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Time and motion study in the industry 4.0 era: A systematic review of the literature

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RESUMO

Objetivo: o artigo busca identificar os principais métodos e ferramentas para o estudo de tempos e movimentos aplicados na indústria nos últimos 10 anos.
Referencial teórico: com a Indústria 4.0 e as novas ferramentas tecnológicas, o estudo de tempos e movimentos ganha novos métodos de aplicação. Com isso, frente a intensa competitividade do mercado, conhecer os métodos e ferramentas utilizados em sua aplicação nas empresas nos últimos 10 anos pode proporcionar competitividade às organizações.
Design/Metodologia/Abordagem: Este trabalho caracteriza-se como uma revisão sistemática da literatura – RSL. Analisou artigos encontrados na Science Direct e no Portal Capes. Os artigos internacionais foram escolhidos pelos termos de busca e filtro estabelecidos.
Resultados: Percebeu-se que, apesar de sua importância, há poucas produções acadêmicas na área. A revisão incorporou 31 artigos publicados desde 2010, que continham conteúdo relacionado à aplicação do conceito. Foi possível observar dois tipos de trabalho: aqueles que utilizam a ferramenta de estudo de tempo e movimento usando cronômetros, pranchetas e observação direta, e pesquisas que aplicaram de forma virtual.
Implicações de pesquisa, científicas, gerenciais e sociais: conhecer os principais métodos e ferramentas utilizadas no estudo pode proporcionar melhorias para a produtividade das empresas e ergonomia dos seus colaboradores, bem como auxiliar a construção de pesquisas futuras na área.
Originalidade/Valor: apresenta a evolução do tema desde o taylorismo até a era digital, bem como os principais métodos e ferramentas utilizados pelas empresas, importante para organizações realizarem a gestão da produção e se tornarem mais competitivas.
Palavras-chave: Estudo de tempos e movimentos; Análise de trabalho; Cronoanálise; Indústria 4.0; Era Digital.

ABSTRACT

***Purpose**: the article aims to identify the main methods and tools used to study time and motion applied in the industry over the last 10 years.*
***Theoretical framework:** with Industry 4.0 and the new technological tools, time and motion studies gain new methods of application. With this, given that the market is intensely competitive, to know the methods and tools used to apply it in companies over the last 10 years can give organizations a competitive edge.*
***Design/Methodology/Approach**: This study is a systematic review of the literature – SRL. Analyzing articles found in Science Direct and on the Capes Website. International articles were chosen by searching terms and using established filters.*
***Findings:** As a result, it was noted that, despite the importance of its effects, there are few academic papers written in the area being studied. The review incorporated 31 articles that have been published since 2010, which contained content related to the application of the concept. Two types of study were found: those that apply the time and motion study tool using stopwatches, clipboards and direct observation, and research that has been applied virtually.*
***Research, management & social implications:** knowing the main methods and tools used in the study can improve the productivity of companies and the ergonomics of its employees, as well as assisting in constructing future research in the area.*
***Originality/Value**: The study presents the development of the theme from Taylorism to the digital age, as well as the main methods and tools used by companies, which are important for the management of organizations and their competitiveness.*
***Key words**: Study of times and movements; Work analysis; Chronoanalysis; Industry 4.0; Digital Age.*

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1. INTRODUCTION

Method Engineering, also known as the study of times and movements or Measured-Time Method (MTM), emerges within the context of Taylorism, where most of the tasks were manual, performed on production lines where operators were placed on benches and operating machines. This scenario Frederick Taylor begins to question the best way to perform these tasks noting the existence of a fundamental variable to increase productivity: time. Through the principles of Scientific Administration, it proposes the analysis of the time of manual operations in different detail levels, dividing the movements of the operations into basic movements. (BÖGE; BÖGE, 2016). Thus, there is a dedication to the quest to achieve, through systematic analysis, the best method to perform a manual operation determining its time and avoiding waste as much as possible, (NEGREIROS; LIMA, 2011). The advantage of this study is that the Measured-Time Method (MTM) not only allows the evaluation of the time of operations, but also the description of processes in a standardized way (NAUSH *et al.*, 2021).

Market competitiveness requires professionals to increasingly optimize manufacturing practices (CARLO *et al.* , 2013). The study of times and movements (MTM) contributes to this context, because it seeks to eliminate waste by being fundamental to increase productivity and, thereby, the competitiveness of a company (GEORGE, 2002).

MTM serves as a tool to eliminate waste such as unnecessary movements, expenses and risks of accidents. In projects with manual activities, for example, unrealistic and inaccurate planning for manual operations can result in increases in labor costs, which typically account for 30% to 50% of total costs (ZHAO; DUNGAN, 2018). In parallel, Kisi *et al* (2018) state that the reliable estimation of the durations of manual activities is essential, because it ensures a more accurate cost estimate. In addition Deuse *et al* (2019) point out that the MTM offers the possibility of deriving weaknesses in the work processes in a more direct and concise way, and that the use of standardized movements is a facilitator to detect different movement sequences automatically. Thus, in addition to eliminating waste, it serves as a tool in approaches to improve occupational health and safety in sectors such as industry (MATTOS *et al.*, 2019).

Furthermore, the new era of the industry, known as Industry 4.0, which is characterized by the increasingly fast and dynamic delivery to the consumer linked to the use of cutting-edge technology, enabled exponential transformations within the industry, such as the use of intelligent machines and equipment. Faced with so many innovations, the Study of Times and Movements gains a new configuration. Unlike the Taylorism scenario, when the tasks were predominantly manual and the time study had as main objective the search for the best method and the standardization of it, with

automation and new techniques, such as Lean Manufacturing, through VSM - Value Stream Map, the industry began to need the study of time to define variables such as cycle time and takt time. Thus, simple stopwatches and clipboards, previously used, are replaced by technological tools, like smartphones, tablets and simulation softwares.

Even in the digital age, to implement time analysis and recognize possible spaces for improvement it is important to determine the amount of time required for work associated with human beings, machines or a combination of both (BON; DAIM, 2010). In addition, MTM is used no longer only for the estimation of manual processes, but also serves as a basis for determining robot times by expanding the concept (SCHRÖTER *et al*., 2016). Zubaidi *et al* (2021) point out that with industry 4.0, new technological tools have emerged in different areas to facilitate processes. As an example, with the advancement of technology some articles are focusing on one of these new tools, related to the MTM method: the creation of automated codes for your application (NAUSH *et al*, 2021). Faced with these changes, there is no standardized method and tool for the study of times and movements. In addition, one of the issues that make it difficult to reliably estimate labor production rates is the difficulty in measuring working hours, according to Hwang and Soh (2013), which could be solved with the knowledge of the main methods and tools for this.

Therefore, considering the relevance of this analytical instrument, this article seeks to find in literature the main methods and tools applied in the industry for the study of times and methods, and also present the content of the selected articles presenting ways to guide you. For this, a systematic review of the literature where the method was applied since 2010 was performed, and also present the content of the selected articles. In this study, it is also discussed about the evolution of study of times and movements since Taylorism until the emergence of automated work methods in industry. This article can serve as a basis for applications in companies, so that they apply the methods and tools presented and can become more competitive, reinforcing the importance of this review.

2. THEORETICAL FOUNDATION

The Measured-Time Method (MTM) is based on the subdivision of manual operations into smaller steps, on the analysis of each one, on the definition of the standard time needed to perform these and on the installation and standardization of the new operational method (HANAMANT et al., 2017).

Research related to the analysis of the time of a process in a manufactured environment started for the first time in the 20th century by Frederick Taylor, who developed a study measuring the times needed to perform each production task, with the objective of reducing these times, eliminating waste and, mainly, increase productivity (TAYLOR, 1914).

Later, Frank and Lilian Gilbreth expanded the subject by also studying the movements of workers during their activities, with the aim of finding the best methods for carrying out tasks and again eliminating waste (BAUMGART; NEUHAUSER, 2009). The “time studies” and “motion studies” became part of scientific management, which he called Time Motion Studies (TMS) or Measured-Time Method (MTM) (PAYNE et al., 2014).

In the scenario in which the context was created, that is, in Taylorism, the tasks were mostly manual and the production carried out in line, with the employees arranged in benches and manual machines (TAYLOR, 1914). According to Eimaraghy and Urbanic (2004), with the advancement of technology and increased competitiveness, human capacities within the technical environment began to be valued, encompassing control interfaces in the human-machine relationship, and not just the execution of tasks.

Over time came Industry 4.0 and with it the digital age, which brought with it the automation of tasks (ZUBAIDI et al., 2021). In it, the man-machine relationship is different from that found in Taylor's time. Thus, the study of times and movements gains a new configuration, and thus, it is necessary a separate analysis of the 2 contexts.

2.1 Studies and times and movements under the taylorism scenario

Smith (1776), Babbage (1835) began the development of industrial dynamics, after presenting the Horizontal Division of Labor. With it, the production process was separated into numerous operations for which the specialized workers were allocated in a continuous assembly line, an event that caused productivity improvements, but also a great intensification of work. After, Taylor (1914) created scientific administration with the objective of increasing the productivity of the individual worker through precise prescriptions of how to produce and in how long, developed with the study of times and movements of each task, which results in the optimal method of each operation to be followed by workers; the Taylorism (1880s and 1890s) was marked by manual and repetitive activities, such as the operations of Bethlehem Steel Company, one of the companies where their studies of times and movements were carried out, where workers had to move pig irons by shovel all day (BAUMGART; NEUHAUSER, 2009). About the tools, works related that in taylorism the analysis was realized with stopwatches and clipboards, seeking the best method to perform an operation determining its time and avoiding waste (NEGREIROS; LIMA, 2011).

In the second half of the 20th century, digital computers emerged and, with them, computerized CRT-displays, technological tools for information management that were introduced in the human-machine interface for the management of operations, and not for the execution of tasks (RIJNSDORP; ROUSE, 1977). Durand (1990) pointed out that the separation of work in conception and execution proposed in scientific administration condemned operators to dull, repetitive and monotonous tasks, and because of these experts began to continuously seek to solve this problem, such as semi-autonomous working groups and Direction Participative per Objectives, generating changes in work organization and in the human-machine relationship. Thus, at the end of the 20th century many companies still used the production technique proposed by Ford and Taylor, but at the same time others sought techniques to enrich the work, such as work teams, job rotation and ergonomics (O'SULLIVAN, 1992).

After Taylorism, different innovations were applied in the industry around the world, with an increasing increase in technology, until the concept of Industry 4.0 was reached (SCHWAB, 2017). Authors like Cezarino *et al.* (2019) and Cazeri (2021) *et al.* appointed that this has been gaining ground mainly in large companies, but it is not yet the reality of small companies, and even in large companies the process has been slow in Brazil. In this way, it is understood that the study of MTM proposed by Taylor will continue to have space in parallel with the new methods of this study, especially in the area of services and manufacturing.

2.2 Studies and times and movements with the development of technology

With globalization business has revolutionized, and thus, unlike the method of scientific administration where man's tasks looked like those of a machine, production systems began to balance human characteristics, needs, skills and capabilities within the technical environment, making the human-machine relationship more multifaceted and human (EIMARAGHY; URBANIC, 2004). In the context of the technological revolution after globalization, mechatronics emerged, the union of machines with technology, and with this, production systems began to include the human being in the control circuit in a human-machine interface, improving the operational skills of the human workforce (DIRICAN, 2015).

Posteriorly, with the rise of technology came Industry 4.0, characterized by the use of state-of-the-art technology, machines, intelligent equipment and mainly task automation (SCHWAB, 2017). This evolution of automation and ergonomics had impacts on work operations. Unlike the taylorism era, when the human directly controlled what and when the machine did the operations (master-servo relationship), in industry 4.0 the man-machine relationship changed from an information system to automation and to an autonomous agent (teammates) (TRUJILLO *et al.*, 2019). Thus, the role of humans in industries is no longer predominantly manual operations for those involving monitoring, diagnosis and prognosis, which use more the cognitive of operators, which in turn makes these operations more challenging to humans, since errors during such operations, because they involve automated machines, can be catastrophic (SCRINIVASAN, 2022).

According to Sharma *et al.*, (2021), even experiencing the fourth technological revolution, the study of MTM cannot be ignored, as the concept has multiple opportunities and impacts throughout society, just like in Taylorism. Duran *et al.*, (2015) point out that, in this technological context, the concept can be used to increase production efficiency with a low investment, reduce costs and bring competitiveness through the application of process improvement (reduction of lead times, for example) and methods of operations, in addition to establishing a feasible work quota, and making the best use of human, material and financial resources. Furthermore, Loghin *et al.*, (2018) believe that technologies from the 4.0 era will significantly contribute to improve the results of the study of times. For example, Root and Jauch, (2019) mention that a challenge of traditional analysis of assembly operations is the detection of dynamic hand gestures and interaction with objects, because due to direct interaction with different objects, conventional tools fail. With the advent of technologies, it is already possible to use electronic devices for data collection, simulation software to carry out such analyses, establishing with more precision and quality the standard time and the preferred method for an industrial environment and the use of virtual reality to build new environments for many companies is already available (KUNZ *et al.*, 2016).

With the context of industry 4.0, a challenge that remains in the implementation of the study of times and movements is the creation of automated MTM codes (FINSTERBUSCH, 2016). Thus, the following work contributes to the current challenge and history of the MTM, presenting the methods and tools used in the application of MTM in recent years that can guide future applications and research.

3. METHODOLOGICAL PROCEDURES

This work is characterized as a systematic review of the literature - RSL, since its purpose comprises to find in literature the main methods and tools applied in the industry since 2010 for the study of times and methods, and also present the content of the selected articles (GOPALAKRISHNAN; GANESHKUMAR, 2013).

The steps that make up an RSL are: planning, application and data analysis. Initially, a planning and organization of the research was carried out, aiming to establish a sequence of actions to guarantee an efficient collection protocol. Based on the systematic review approach proposed by Kitchenhamet *et al*. (2009), an attempt was made to draw a general panorama of the theme, thus defining a search strategy. Was adopted two main databases with articles in Portuguese and in English: the international base Science Direct and the main virtual library in Brazil, the Portal Periódicos CAPES. For a better presentation of the development of the systematic review, the PRISMA model was used, which consists of a checklist with 27 items and a flowchart with four stages, to help the authors to improve the reporting of their systematic reviews and meta-analyses (MOHER *et al*, 2009).

3.1 Article selection method and sample analysis process

Aiming to identify the widest range of articles and guarantee the quality and reliability of relevant studies on the topic, criteria were established for the selection of articles that could be useful for the investigation. For this first stage of research, a preliminary study was carried out over a period of two weeks on the subject studied. From there, a selection of search keywords for the articles was defined, being divided into two groups of words together with the conjunction “AND”. The first group consists of the words: “MTM”, “motion time measurement”, “time study”, followed by the conjunction “AND” and the additions: “production”, “industry”, “operation” and “Method OR Mechanism OR Tools”.

3.2 Elaboration of the article collection and selection protocol

Secondly, based on a preliminary reading that involved analysis of the abstract, title and keywords, articles that demonstrated a degree of connection with the topic were selected. The next step was the use of filters in which articles with a date lower than 2010 were discarded and the disposal of articles from congresses, books, dissertations, and abstracts, searching only for articles by Journals, that is, articles that obtained an evaluation. in pairs. After this selection, the Sucupira Platform was used, which is an important Brazilian tool for the evaluation of scientific journals, which establishes a ranking ranging from A1 to C for each journal. This classification is made according to the quality of the articles, periodicity, diversity of work sources, diffusion and popularity of the magazine.

With this platform it was possible to evaluate each pre-selected article, aiming to discard articles that had a rating lower than the classification proposed in this research, in case B4. Then, a complete reading of the pre-selected articles was made. For each selected article the Snowball technique was applied, until the end of identification of articles relevant to the subject of analysis.

Using the keywords “Methods Time Measurement (MTM) AND Production”, in the two selected databases: Science Direct and CAPES, 3,014 articles are available. Since, from these articles, articles were reviewed by date of publication and, from Journal and Journal, peer-reviewed, reducing the sample to 967 units. With this sampling the preliminary reading was done.

Were found 210 articles in the Science Direct database and 757 in the Capes Portal. From these, a dynamic reading was carried out, that is, the main parts of the article were read as a summary, method and results. In sequence, Snowball Sampling was used, aiming to find the maximum number of articles related to the theme. All of these procedures are shown in Table 1, showing how the 21 selected articles was arrived at.

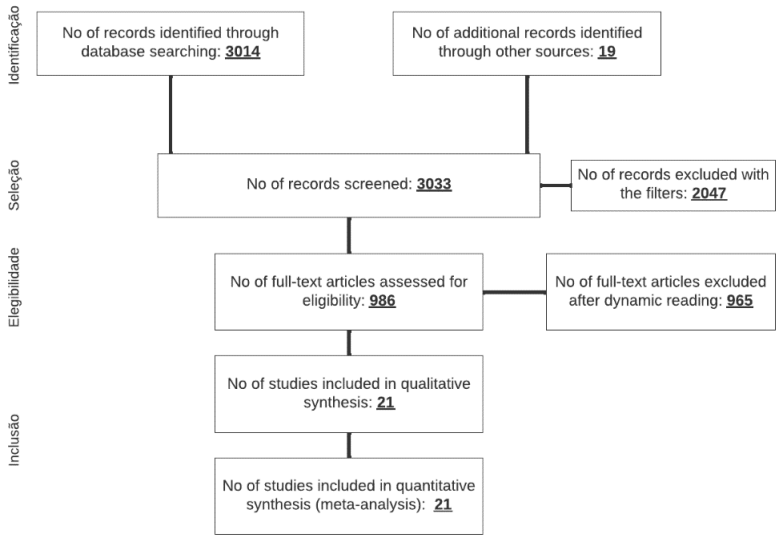
TABLE 1 - Research data in databases related to the Study of Times and Movements

Keywords	Science Direct	Capes	TOTAL
Methods Time Measurement (MTM) AND Production	1818	1196	3014
	Total search	no filter	
Year selection (2010- 2020) Journal e Journal peers	210	757	967
Dynamic reading and selection of evaluation criteria	9	2	11
Snowball			
Year selection + dynamic reading	15	4	
Snowball	8	2	10
TOTAL			21

Source: The authors, 2022.

Figure 1 shows the flow of article selection, it details articles included and excluded according to the prism model.

FIGURE 1. Flow chart of articles identified, include and excluded



Source: MOHER *et al.*, 2009 (adapted).

Finally, after the last step of the systematic literature review (analysis of results and report), the PRISMA model checklist was applied. With it, it was possible to present in a more objective way the structuring of the summary, introduction, methods, results and discussion, verifying that all necessary elements of each section have been included in the article, except the risk of bias in individual and across studies, and additional analyses. With the complete Checklist, with its 27 points answered, it can be affirmed that the article fulfilled most of the requirements of a systematic literature review.

Finally, after all the procedures listed above, another search was conducted in the chosen databases looking for articles published in 2021 and 2022, in order to present the latest state of the art articles. In this search, 10 articles were found, which were included in the quantitative and qualitative analyses.

4. RESULTS

Given the above, this work seeks to find in literature the main methods and tools applied in the industry since 2010 for the study of times and methods, and also present the content of the selected articles. In the first stage of the results, bibliometric analysis will be presented, and in the second stage, content analysis.

4.1 Bibliometric analysis

Through the selection of the 31 articles identified in the literature from 2010 to 2022, there is a predominance of articles belonging to the European continent, about 42%, after 35% Asia and 23% America (Figure 2). This can be explained by the appearance of the Study of Movements having been in Europe, within the period of Industrial Revolution. In this scenario, starting from the principles of Scientific Administration, proposed by Taylor, a concern with systematizers of scientific discipline and business administration begins (PAYNE *et al*., 2014).

FIGURE 2 - Article publication continents

Source: The authors, 2022.

With regard to the years of publication, there was no pattern of publication over the years studied. However, in the articles founded in the first search, there is a more expressive number of publications as of 2014 (see Table 2). This can be explained by the increased interest of companies and large organizations to understand the production line in a rationalized way in order to increase their productivity, as suggested by Carlo *et al.* (2013). Furthermore, the second search found more articles than the first (10 papers). It proves the advance of the technology and relevance of the MTM concept nowadays appointed by the literature.

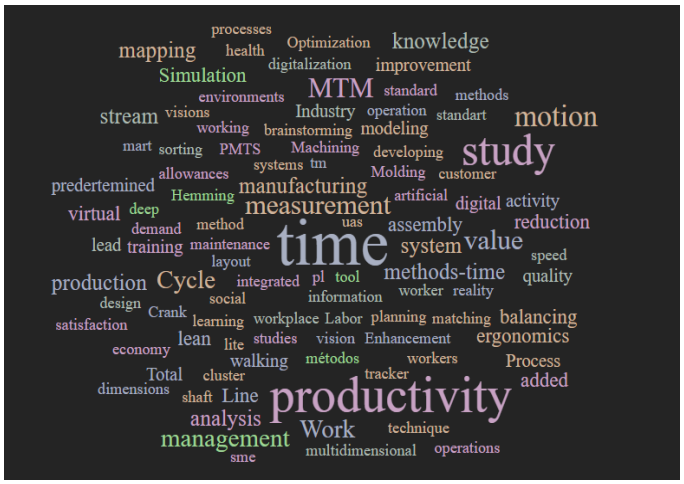
TABLE 2 - Year of publication of articles

Year	Articles	Quantity
2011	[1], [2], [3], [11], [15]	5
2012	[10]	1
2014	[7], [16]	2
2015	[5], [6], [14], [17], [18]	5
2016	[4], [9], [12],	3
2017	[8], [13],[19], [20], [21]	5
2021	[22], [24], [26], [27], [28], [30], [31]	7
2022	[23], [25], [29]	3

Source: The authors, 2022.

In order to create a general overview of the study theme, a word cloud was created using the “Word it out” software, as shown in Figure 3. This cloud was created using the keywords identified in the 31 articles, being the words of larger size those with higher frequency. Thus, as a result of this visual representation, the words "time", “productivity”, "study", “motion”, "MTM", "value", "measurement" and "management" are the most prominent. This means that the works that work with Study of Times are mainly focused on the search for greater control and productivity of the processes.

FIGURE 3 - Word cloud with the keywords of the articles



Source: The authors, 2022.

The study of times and movements is applied in order to generate a quality management instrument, guaranteeing the continuous improvement of processes. The process of implementing the study of times found in the literature is consistent with this definition. Based on the literature, which points out that new tools have emerged with industry 4.0, and the results of the selected articles, two categories of work were identified (Table 3): works that make the analysis of MTM in the real environment, using simple stopwatches and clipboards, and works that make analyzes in virtual environments in order to determine the time of an operation even before its implementation.

TABLE 3 - Study applied and study theoretical

Study applied	Study theoretical
[1], [3],[4], [5], [6], [7], [8], [9], [10],[13], [17], [19], [20], [22], [23], [24], [25], [26], [27], [28], [29], [30], [31]	[2], [11],[12],[15], [16], [18], [21]

Source: The authors, 2022.

In simulation environments, it realizes that the most studied elements were useless movements and elimination of user fatigue. This is possible through software tools that help analysts to determine movements and calculate the estimated time for different operations (KUNZ *et al.*., 2016). Table 4 presents the tools found.

TABLE 4 - The tools

Year	Articles	Tools
2011	[1], [2], [3], [11], [15]	Simulation Software Documentation of process and use of software Use of stopwatches
2012	[10]	Stopwatch Direct observation Time collection
2014	[7], [16]	Standard timer and time system
2015	[5], [6], [14], [17], [18]	Computers and tablets Electronic timer
2016	[4], [9], [12]	Analysis of performance indicators and stakeholders Simulation Software Operation flow analysis Time analysis with aid of stopwatch

2017	[8], [13],[19], [20], [21]	Computers and tablets Simulation Software
2021	[22], [24], [25], [26], [27], [28], [30], [31]	Stopwatch and videos Time collection Sensors (like GNSS clock sensor) Excel Depht camera Algorithm 3D models (like PMTS)
2022	[23], [29]	Softwares (ArUco, YOLO v4, Azure Kinect Body Tracking [AKBT], OpenPose)

Source: The authors, 2022.

It is also that the most recent articles start to apply MTM in software tools and virtual reality, allowing to predict behaviors and facilitating the validation of design changes. In applied research the vast majority of studies developed took place within industries, mainly within the automobile industries, as shown in Table 5. A fact that can be explained by the high competitiveness of the sector, which needs to be constantly changing, adaptations in the world scenario and mainly, because it still has good part of the manual activities.

TABLE 5. The industries

Articles	Industries
[1],[3], [5], [10], [11], [24], [25], [27], [30]	Automobile
[20]	Health
[4], [6] [7], [19],	Electric
[2], [8], [9], [11], [15], [21], [22], [26], [28]	Industrial
[23]	Mining
[29], [31]	Civil construction
[12],[16], [18],	Notspecify

Source: The authors, 2022.

4.1 Content analysis - discusion

The systematic analysis of the literature was performed with 31 articles, 21 found in the first search (2010-2020) and 10 in the second search (2021 and 2022). Analyzing the studied workers, one realizes that one of the most recurring objectives in using this methodology is to measure the time of operations. This is because, once the tasks of the production line are known, it becomes more assertive to carry out actions aimed at increasing productivity and reducing costs (KUMAR *et al.*, 2021).

As presented in the most recent articles that are within Industry 4.0, although the Study of Times and Movements is an old methodology that originated in the Industrial Revolution environment, it is still an essential tool, as Sharma *et al.*, (2021) pointed out. This is because, this time analysis allows organizations to improve their processes, making them of better quality and with reduced cost. This benefit was seen, among other articles, in the study by Duran *et al.*, (2015), who applied the study of times and movements and, with this, found the standardized time, compared it with real time and then took the necessary precautions, achieving an increase in efficiency of 53%, increasing the production capacity of 155 to 237 products per time interval.

With the expansion of the use of technology in the production lines during the late 90's until today shown in section 2, it became functional to make digital models of the Studies of Times and Movements. Thus, it is observed that this digital reality has been generating a valuable guide in the continuous improvement of processes. Studies prove that there are several reasons that explain the success that this virtual trend is having, the main ones are the flexibility and adaptability of web applications and technologies for different types of users and situations, in addition to the ease and familiarity of people with the use of these browsers.

Analyzing the articles, it was possible to understand a pattern for the implementation of the Study of Times and Movements, being necessary to choose an operation that is fully standardized to be measured. With the chosen and determined operation, the next step is select the operator – taking into account skills, experience, training and commitment to the organization of each one – and the observer – who has deep knowledge of the process, good visualization of the elements of the activity and accuracy in recording the information, (TORRES *et al.*, 2022). Then, the step is to divide the standard time of operations into two parts: the basic time (1), time taken by a qualified worker, who does a qualified job with standard performance; and tolerance (2), concessions added to the basic time to allow rest, relaxation, and personal needs (SLACK *et al..*, 2007). Thereafter it is up to the supervisor to assess whether the time is in accordance with the necessary effort, and if possible, to improve it.

In the most recent articles, the methodology for implementing chronoanalysis was identified from the creation of virtual environments, one of the tools that emerged with industry 4.0 that expand the application of the MTM, as pointed out Loghin *et al.*, (2018). In practice, this reality allows the user to navigate and see, in real time, a world of three

dimensions and with different inclinations. The great advantage of this type of interface is that the user's intuitive knowledge about the physical world can be transferred to manipulate the virtual world. The user enters the virtual space and becomes able to manipulate and simulate operations, making it possible to predict bottlenecks and losses in the production line. An example is the application of MTM performed by Kunz *et al.*, (2016), which presented a system that allows performance measurements of manual operations completely within a virtual environment The study expanded the traditional methods of MTM, given that the system replaces physical models with virtual representations of workplaces and machines from existing CAD data, allowing for real walking in such a virtual environment, the perception of sizes and distances, and thus measuring worker walking times at all levels accurately. Instead of video recording and subsequent manual transcription of movements, all worker operations will be automatically captured and evaluated.

The application of MTM results in consequences for both the production line and the organization's worker. Since they start to use the knowledge and content generated to optimize the results and adapt and remodel their operations. Thus, some of the main actions and recommendations suggested after using this methodology in industries were identified, they are:

- Standardization and monitoring of compliance with changes. It is necessary to make each activity very detailed and measured, in order to make the system palpable and subject to rapid and efficient changes. In order to control and ensure that all actions proposed by this methodology are being carried out in accordance with what has been studied (HANAMANT *et al*., 2017).
- Improvements in the physical arrangement: it appears as a possibility to reorganize the layout of the post, in order to maximize the work. This change is made from the aspects of improvement that were identified through the study of times, where it was possible to map the areas of loss of value (BATTINI *et al.*, 2011).
- Activity redistribution: changing operations that exceed Takt-Time (i.e. the time that a part or product must be produced), since it will influence the production time of the line. In order to develop effective actions to ensure that production is carried out continuously and levelly, avoiding waste generated by the production of intermediate

stocks and idleness caused by waiting time during production (VIJAY; PRABHA, 2021).

- Change in ergonomics. This is because human posture and physical effort influence the time needed to perform tasks. Since good ergonomics not only promotes worker comfort and safety, it is responsible for enriching the concept of productivity. In other words, by reducing the human being's pain, by promoting their better adaptation to work, productivity arises naturally, because of this whole process (JAISWAL *et al.*, 2016).

Therefore, it is worth mentioning that, among the 31 articles, no application was equal to another, since each case adjusted the MTM with the appropriate tools for its reality. The best results, such as productivity improvement, waste reduction, among others, were achieved with the correct application of methods and tools, whether technological or not, which helps in understanding the evolution of the theme. In addition, in addition to the evolution of the theme presented in section 2., the technological tools that Loghin *et al.*, (2018) stated that they would contribute significantly to the study of times were identified and presented. Thus, the present study contributes to the development of best practices in the application of MTM, and can serve as the basis for future studies in the area.

5. CONCLUSIONS

This article sought to analyze the available literature on the Study of Times and Movement applied to industry, finding the main methods and tools of the application of the subject. Initially, the study presented the evolution of time and method studies, closely related to the development of production and operations engineering, contributing to the construction of knowledge in the area of the study of times and movements, from the reading of 31 articles.

In this sense, from the search for methods of application of the methodology it was possible the main methods and tools used in the application of MTM. Also was identified two fronts of employment: the most simply one that uses timers to measure operational work in production lines, and the most recent related that is within the Digital Era and is characterized through the use of simulation software. This points to society that Industry 4.0 does not come to eliminate traditional methods of analysis and optimization of operations, such as MTM, but to provide tools that complement these processes.

Thus, the articles show that although time analysis is an age-old study, it still has major industry applications. In addition, the main results and consequences for organizations that apply the Study of Times and Movements were identified. Thus, this article can serve as support for the application of MTM in companies and, thus, enable them to manage management benefits, such as standardizing operations, increasing productivity and eliminating waste such as wrong costs and movements, which in turn reduces the risks of accidents involving workers (social benefit).

In view of the foregoing, it is recommended to carry out more detailed research addressing how each action, from MTM, impacts on the routine, and especially on the organization culture of the company.

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