone using a rifle for target practice. We watch as the person lifts the gun, sights down the barrel, and pulls the trigger. We observe a set of behaviours that can be measured. For example, we can time how fast the person is able to raise the rifle, sight and fire (or each behaviour separately). We can measure the width of the person's stance, the steadiness of the aimed gun and the pressure exerted on the trigger. And we can interview the person about the planning and thinking involved in shooting a rifle. But no matter how thorough these measurements are, we still do not have any information on the performance level of the person shooting the rifle, that is, how many shots are on targets.

[27] also gave another illustration where we find a designer working hard to ensure that a system measures certain carefully selected behaviours rather than performance. Consider, for example, companies that have elaborate system for reporting absenteeism. They may accurately measure some interesting behaviours, but end up providing little, if any, useful information about performance. One good way to measure the performance of a rifle shooter is to inspect the bullet holes in the target. By evaluating the location and pattern of bullet holes, we know something about the performance level of the bullet shooter.

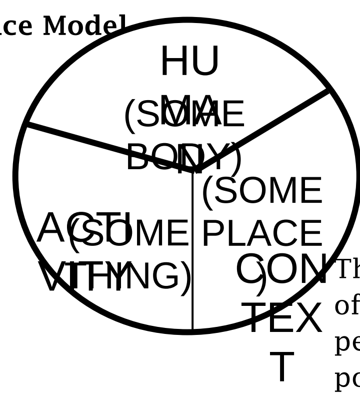
The Corollary of the argument by [28] is that many designers seeking to measure human performance actually measure system performance. In many systems, human performance is only one consideration. The adequacy of equipment, computers, or even people outside the system boundaries may all partially determine the success of a system. When trying to understand why a system may have problems, the various components must be evaluated separately. According to [29] too often, people equate poor system performance with poor human performance without taking into account other system components. According to him, one of the most interesting examples of this the consistency with which human error is considered the cause of so many human airline accidents. Within two or three days of any major airline accident, the newspapers usually begin to report that human error is responsible. More investigation frequently indicates that other components were equally at fault. Even with many automobile accidents, investigators attempt to attribute the mishap to degraded human performance, frequently ignoring the mechanical inadequacy of the automobile and the conditions under which the automobile was driven (including misleading road signs, rough road surfacing, sharp corners, or unusual weather conditions.

The discussion here is about human performance, not system performance. The human is the most complex of all components in any system and rightly deserves to be singled out as the most likely reason an accident occurs or a systems failures. [30] provides a good example of problems associated with measuring human performance rather than system performance of a boy on a bicycle with of a boy on a pogo stick helps to illustrate the difficulties. In this case, the main performance measurement is the speed at which they travel a quarter of a mile. After several traits, we find that the boy on the bicycle consistently traveled the distance in a shorter time. What can we conclude about human performance in this situation? The answer is very little. The performance measures that are selected is not a measure of human performance but a measure of system performance –boy/pogo stick versus boy/bicycle. It is apparent that one system is better than the other but this does not mean that human performance in one system is better than human performance in the other. As long as we are dealing with a system-level performance measure, human performance can only be inferred and the inference in this case could be misleading.

Human Performance Model

Predicting human performance in any situation requires an understanding of the human, the activity being performed, and the context in which it is performed. [31] suggest that this model of human performance is general enough to serve as model for many, if not all, performance situations (see figure 1)

Human Performance Model



Somebody does something someplace

Fig1: Human Performance Model.

People sometimes seek to attain super (near perfect) performance.

As illustrated in fig. 1, in all performance situations, we have somebody during something someplace. According to [32] designers should consider these three elements separately and in combination to help reach the desired level of human performance. This helps to simplify ensuring that the critical elements and their interaction are recognized and dealt with. For instance, to have a super optimal or acceptable level of human performance (or simply to avoid degraded performance), a designer must take into account each of the following elements:

(i) the general state or condition of the human.
(ii) the activity, including any required tools or equipment.
(iii) The context in which the activity is performed.

Therefore, acceptable human performance depends on:

(i) The adequacy of each major component.
(ii) The adequacy of the interface between and among major components. Each of these elements will be briefly discussed.

The Human Element

The human element is the most complex of the three elements. Human performance can be affected either positively or negatively by a wide range of conditions or influences that exist within a user, even without considering the nature of the activity or context. The designer should understand the possible sources of deficiencies in people and take them into account when making decisions. For example, color coding of displays is more common in many systems. However, color coding should not be the sole form of coding because many people are color blind [33]. The major considerations of the human element of a system are the sensors, brain (cognitive) processing and responders. In his own contribution, [34] opines that people bring a wide range of basic abilities to an activity. These include good vision and adequate hearing (sensors), arms, fingers and a mouth that functions properly (responders) and the ability to think, reason and make decisions (brain processing).

It is in the light of this [35] affirm that to design a system without having a good understanding of how people sense, respond, and process information is like attempting to wire a house without understanding the principles of basic electricity. In both cases, it can be done, but the results may leave much to be desired. Degraded performance could result if any of the basic capabilities required to perform an activity are lacking or reduced. Human deficiencies, for whatever reason, may rule out optimal human performance. Thus, we come to expect degraded human performance in certain activities if, for example, a person has not had adequate sleep, has less than perfect vision, has not learnt certain basic skills, or does not desire to perform the activity requested.

In addition, [36] adds that handlers of the system must be mentally healthy. For example, they are not severely depressed, or do not have a chronic high anxiety; do not have a performance – affecting phobia; are not compulsive in their reactions; and do not have perverse or obsessed ideas relating to the performance of an activity. To complicate matters further, we tend to assume that all people are the same, and that one individual does not change over even a short period of time. However, a depressed or anxious person may "level out", a phobia may be overcome, or irrational thinking may be replaced with clear, rational thought.

The Activity

The second major consideration in understanding human performance is the activity performed. Major characteristics of this element are shown to include:

Work Analysis

- Interfaces
- Controls
- Displays
- Work Place
- Human/ Computer

Performance Aids

- Instructions
- Training

One wonders if a hundred years ago anyone might have thought that thousands of people would someday be employed to create jobs for thousands of other people. [37] writes, ''for a period measured in millennia work was carried out in the form of crafts. The craftsman or artist was at one and the same time the organizer and executor of his own works. With a look to agriculture, one sees a very slow, from generation to generation, refining of hand tools brought about by the users themselves. Today, we live in a situation where the craftman's function has, so to speak, split into two parts: those of the organizer (system designer) and those of the executor (system users). In many ways, many cases, the designer is no longer a user and a user has limited or no input to a designer''. [40] admits that today, we live in a situation where the craftsman's function has, so to speak, split into two parts, those of the organizer (system designer) and those of the executor (System Users). In many cases, the designer is no longer a user and a user has limited or no input to a designer. On the one hand, we see the designer concerned with economic and technical aspects. On the other side, we have the user whose thinking is more oriented toward just getting things done. For many years, work is merely a means of existence. In a large number of cases, however, success at work may determine a person's other success or failure in life. Thus, the activity to be performed should be thoughtful than simply being left to evolve. [41] admits that because the designer can control certain conditions relating to the performance of an activity, he or she must know which factors lead to better performance and which tend to degraded performance. For example, designers should know what kinds of work are best done by people, what tasks should be combined into a module of work and what training is required to build of human performance. If a system uses tools such as a computer, some special interface considerations must be taken into account.

The Context

The final consideration in human performance model concerns the context in which a human performs a particular activity. [42] suggests that there are actually two different considerations, the physical context and the social context. The physical context many includes: Noise, lighting, temperature etc. While, the social context includes: Other people, crowding verses isolation etc. It can make a consideration difference if an individual is attempting to connect a cable in top of a telephone phone in shirt-sleeves in florida as opposed to performing the same activity in Minnesota during the writer, wearing a heavy coat, hood, and gloves. In both cases, it could be the same person performing the same activity, the mayor difference is the context.

The performance of a person attempting to communicate over the telephone can be degraded if noise interferes with the perception of speech by one or both parties. Noise, in fact, is probably the single most studied physical context factor. Other physical context related conditions of interest to researchers in recent years include weightlessness, vibration and insufficient oxygen.

[43] submits that conditions in the social context that may affect human performance to include the effects of other people, crowding, and isolation. The effects of the social and physical context are well demonstrated by considering a football player who performs the same task over and over during practice and in a series of games. The main difference is the context in which the performance takes place. During a football season, the player may perform in snow, rain, sunshine, 20-degree temperature, 95-degree temperature, with a noisy partisan crowd or a noisy nonpartisan crowd, or in a practice game with no observes. As the so-called "home court advantage" seems to suggest, the context may make a big difference in the human performance that takes place [44].

Measuring Human Performance

[45] defined performance as the result of a pattern of actions carried out to satisfy an objective according to some standard.

The action may include observable behaviour or non-observable intellectual processing (e.g. problem solving, decision making, planning, and reasoning). Things change when people perform. In the opinion of [46], any performance objective must be met according to some standard. The two most common standards are quality or quantity. To measure the height of a table, we might refer to the number of inches on a tape measure. To measure the weight of an object, we use pounds recorded on scales. Human performance is commonly measured using the standards outlined by [47] which include accuracy, speed, training time, and satisfaction.

Measuring Accuracy

Human performance is frequently measured in terms of accuracy – performing an action with the fewest errors. In sports, emphasis is placed on accuracy as for example, in rifle marksmanship or executing the co-ordinated body movements necessarily in gymnastics. In the work situation, particularly in computer-based systems, emphasis is placed on imputing large amounts of data in a short time with the fewest errors. In both situations, those who make few errors are superior performers.

One of the main goals in almost any system is fewer errors. In fact, many believe that the very essence of acceptable human performance is to have activities performed in a reasonable time withfew or no errors. [48] made this insightful statement when he posited that human factors engineers were the first to grant that people make mistakes.

Measuring Speed of Performance

[49] opines that improving efficiency in a system often means reducing the speed of human performance to a minimum. The prediction of efficiency is based on the study of variables affecting the speed of performance in many different activities such as reading, computing, checking etc. frequently, the designer's ultimate goals is to have activities performed in the shortest possible time. This results in the most work being performed per person in a given time, and a need for the fewest people.

Measuring Training Time

Another important performance measure is the total time required to bring system users to a desired level of performance. One of the main goals of a designer is to find ways of designing activities so that training is reduced to the minimum and whatever level of proficiency is obtained in training is maintained after training has been completed. [50] affirms that performance aids can substantially reduce the time required to train a person. Performance aids can substantially reduce the time required to train a person. Instructions, if well done, also will minimize the need for training. It makes good sense not to spend a good deal of time training someone to perform an activity when the activity only will be required twice a year. In these cases, a set of instructions that can lead someone through the activity step by step should be used in lieu of training. [51] agrees that generally the less time it takes to train people, the lower the cost of operating the system. Reducing errors and shortening processing time produce the same result. Fewer errors require fewer connections. Shorter processing times require fewer people. Reducing errors, processing time, and training time all contribute to a system that costs less to operate.

Measuring User Satisfaction

[52] in his contribution to human performance concerns himself with whether or not the human performing an activity in a particular context receives satisfaction. He queries, is the activity/context situation rewarding? Some work activities are satisfying for a large number of people; unfortunately, large numbers of work activities are only satisfying for afew people. In the opinion of [53] a designer should strive to build a system that will allow work to be done in the shortest times, with few errors and at the same time satisfy the worker. There is an irony in expecting people to want to work (versus being on welfare) when we are still designing jobs that are not satisfying.

Evaluating Tradeoffs

By attempting to perfect the results of all performance measures, the designer constantly faces tradeoff decisions. In some cases, decisions to increase satisfaction may lead to more errors or shower processing time. On the other hand, by always making decisions that reduce errors and processing and training times, a designer may develop a system that is not at all satisfying to work in.

[54] therefore suggests that human performance, then, should be measured using a clear and consistent set of performance measures. The measurement should focus on a particular group of people performing the same activity in a similar context. According to him, when measuring accuracy, the data must be collected over a period of time long enough to get reasonably reliable results. These results can then be compared with a standard. Ideally, the standard is determined ahead of time and documented as human performance requirements. Thus, the acceptable accuracy level for these activities should be known, as well as the acceptable processing times the acceptable time period for training and the acceptable criteria for scoring a questionnaire on preference, comfort, and satisfaction for the activity in the context. When measurements taken may indicate problems, a designer can make human performance adjustments through changes to the people, activity, or context.

In summary, adequate human performance in a particular system can be measured using any one or all of these performance measures. In fact, no matter what other performance measures that are used, one could argue that human performance should always be measured in terms of how well a designer deals with errors, manual processing time, skill development time and user satisfaction.

CONCLUSION

The field of human factors engineering in contemporary times is experiencing a state of expansion but how this divergence will unfold is not totally clear. Whether it will excel in establishing itself as a widely uniquely recognized discipline of study or settle for influencing designs through more established disciplines and emerging specialties is vague to forecast [55]. However, it is obvious that its content and methods are driven in a large extent by advances in technology (especially information technology) and other cultural forces as reflected in public policy, litigation and social issues.

Nevertheless, there is no gainsaying that human factors engineering has linkages with other disciplines. [56] admits that its traditional linkages were with experimental Psychology and engineering; its principal model, the human-machine system; its conceptualization of the human of the human component, the human information processing, model. Human factors engineering's cognitive approach is being challenged by an ecological one that has profound implications for the direction of both research and application. This alternative approach emphasizes systematic field observation aimed at understanding systems in the wild, blurs the distinction between research and application and this highly eclectic and recognizing the need for many disciplinary perspectives if complex systems are to be truly understood [1,13, 25, 40 and 56]. In this regard, therefore, the ecological perspective supports the growing awareness within human factor engineering that limiting attention to just the human-machine (Micro) system level hampers the field's ability to contribute to human oriented design.

Most importantly, human factor engineering would seem conducive to the establishment of linkages with industrial and organizational psychology. Although, movement to date has been minimal, the climate for convergence of the two fields on technology-driven issues connected with work has never been more favourable. The workplace, the nature of work and the workforce are changing in ways that neither field is equipped to deal with alone, but each has important and complimentary contribution to make [11, 17]. In this light, some scholars argue that general human performance principles are difficult to translate into specific design applications because their validity rests heavily on particular system's characteristics [23, 28].

In summary, it would be factual to opine that no matter what performance measures that are used, one could argue that human performance should always be measured in terms of how well a designer deals with errors, manual processing time and skills development time and user satisfaction.

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