

ERGONOMICS AND HUMAN FACTORS: AN OVERVIEW OF DEFINITIONS BASED ON THE LITERATURE

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Abstract

This article addresses the definitions of ergonomics (or human factors) and their varieties and changes since the 19th century when it originated. Seeking this theme, research was conducted aiming at reviewing and surveying the literature. Also, the definitions of ergonomics were contextualized through a timeline. Based on the results, it was possible to verify that the most accepted definition today is that of the IEA - International Ergonomics Association. When analyzing the data, it is concluded that even though the growth in the number of publications in recent years has been almost exponential, there are still gaps in research, so it is recommended to continue this study by expanding the search terms with the inclusion of words correlated to enable a systematic review of the current literature on the topic.

Keywords: Ergonomics, Human Factors, Definition.

1. INTRODUCTION

The origins of ergonomics are still controversial and some reflections lead to believe that it is associated with the principles of instrument manipulation in the Paleolithic period (ONOFRE *et al.*, 2010). According to Láuar *et al.* (2010), the actions of adaptation of the environment carried out by prehistoric man and the high number of isolated actions in different times and cultures were factors that contributed to the formation of ergonomics. In ancient cultures, these factors were organized, but in these periods there was still no concern to study or systematize human activities (LÁUAR *et al.*, 2010).

With the European Renaissance, systematic studies in this area began, in order to make scientific the knowledge of the countless variables of the dynamics of work, the body,

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production, movement, among others. This phase of ergonomics is called gestational (LÁUAR *et al.*, 2010). Still in the nineteenth century, according to Perussiet al. (2010), more systematic studies on work emerged, which began with Taylorism (Frederick Winslow Taylor), the new concept of scientific management. In this concept, it was considered that the work should be systematically observed and that, for each task, a correct method to perform it should be developed, so that it could be carried out in a certain time and using the correct tools (PERUSSI *et al.*, 2010).

Onofre *et al.* (2010) points out that the officialization of ergonomics has as its starting point the year 1949, resuming Jastrzebowski's initial ideas almost a hundred years later, when "... for the first time, a group of scientists and researchers interested in discussing and formalizing the existence of this new branch of interdisciplinary application of science met in England" (MEISTER, 1991). Thus, in that year, the *Ergonomics Research Society*, known only as the *Ergonomics Society* (ONOFRE *et al.*, 2010), and in 1959 the *International Ergonomics Association* (IEA) was founded in Oxford (LÁUAR *et al.*, 2010).

In the United States of America, according to Perussi *et al.* (2010), as in most nations, there was a concern with production systems and, as a consequence, the tasks and activities of workers became a prerogative for studies, called *Human Factors Engineering*. These conditions led to the redoubling of efforts to research ways to adapt war instruments, in the context of the Second World War (1938-1945), to the characteristics and capabilities of operators, in order to reduce fatigue and accidents (PERUSSI *et al.*, 2010).

In Latin America, according to Onofre *et al.* (2010), the beginning of ergonomics studies took place in the 1960s, with research developed at the Polytechnic School of the University of São Paulo, in Brazil – a country that, according to Soares (2006), has shown to be the most consolidated of the block in the development of the discipline. The first ergonomics book written by a Brazilian author was published in 1973, entitled "Ergonomics: class notes", by Professor Itiro Iida and Henri A. J. Wierzbicki (FERREIRA AND DONATELLI, 2001). After ten years of this publication, Iida together with Anamaria de Moraes, Franco Lo Presti Seminério and Ued Martins Manjub Maluf, founded the Brazilian Association of Ergonomics (ABERGO), which in 1984 was accepted as a member of the IEA (LUCIO *et al.*, 2010).

Therefore, according to Silva and Paschoarelli (2010), the scope and scope of ergonomics have been expanding, as is expected in a scientific discipline. On the other hand, these numerous definitions raise the question: Which definition of ergonomics is the most accepted and used in publications by researchers in the area?

2. GOAL

The objective of this study is to identify which definition of Ergonomics (or Human Factors) is the most used in international scientific publications, in addition to presenting an overview of these publications, identifying their main contributions.

3. STUDY METHODOLOGY

According to Silva and Menezes (2005), there are several ways to classify research. All research must be classified according to some criteria, namely: nature of the research, way of approaching the problem, objectives and technical procedures.

From the point of view of its nature, this research is classified as basic because there is no practical application (SILVA AND MENEZES, 2005). In terms of its objective, it is classified as exploratory, because according to Gil (1991), it aims to provide greater familiarity with the problem with a view to making it explicit. Finally, as for the approach, it is a qualitative research, as it does not use statistical analysis (SILVA AND MENEZES, 2005). In terms of technical procedures, a bibliographic research was carried out.

Considering the objective of this work, a search was carried out on the Portal of journals of CAPES (Coordination for the Improvement of Higher Education) on the theme Ergonomics in December 2018. The terms searched for the collection of materials were "*definition of ergonomics*" and "*definition of human factors*" because both are equivalent. Considering that the term Human Factors is widely used in North America and Ergonomics in other countries, the scope of the present study was limited to the search for these terms.

After the initial selection, the scientific texts were read and tabulated, resulting in a classification of the ergonomics definitions used by the authors. In addition, the articles were analyzed taking into account the following aspects: year of publication, country of publication, and adequacy to the theme of this study. Subsequently, the data analyzed in the panorama of such research is discussed.

4. FINDINGS

4.1. Overview of studies

The initial research on the definitions of *Ergonomics* and *Human Factors* on the CAPES Journal Portal resulted in 52 (fifty-two) articles distributed between the years 1978 and 2017. Of these articles, 16 (sixteen) were disregarded in the analysis for the following reasons: 7 (seven) were unavailable, 4 (four) were duplicated and 5 (five) dealt with "human factor"

outside the context of ergonomics, not presenting relevant questions for the research. Thus, 36 (thirty-six) publications remained as the basis for this study.

In this scenario, it was possible to identify that in 30 years (1970 to 1999) there were a total of 6 (six) publications that included the definition of ergonomics. In the year 2000 to 2009, 13 (thirteen) productions were observed, and from 2010 to date (2018) 21 (twenty-one) publications were found. Thus, it is possible to analyze the growth in the interest of studies that address the definition of ergonomics, as shown in Graph 1

Figure 1: Number of publications with the definition of ergonomics and human factors over the years



Source: The authors, 2018.

In addition to the number of publications, another factor taken into account in this research was the nationality of each article. Thus, it was possible to identify that the United States is the country with the largest number of papers, presenting 22 (twenty-two) articles and in second place is England, with 4 (four) researches. In addition, Germany, the Netherlands (Netherlands) and Canada have 2 (two) publications each, and Iran, Colombia, Brazil and Serbia only 1 (one).

The most referenced definitions of ergonomics and human factors were also analyzed in this study, reaching the authors most cited in these publications. Thus, it was possible to conclude that the IEA definition (2000) was referenced 20.6% of the times, being the one with the highest citation among the articles analyzed. Jastrzebowski (1857), *Clinical Human Factors Group* (2011), *Occupational Safety and Health Administration* (2002) and NIOSH (2000) – *National Institute for Occupational Safety and Health –* represent 5.9% of the citations, while dictionary definitions were used in 11.8% of the situations, it should be noted that the authors who used the dictionary definition did not specify the dictionary used. Finally, it was observed that most of the articles (44.1%) referenced different authors in each of the studies, whose definitions were cited only once based on this research, namely: Iida (2005), Hendrick (2002), Lichet al. (1989), Wogalter*et al.* (1998), Storey and Rea (1985), Vink P. *et al.* (2006), Catchpole K. (2011), *Human Factors and Ergonomics Society* (2000), Wilson and Corlett (1995), Chapanis (1996), Sanders (1988), Fitts

(1951), Lynch (1984), Mark *et al.* (1987) and Henzelman (2000). Thus, Graph 2 shows the percentage of citations of each author when defining Ergonomics and Human Factors.



Graph 2: Frequency of citations of other authors in publications

4.2. Ergonomics and human factors: definitions

Figure 1 shows a timeline of citations of the definitions of Ergonomics and Human Factors in the publications under analysis, representing the variety of definitions on the subject. For analysis purposes, the histogram was organized in order to represent the historical evolution of ergonomics according to Hendrick (IIDA AND GUIMARÃES, 2016). In the 50s, with the end of the second world war, physical ergonomics has its origin that over the years, in the 70s, there is environmental ergonomics. The studies of cognitive ergonomics took place in the 80's, which boosted the rise of organizational ergonomics studies in the 90's. This organization is important because throughout history the performance of ergonomics has increased both in its scope and in its scope of action.

Figure 1: Timeline of Ergonomics citations in publications

Source: The authors, 2018.



Source: The authors, 2018.

As shown in Figure 1, the term ergonomics was used for the first time by the Polish Wojciech Jastrzebowski in the publication of the article "Essays on ergonomics or work science, based on the objective laws of science on nature" in 1857 (FRANCESCHI, 2013). Jastrzebowski (1857) defines Ergonomics as "the involvement of the interactions of human factors (the physical and mental capacities and their respective limitations) of the worker with the machines and equipment found in the work environment".

Over the years, in 1951, Fitts deals with Ergonomics as guidelines that allow optimizing performance (i.e., efficiency and safety) by making the workplace (environment, machine, product or system) fit with human capabilities and needs (FITTS, 1951). Subsequently, in 1984 and 1987, Lynch and Mark *et al.*, respectively, approach Ergonomics based on Fitts' definition (LYNCH, 1984; MARK *et al.*, 1987).

Still in the 80s, Storey and Rea (1985) argue that ergonomics is not a science or a technology, but rather a set of concepts that help maximize the design of the interaction between humans and machines, systems, work methods and environments while taking into account the physical safety, mental capacity and productive potential of the same workers (STOREY AND REA, 1985).

The last definitions cited at the end of the 80s were those of Sanders (1988) and Licht *et al.* (1989). Sanders makes an intertextuality with the previous authors in his definition, and defines Ergonomics as "that branch of science and technology that includes what is known and theorized about human behavior and biological characteristics that can be validly applied to the specification, design, evaluation, operation and maintenance of products and systems, to

increase safe use, effective and satisfactory by individuals, groups and organizations" (SANDERS, 1988). For Licht (1989), Ergonomics is "the science that studies work and the development of tools for the evaluation and improvement of working conditions in a system".

In the 90s, when Organizational Ergonomics emerged, new definitions for Ergonomics or Human Factors were manifested. The first definition in this century is presented by Wilson and Corlett in 1995, where they reiterate that the definition of human factors is "the division of labor between humans and machines". For the authors, "humans are assigned to tasks and machines are assigned to functions" (WILSON AND CORLETT, 1995).

In 1996, Chapanis observed the applicability of Ergonomics to design, and defined human factors as "a body of information about human abilities, human limitations and other relevant characteristics" (CHAPANIS, 1996).

Two years later, in 1998, a complement to the definition of Ergonomics by Wogalter *et al.*, which adds that, in addition to being a science, it is "a technology applied to solving problems involving interactions between humans and systems" (WOGALTER *et al.*, 1998).

In the year 2000, there was an increase in publications on Ergonomics and Human Factors, where most of these studies were carried out by recognized organizations, such as the IEA (*International Ergonomics Association*) and *the Ergonomics Society*. For the IEA (2000) and the *Ergonomics Society*, Ergonomics (or human factors) "is the scientific discipline related to understanding the interactions between 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". It also adds the importance of the contribution of ergonomists to the design and evaluation of tasks, jobs, products, environments and systems, in order to make them compatible with people's needs, abilities and limitations (IEA, 2000).

Still in 2000, Ergonomics is succinctly defined by the *Occupational Safety & Health Administrations* as "[...] the practice of designing equipment and managing workstations according to the needs of the worker" (BEAUCLAIR AND SLAPER-HAWRANKO, 2017).

Finally, the last definition found in the 90s was that of the *National Institute of Occupational Safety and Health* (NIOSH), which conceptualizes Ergonomics as "[...] the moment and the task where human needs at work are taken into account, in order to adapt the work to the worker" (NIOSH, 2000). Furthermore, Heinzelman (2000) adds that "[...] we are concerned with understanding the environment in which a device must be used and the particularities and constraints of that environment" (HEINZELMAN, 2000).

In 2002, Hendrick defined "system" based on the IEA's definition of ergonomics. According to Hendrick (2000), "a system is defined as two or more people interacting with a work design". Next, Iida (2005) argues that ergonomics "is defined as the adaptation of work to man, covering planning and designing activities that occur before the work is performed and controlling and evaluating activities that occur during and after the work has been done". All of this is necessary for the work to achieve the desired results. Work must be adapted to man and not the other way around (IIDA, 2005).

Vinket al. (2006) state that ergonomics can contribute to the prevention of inconveniences and, to a considerable degree, improves the performance of the system in terms of increased productivity (VINK *et al.*, 2006). In addition, for Catchpole (2011) and the *Clinical Human Factors Group* (2010), Ergonomics is a means of improving the performance of the system by understanding the effects of teamwork, tasks, equipment, workspace, culture and organization.

Finally, according to Morales *et al.* (2013), it is necessary to create bridges between different paradigms instead of using a general definition of ergonomics. The practice of ergonomics makes the study of the human being possible and provides an understanding and form of intervention in public health.

5. CONCLUSION

In order to meet the objective of this research, a search was carried out in the CAPES journal portal for publications that presented definitions of ergonomics or human factors. The publications cited in this article, and extracted from the portal, represent an overview of studies in the area that contemplate the definition of ergonomics. It was possible to notice an increase in the number of publications since the 90s, in nine decades (from 1870 to 2000) 19 publications were found and, in the last 8 years, 21 publications were found, with the largest number of searches recorded by the United States (23), followed by England (3), showing a greater periodicity in the most economically developed nationalities.

Especially in the year 2000, the definition most referenced by the authors (20.6% of the cases) was published, which is the definition of the IEA (*International Ergonomics Association*). This definition represents an expansion in scope and scope in relation to the definitions mentioned above; Especially because it makes explicit that in addition to improving human well-being, it is necessary to promote the improvement of the overall performance of the system in parallel.

The contributions of these articles elucidate the definitions of ergonomics by several authors over time, in addition to showing practical studies and important research related to different areas of ergonomics. Finally, it is recommended that this study continue by expanding the search terms with the inclusion of correlated words in order to enable a systematic review of the current literature on the subject.

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