Ergonomics: A bridge between fundamentals and applied research

Abstract

Ergonomics is becoming a subject of applying fundamentals on anthropocentric dimensions for holistic welfare. The so-called conflict between Basic science and Applied research finds one of its edges in Ergonomics. Be it cutting-edge technology or frontiers of scientific innovation—all start from understanding basic scientific aptitude and skill, and the best way to get familiar with the situation is practicing basic science again and again at a regular basis. Ergonomics is diversified in such paradigms that truly set an example of such harmony between two apparently never-ending straight lines. If the spirit of Science is true human welfare, be it in the form of environmental development, machine development, technological advancement, human resource development, or development of consecutive interfaces between these components, Participatory Ergonomics is one of the vivid examples of such conglomeration. Although fundamental science may appear to be of very little practical significance, it turns out that eventually it has far greater impact on human society than much of the so-called “applied research.”

Key words: Applied research, basic science, conflict, ergonomics

INTRODUCTION

The interplay between nutrition and physical activity is as frequently misunderstood as the relationship between industrialization and global climate; most people tend to either underemphasize ("as long as I get enough exercise I can eat whatever I want") or overemphasize ("each mouthful of food must conform to rigid requirements") the importance of nutrition to exercise performance. Similarly, in the broader sense, there exist an arbitrary battle between so called "Basic Science" and "Applied Research." Our sweetest songs are those that tell us of our saddest thoughts and our applied research is totally based on the sound fundamentals of the subjects concerned.

More than 200 years ago, at the beginning of 1782, the German physicist and philosopher Christ of Lichtenberg wrote in his diary:

"To invent an infallible remedy against toothache, which would take it away in a moment, might be as valuable as and more than to discover a new planet... but I do not know how to start the diary of this year with a more important topic than the news of the new planet."

He was referring to the planet Uranus, discovered in 1781. The question Lichtenberg implicitly raised, of the relative importance of looking for technical solutions to specific problems, and of searching for new fundamental knowledge, is even more pertinent today than it was 200 years ago.[1]

The argument is still alive very much but in newer mode.

It is becoming more and more interesting when we recapitulate the sayings of George Porter (Nobel Laureate in Chemistry) who pointed out that "Thermodynamics owes more to the steam engine than the steam engine owes to science."

Time and again, it is repeatedly proved that the connection of science and technology is neither linear nor antilinear, but in fact highly nonlinear, and it has been claimed that "historical study of successful modern research has repeatedly shown that the interplay between initially unrelated basic knowledge, technology and products is so intense that, far from being separate and distinct, they are all portions of a single, tightly woven fabric."[1,2]

However, the terms can be useful provided they are defined in terms of motivation.

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Basic science motivated by curiosity

Applied science - designed to answer specific questions.

Ergonomics, to the best of our interpretation, can explain this seemingly differentiated but exclusively interrelated coexistence of these two dimensions.

As we look towards the future, we find that it is neither totally random nor it is totally predictable. If it were completely predictable, there would be no point looking forward because we would already know what was to come. If it were completely random, we would not bother because we could not know anything systematic about the forthcoming events. That life lies between these two polar extremes gives us both the motivation to try to understand the future and the belief that we can do so, at least to a useful degree. Indeed, the triumphs of science encourage us to believe that we are making "progress" in so far as our predictions of the future. At least in relation to many physical processes, these are growing more accurate as the year's progress. And, of course, the more we can know about the future, the more we generate rational courses of action based upon this understanding. This respective confluence of ideas encourages us to develop theories, models, methodologies and other such instructions to continue to improve our predictive capabilities. The very concept of "Basic Science" at present needs to be rationalized and rationally simulated.

As a tool, simulation is an aid to scientific imagination. It allows us to create, populate, and activate possible futures which explore the ramifications of these developed scenarios of "Human-Machine Environment" interactions, that is, "Ergonomics." This branch of science turns the "user-machine antagonism" into "user-machine synergy."[3]

The question whether basic research can be left to others began to be asked in the 1980s, especially in the USA, when many science-based markets were lost to Japan, including very sophisticated areas such as dynamic access random memory, and the question was even raised whether the US semiconductor industry could survive at all. Japan (together with Singapore, Hong Kong, and South Korea) was often quoted as a country that had been very successful economically, and captured science-based markets, but had supported applied research and product development rather than basic science.

Funding of basic science is important for society as a whole, but is not in the interest of any individual investor. Those who make fundamental discoveries generally do not reap the benefits; the laws of nature cannot be protected and the applications are too long-term and unpredictable and the cultural and educational benefits do not generate direct profits.

Newton’s heirs (if he had had any) would be rich if it had been possible to patent the calculus and they received a royalty whenever it was used, but one cannot patent laws of mathematics.

If Rutherford, who discovered the nucleus, could not foresee nuclear power, could a government committee do better? Who could have foreseen warm superconductors, fullerenes, or the World Wide Web?

“Human Resource Development” in terms of ergonomics is really crouched for better, cleaner productivity.

Ergonomics developed into a recognized field during the Second World War, when for the first time, technology and the human sciences were systematically applied in a coordinated manner. Physiologists, psychologists, anthropologists, medical doctors, work scientists, and engineers together addressed these problems arising from the operation of complex military equipment. The results of this interdisciplinary approach appeared so promising that the cooperation was pursued after the war, in industry. Interest in the approach grew rapidly, especially in Europe and the United States, leading to the foundation in England of the first ever national ergonomics society in 1949, which is when the term "ergonomics" was adopted. This was followed in 1964 by the creation of the "International Ergonomics Association (IEA)," which, at present, represents ergonomics societies which are active in 40 countries or regions.[4]

The subject then developed in different modes of simulation and controlled imaginations, although, in India, its introduction and application started much later.

DISCUSSION

The formal definition of Ergonomics as approved by IEA reads as follows:[4]

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

The focus of ergonomics is man and a large number of factors play a role in ergonomics, while designing work with minimum limitations and higher productivity. The factors are body posture and movement (sitting, standing, lifting, pulling, and pushing), environmental factors (noise, vibrations, illumination, climate, chemical substances), information and operation, as well as work organization. These factors determine to a large extent safety, health, comfort, and efficient performance at work and in everyday life. Ergonomics draws
its knowledge from various fields in the human sciences and technology, including anthropometrics, biomechanics, physiology, psychology, toxicology, mechanical engineering, industrial design, information technology, and industrial management. Conventional simulation exists, but future challenges are ahead which share the involvement of human genomics and nanotechnology in enriching the improvement of ergonomic thought processes. It has gathered selected and integrated relevant knowledge from apparently unrelated fields. In applying this knowledge, specific methods and techniques are used. Ergonomics differs from other fields by its interdisciplinary approach and applied nature. It relates to many different facets. As a consequence of its applied nature, the ergonomic approach results in the adaptation of the workplace or environment to fit people, rather than to fit the job or other way round. It can contribute to the solution of a large number of social problems related to safety, health, comfort, efficiency, and production. India mostly needs these benefits.

Since ancient times, India has had an illustrious tradition of scientific inquiry. Numerous fundamental scientific and mathematical concepts are attributed to ancient Indian scientists. They also developed applied knowledge in medicine, metallurgy, agriculture, textiles, and other fields. But far more important than these specific contributions of ancient Indian scientists and philosophers is their integral approach to knowledge and life. They explored all areas of "Jnaan" and "Vijnan" in a holistic way, emphasizing that man's material and spiritual development should be pursued in a balanced manner, without ignoring one at the expense of the other. Our country needs this approach. Ergonomics is not an exception to that.

The scientific culture has a universal appeal which transcends limitations of geographical boundaries. Its profound impact has changed social, cultural, and economic landscape of the globe and it continues to do so. Indian Ergonomics presently attempts to take care of its huge "Human Resources" and its proper use and implementation sector, despite the marginalized slogan of "population explosion."

Human Factors in Simple and Complex Systems have been well documented in several facets. Historical foundations of Human Factors and official birth of First ergonomics Text took place in 1949 when Alphonse Chapanis, Wendell Garner, and Clifford Morgan published the text entitled "Applied Experimental Psychology: Human Factors in Engineering Design." The purpose of the text was to summarize much of what we know about human cognitive, physical, and social characteristics and to show how this knowledge can be brought to bear on designing machines, tools, and systems that are easy and safe to use. Then the research methods in human factors came. It may be said fairly enough that science progresses by the exposure of error and that in so far as an endeavor is scientific it is as ready to look for error within its own contents as in those opposing it. In particular, it has to be stressed that observation, which plays so special a role in science, is not regarded as error-free. By far the largest part of total research and development effort in science and engineering today is concerned directly or indirectly, with human needs, relationship, health, and comforts. So, anthropocentric faces in all relevant areas of research centrally focus on human. Human factor is an applied science. It is fundamentally an artifact of Basic Science altogether. Reliability and Human Error in Systems is another topic of contemporary interest.

Human Information Processing lies at the heart of human performance. In a plethora of situations in which humans interact with systems, the operator must perceive information, must transform that information into different forms, must take action on the basis of the perceived and transformed information, and must process the feedback from the action, assessing its effect on the environment. In this context, Perceptual Factors and Their Applications is a mandatory subject of discussion. Visual Perception, objective perception in the World, Color perception, perception of motion, pattern recognition, hearing, pro-prioception, and the chemical senses—all refine our search for perfection. Our lives are multisensory and our interactions vary from the bold to subtle.

Attention and the Assessment of Mental Workload is gradually becoming a compulsory affair, because in stressed situation, people are often subjected to sensory and cognitive overload.

Retention and comprehension of information is another facet of information processing as Memory does not always comprise a single unitary system and it is intricate and diverse. Memory failure always leads to error and malperformances.

The study of expertise covers remarkably diverse domains, such as sports, chess, music, medicine, and arts and sciences, and examines the entire range of mastery from beginners to world-class performer. Human Factor Engineering is silently opening up this opportunity of research.

Response Selection and Principles of Compatibility further saturate the levels of understanding and so-called depth of the performance efficiency and speed. Control of Movement and Learning of Motor Skill are becoming fundamental avenues of contemporary research. Control System of Performances is mostly the topic of interest.

Environmental factors and their applications showed the other half of the coin. Anthropometrics and workspace design are the application areas of ergonomic intervention. The measurement of human physical characteristics is called anthropometrics, and engineering anthropometry refers to design of equipment, tasks, and workspaces to optimize the compatibility of worker and working environment.

The modern concepts of environmental ergonomics enrich the detailed intervention of working attitude and moods. Factors like noise, vibration, light, heat and cold, particulates in the
air, gases, air-pressures, gravity, etc., do also play active role in formulating the working quality and quantity.

Newer concepts like Human Resource Management and Macroergonomics already developed where interactions between the social and organizational context of a system and the design are being focused. Macroergonomics stands for “Human-machine-organization-environment-interface.” The performance and productivity of any organization is a function of how well the organization manages the human resources.

Moreover, Practice of Human Factors should be there as a corollary study as proper design can make a difference in our quality of life. Safety and security of workers are of prime importance. Although the burgeoning rate of overpopulation is an unpleasant reminder to us, particularly in the context of the subcontinent, it is really an irony that the human reproductive success is thought to be reproductive excess in the long run, and our huge human resource is gradually becoming burden instead of developmental resources. Ergonomic research can do magic in transforming the situation.

**CONCLUSION**

The widespread influence of computer technology in recent decades has permeated every aspect of the human-machine system. The systems are becoming more complex, so it should stand to reason that new theories are needed to cope with the new sources of complexity. The challenge ahead is to tame the complexity and to harmonize the situation in making India a developed nation. The Eleventh Plan has recognized that productivity-led growth is the path India has to take in order to attain the ambitious target of more than 8% GDP growth rate. Appropriate Science and Technology inputs at all levels and in all sectors of economy are needed to pave this path. Neoergonomics also fosters for improved productivity in all sectors, particularly in agriculture, medicinal plants, and agroprocessing industries.

Application of new scientific and technological capabilities generated through Biotechnology, IT, space technology, and improved ergonomics should be extensively pursued. Minimizing wastage is mandatory in all sectors.\(^5\)

All these efforts are essential to increase rural incomes and generate new employment opportunities in the rural economy, which is our first developmental priority.

India is also facing challenges in meeting the basic healthcare, land and water conservation, energy security, and environmental protection. Ergonomics and controlled simulations are capable of making newer frontiers in addressing such challenges. Disaster management, maximizing work on all developmental fronts, proper maintenance of policy implementation interfaces, and war against malnutrition are some of the basic as well as future challenges of our country, and ergonomic research and application can make the two far ends coalesce.

Central to the above accomplishments is a strong human resource base. World-class achievements such as green revolution, leading work on string theory, contribution in frontiers of astronomy and astrophysics, or development of several exotic materials could not have come about without inherent quality of our human resources. Ergonomic intervention in this interface is of mandatory requirement.

On the other side, our further forays into basic sciences hold the key to our future. Although fundamental science may appear to be of very little practical significances, it turns out that eventually it has far greater impact on human society than much of the so-called “applied research.” The following example serves to illustrate the point and conclude the discussion.

While delivering the Gandhi Memorial Lecture entitled “Scientific discovery and search for perfection” at the Raman Research Institute in 1979, the Nobel Laureate Dorothy Hodgkin made the following point emphasizing that roughly 60 to 70% of medicines that have helped to alleviate human misery have resulted from fundamental research which did not aim to address such social questions at all. It is interesting to recall that Dorothy Hodgkin received the Nobel Prize for discovering the molecular structure of Penicillin and Vitamin B\(_12\); later, she went on to solve the structure of Insulin!

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**REFERENCES**


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