Journal of Management & Technology
e-ISSN: 2177-6652

THE INFLUENCE OF INDUSTRIAL REVOLUTIONS TO THE EVOLUTION OF MANAGEMENT THEORY

A INFLUÊNCIA DAS REVOLUÇÕES INDUSTRIAIS NA EVOLUÇÃO DA TEORIA DA GESTÃO

LA INFLUENCIA DE LAS REVOLUCIONES INDUSTRIALES EN LA EVOLUCIÓN DE LA TEORÍA DE LA GESTIÓN

Cite as:
Klečina, Ante, Buntak, Krešimir & Krpan, Ljudevit (2024). The influence of industrial revolutions to the evolution of management theory. Journal of Management & Technology (Revista Gestão & Tecnologia). Special Edition. v. 24, n. 2, pp:114-142

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Scientific Editor: José Edson Lara
Organization Scientific Committee
Double Blind Review by SEER/OJS
Received on 22/03/2024
Approved on 20/04/2024

ABSTRACT
In the beginning of industrial revolution in Great Britain, around 1760, the manufacturing processes around the country started witnessing a large wave of machinery being used for production. Usage of the machines needed skilled workers, new manufacturing techniques and new organisational skills. This wave gradually spread across Europe and changed the entire economies. By the 1840, when the industries started to use steam engines more and more, when transportation was revolutionized by usage of canals, steamboats, and the railways, a new, second industrial revolution spread across the most developing countries of the time. Machinery and new skills helped countries like United Kingdom, France, Belgium, United States, Germany and even Japan to become new industrial superpowers. In order to boost productivity and to meet the demands from rapidly growing working population, new thinking from prominent businessman gave birth to a new discipline – management. It became essential to manage the machinery and the people in efficient way in order to increase the level of production and the working conditions. The thinkers like F. W. Taylor, Max Webber, Henri Fayol and others started writing about Management theories. The first classical management schools dating way to the beginning of the 20th century were replaced with neo-classical management theories from 1930 to 1950. Usage of the microchips and computers saw the birth of the third industrial revolution and many new authors, like Jeremy Rifkin, wrote about it. Recently, Klaus Schwab wrote about "ubiquitous computing", "the Internet of and for things", "Smart cities", robotics, blockchain, crypto currencies and similar things, rounding it up in his book "Fourth industrial revolution". Of course, new management theories were present at both third and fourth revolution. This article is researching the connection between the industrial revolutions and the management theories. To be more precise, it is researching on how industrial revolutions affected the management schools and theories and vice-versa.

Keywords: management theories, industrial revolution, evolution of management, schools of management

RESUMO
No início da revolução industrial na Grã-Bretanha, por volta de 1760, os processos de fabricação em todo o país começaram a testemunhar uma grande onda de máquinas sendo utilizadas para a produção. O uso das máquinas exigia trabalhadores qualificados, novas técnicas de fabricação e novas habilidades organizacionais. Esta onda espalhou-se gradualmente pela Europa e mudou todas as economias. Em 1840, quando as indústrias começaram a usar cada vez mais motores a vapor, quando o transporte foi revolucionado pelo uso de canais, barcos a vapor e ferrovias, uma nova e segunda revolução industrial se espalhou pela maioria dos países em desenvolvimento da época. A maquinaria e as novas competências ajudaram países como o Reino Unido, a França, a Bélgica, os Estados Unidos, a Alemanha e até o Japão a tornarem-se novas superpotências industriais. A fim de aumentar a produtividade e satisfazer as exigências da população activa em rápido crescimento, o novo pensamento de um empresário proeminente deu origem a uma nova disciplina – a gestão. Tornou-se essencial gerir as máquinas e as pessoas de forma eficiente para aumentar o nível de produção e as condições de trabalho. Pensadores como F. W. Taylor, Max Webber, Henri Fayol e outros começaram a escrever sobre teorias de gestão. As primeiras escolas clássicas de gestão que datam do início do século XX foram substituídas por teorias neoclássicas de gestão de 1930 a

1950. O uso de microchips e computadores viu o nascimento da terceira revolução industrial e muitos novos autores, como Jeremy Rifkin, escreveu sobre isso. Recentemente, Klaus Schwab escreveu sobre "computação ubíqua", "a Internet das e para as coisas", "cidades inteligentes", robótica, blockchain, moedas criptográficas e coisas semelhantes, resumindo-as no seu livro "Quarta revolução industrial". É claro que novas teorias de gestão estiveram presentes tanto na terceira como na quarta revolução. Este artigo pesquisa a conexão entre as revoluções industriais e as teorias de gestão. Para ser mais preciso, está a investigar como as revoluções industriais afectaram as escolas e teorias de gestão e vice-versa.

Palavras-chave: teorias de gestão, revolução industrial, evolução da gestão, escolas de gestão

RESUMEN

Al comienzo de la revolución industrial en Gran Bretaña, alrededor de 1760, los procesos de fabricación en todo el país comenzaron a ser testigos de una gran ola de maquinaria utilizada para la producción. El uso de las máquinas necesitaba trabajadores cualificados, nuevas técnicas de fabricación y nuevas habilidades organizativas. Esta ola se extendió gradualmente por Europa y cambió economías enteras. En 1840, cuando las industrias comenzaron a utilizar cada vez más máquinas de vapor, cuando el transporte fue revolucionado por el uso de canales, barcos de vapor y ferrocarriles, una nueva segunda revolución industrial se extendió por los países más desarrollados de la época. La maquinaria y las nuevas habilidades ayudaron a países como el Reino Unido, Francia, Bélgica, Estados Unidos, Alemania e incluso Japón a convertirse en nuevas superpotencias industriales. Para aumentar la productividad y satisfacer las demandas de una población activa en rápido crecimiento, el nuevo pensamiento de un destacado empresario dio origen a una nueva disciplina: la gestión. Se volvió esencial gestionar la maquinaria y las personas de manera eficiente para aumentar el nivel de producción y las condiciones de trabajo. Pensadores como F. W. Taylor, Max Webber, Henri Fayol y otros comenzaron a escribir sobre teorías de la gestión. Las primeras escuelas de gestión clásicas que datan de principios del siglo XX fueron reemplazadas por teorías de gestión neoclásicas de 1930 a 1950. El uso de microchips y computadoras vio el nacimiento de la tercera revolución industrial y muchos autores nuevos, como Jeremy Rifkin, escribió sobre ello. Recientemente, Klaus Schwab escribió sobre "computación ubicua", "Internet de y para las cosas", "ciudades inteligentes", robótica, blockchain, criptomonedas y cosas similares, y lo resumió en su libro "Cuarta revolución industrial". Por supuesto, tanto en la tercera como en la cuarta revolución estuvieron presentes nuevas teorías de gestión. Este artículo investiga la conexión entre las revoluciones industriales y las teorías de la gestión. Para ser más precisos, está investigando cómo las revoluciones industriales afectaron a las escuelas y teorías de gestión y viceversa.

Palabras clave: teorías de la gestión, revolución industrial, evolución de la gestión, escuelas de gestión.

1. INTRODUCTION

British industrial revolution, also more often referred as the First industrial revolution, started in 1760 and lasted for almost a century according to Kapas (2008). Some other authors like Stearns (2013) stretch it even to 1880. Many circumstances lead to the first revolution. Many of them are based on technology and inventions, while some authors mention very important aspects of energy sources, entrepreneurship, invention, trade, transportation and similar that lead to it as well. An interesting observation from Kapas (2008) puts a lot of emphasis on organisation of work and production to be one of the key factors that lead to start of the first industrial revolution since she sees the establishment of a factory as opposed to "family firm" or a craft-shop. The factory was a new organizational form: it was a firm, while the putting-out system was a market-like organization based on market contracts.

It is generally regarded that the First industrial revolution started around 1760 in United Kingdom. It was generally based on several machine tools invention which were driven by water or by steam while factories with job division, organization and higher productivity started replacing smaller family-based craft-shops. The Second industrial revolution started in the second half of the 19th century. According to Mokyr (1990) this era lasted from 1870 to 1914 and it was mostly based in the United Kingdom and the USA while other countries followed some years later. It was often called the technological revolution due to many technological inventions that revolutionized production, energetics, transportation and communication. The start of the Third industrial revolution is seen very differently among experts and authors. To some like Kahn (1987) it started with the invention of transistors in 1948 which led to the development of new information technologies. Other influential authors like Rifkin (2011) wrote about the Third industrial revolution as the one that started after 2010 with usage of clean energy and technologies that will make the world carbon neutral. Schwab (2016) wrote about the Forth industrial revolution coming with new technologies like Artificial Intelligence and smart and connected machines in general. Schwab (2016) wrote that the Third industrial revolution started in 1960-ties.

On the other hand, management as a discipline was starting to appear in the last decades of 19th century. According to Jones and George (2016) the evolution of modern management began in the closing decades of the 19th century, after the industrial revolution had swept through Europe and America. In the new economic climate, managers of all types of

organizations—political, educational, and economic—were trying to find better ways to satisfy customers' needs. Since around 1980 there have been several schools of management, roughly divided into classical, neo-classical and modern.

It is most likely that energy sources like coal and technological advances were the most important factor for starting the first industrial revolution. But this finding that the organization of work and managing the work and production in a different and probably more efficient way is the main driver for the research work done in this article.

The main goal of this article is to research links between industrial revolutions, from 1760 until today, and management styles and management schools from 19th century also until today. Different industrial revolutions have set new needs for company management, but it was also the case on some occasions that some specific management styles lead to certain innovations or certain shift in the economy that fuelled new technologies and new industrial revolutions as well. This leads to some research questions related to this article:

- How did industrial revolutions affect the birth of management schools?
- How did management schools affect the creation of new technologies and possibly new industrial revolutions?
- How did new technological advances affect new advances in management?
- The methodology used is the following:
- Method of qualitative analysis: the macroeconomic data gathered is being analysed through different time periods, meaning different industrial eras and different eras of management.
- Method of quantitative analysis: certain descriptions are gathered from different industrial eras and different eras of management and their qualitative impact is being analysed.
- Method of comparison: impacts from different industrial eras and different eras of management are being compared in terms of efficiency, economic and social impacts.

After literature review, the first part of the article is describing the circumstances and most important factors for the start of the first industrial revolution.

Third part elaborates the birth of the management thought and the first school of management. It also provides insight into the most important developments in management during the era of classic school of management.

The following two parts discuss the third industrial revolution, the period covering the second half of the 20th century and the beginning of the 21st century.

The last two parts are covering the fourth industrial revolution and the modern school of management thought.

2. LITERATURE REVIEW

There are many authors that wrote about industrial revolutions in history and changes that they brought to world's societies. There are several authors that wrote very influential books regarding the First industrial revolution (FIR) like Landes (1969), Deane (1979) and more recently Stearns (2013). Also, Hobsbawm (1962) wrote about the links between British industrial revolution and the French revolution. There are authors that recently wrote about FIR like Mohajan (2019) seeing benefits of IR, like creation of modern industrial and technological era, with certain downsides like deterioration in life conditions for more and more low skilled, overworked and underpaid workers.

The second industrial revolution was covered also by Landes (1969), by Mokyr (1990) and Hobsbawm (1987).

The third industrial revolution, meaning digital revolution, was covered by Kahn (1987), Danzin (1987), Filemon (1987), Boutzev (1987), Aitmatov (1987), Fengquiao (1987) and other authors. All the mentioned authors have published their articles in No 146 issue of Impact of science on society, a journal that has been published since 1950 by UNESCO. The No 146 had a significant headline – The third industrial revolution. All of the authors wrote about the digital revolution, meaning introducing transistors, microchips and information technology into the economy and society, as a new industrial revolution.

Another significant author, Jeremy Rifkin (2011), wrote also about the third industrial revolution in his book simply named The Third Industrial Revolution. Unlike the authors that

wrote for the UNESCO's journal, Rifkin was writing about clean energy and technologies based on carbon neutral economy and production as significant for the start of the new industrial era.

Also, Schwab (2016) wrote a book called The Fourth Industrial Revolution, in which the main shift towards a new industrial era are artificial intelligence and new advanced, automated and connected machines.

When it comes to management theory and the schools of management Jones and George (2016) gave a comprehensive history of it. Shafritz et al. (2014) gave a comprehensive overview as well, including some research regarding the organization theory dating before 18th century. Wren and Bedeian (2009) are very thorough in displaying the development of management through history as well. Drucker (1954, 2001) is also an influential author that wrote about history of management.

Kohnová and Salajová (2019) wrote about industrial Revolutions and their impact on managerial practice. Kapas (2008) wrote about the the Co-evolution of Technology and Institutions, meaning that organisations had grown together with technological advancement. Gulzar (2015) wrote about how industrial revolution could have revolutionized the management thought process. Anshari et al. (2022) were examining the role of Knowledge Management (KM) strategies in responding to the emergence of the Fourth industrial revolution (4IR), its impact on and challenges to the labor market, and employment. Shaturaev (2022) wrote about economies and organizations would have to adopt "Algorithmic Management" to remain competitive in the new digital environment, meaning in the 4IR. Turner (2021) evaluates how and why the various definitions of management emerged and investigates their historical antecedents. This author addresses this question by tracing the evolution of management competencies from the First to the Fourth Industrial revolution, investigating the role and style of managers in each 'revolution' and in multiple geographies.

Wren and Bedeian (2009) have also evaluated how management thought have evolved through industrial revolutions. They have covered preindustrial era and set different stages of management thought development up to this day.

2.1 The first industrial revolution - The creation of the industrial world

The industrial revolution in the United Kingdom started at the middle of 18th century. Landes (1969) wrote that in the eighteenth century, a series of inventions transformed the manufacture of cotton in England and gave rise to a new mode of production - the factory system. During these years, other branches of industry effected comparable advances, and all these together, mutually reinforcing one another, made possible further gains on an ever-widening front. The abundance and variety of these innovations almost defy compilation, but they may be subsumed under three principles: the substitution of machines-rapid, regular, precise, tireless-for human skill and effort; the substitution of inanimate for animate sources of power, in particular, the introduction of engines for converting heat into work, thereby opening to man a new and almost unlimited supply of energy; the use of new and far more abundant raw materials, in particular, the substitution of mineral for vegetable or animal substances.

Watt's improvement and innovation to the steam engine created revolutionary effect on the modern technology and production, being of epoch-making significance. Before Watt production mainly relied on human, animal and hydraulic power. The steam engine provided unprecedented power, marking a new era of steam power. Consequently, it led to the rapid development of the First Industrial Revolution.

According to Deane (1979) the first industrial revolution occurred in Great Britain and is of particular interest in that it occurred spontaneously, without the government assistance which has been characteristic of most succeeding industrial revolutions. Exactly when it took place is a matter of controversy. The first economic historian to discuss the British experience of industrialization in terms of this concept of a specific revolution was Arnold Toynbee, who delivered a course of lectures on the subject in the University of Oxford in the year 1880/1. He took his starting point as 1760 and for about half a century this view of the matter went unchallenged, until Professor Nef, the American historian, questioned the significance of the historical boundary it implied. He stressed the essential continuity of history and traced the beginnings of large-scale industry and technological change back to the sixteenth and early seventeenth centuries. According to Nef (1934) 'The rise of industrialism in Great Britain can be more properly regarded as a long process stretching back to the middle of the sixteenth century and coming down to the final triumph of the industrial state towards the end of the

nineteenth, than as a sudden phenomenon associated with the late eighteenth and early nineteenth centuries.'

Zhang and Yang (2020) gave a lot of significance to the start and the development of the first industrial revolution on the improvement of steam engine done by James Watt. The first practical steam engine was invented by Thomas Newcomen is 1712 (Rolt and Allen, 1997). Watt started making improvements to the steam engine, the Newcomen engine or an atmospheric engine.

The steam engines were not invented by Newcomen. In 1698, Thomas Savery invented a steam pump (Lovland, 2007; Shubov 2021).

After 1759, Watt made a series of tests to improve the steam engine (Hills, 1989). To the year of 1790 when he invented the cylinder indicator, Watt completed the invention of steam engines in about 30 years, obtaining a series of patents (Zhang and Yang 2020).

Zhang and Yang (2020) also stated that industrial revolution and improved steam engine started a transportation revolution.

The railway was a new technology that offered transport of people and goods several times faster than before. The transportation revolution changed the state of isolation between regions on the earth. It expanded rapidly the scope of human activities and strengthened the communication between different areas and countries. The British ocean ships transported consumer goods produced in Britain to every corner of the world, and took back industrial raw materials needed, creating the conditions for the formation of a world market.

Railway was called “the industrial crown”. The Industrial Revolution transformed the shop-based industry into large factory-based one which laid solid material and technical foundation for the capitalist economy. While the transportation revolution accelerated the agglomeration and centralization of capital, forming a new starting point of rapid development of the capitalist economy (Zhang and Yang 2020). Regarding the most notable things that separate industrial from non-industrial era Kapas (2008) argued about the factory and wrote

that the macro-inventions[1] of the BIR[2] induced significant changes in various elements of social technology, more importantly in the way the work was organized, which led to the rise and spread of the factory. The factory itself was the major novelty in the BIR which had an enormous effect on the development of economies as a whole. Further on, Kapas (2008) wrote that the factory replaced the putting-out system that was based on the "family firm" craft-shop. The craft-shop was run by a master craftsman with a couple of journeymen, apprentices and family helpers. Under the putting-out system the merchant-entrepreneur owned the raw material, the goods in process, the equipment and tools, and outsourced the work at piece rates to workers who usually worked at home. The factory was a new organizational form: it was a firm, while the putting-out system was a market-like organization based on market contracts. And as argued in the theory of the firm literature (e.g., Foss, 2002; Kapás, 2004) the distinctive feature of the firm is the predominance of authority among the coordinating devices used within the given organizational form[3]. Accordingly, it is not large-scale production as such that was the essence of the factory, but rather firm-like monitoring[4].

Many also said (e.g., Landes, 1969; Mokyr, 2002; Leijonhufvud, 1986) that the rise of the factory was primarily or at least largely driven by the new technology.

The factory had to be organised and managed in a completely new way when compared with pre-industrial family-based craft-shops. New organizations needed workers specialized for certain skills and workplaces organized in chains. Such chains, using work and materials, lead to the final products.

[1] Kapas (2008) wrote that it is important to distinguish macro-inventions and micro-inventions and states that Mokyr (1990) proposed to call major technological advances macro-inventions, which essentially create new techniques and tend to be abrupt and discontinuous. They represent a break compared to the previous techniques. Macro-inventions are usually followed by many micro-inventions that improve and refine them or make them workable without changing the context of the macro-inventions.

[2] BIR is an abbreviation from British Industrial Revolution. The term is often used instead of The First Industrial Revolution because the industrial revolution and the industrial era started first in Britain for several specific political, economic and social reasons.

[3] Kapas (2008) also wrote that this argument is based upon the view that the firm is a complex of coordinating devices (Ménard, 1994).

[4] Kapas (2008) also explained that to underpin this claim one must note that many entrepreneurs in the putting-out system worked with many masters (Pollard, 1965), and on the other hand, there were plants working only on small scale (Landes, 1969).

The essence of the BIR was technical. The technological advances occurred mostly in the following four areas: energy (waterpower, steam engine), metallurgy (iron making), cotton (cotton spinning, mechanical weaving) and diverse industries and services (canals and road building) (Kapas, 2008).

2.2 The second industrial revolution - The need to manage

After the First Industrial Revolution, steam power rose productivity enormously. With the development of mass production and mechanization in the industry, however, the shortcomings of steam power became outstanding. To name a few, steam engines were large in size, and were difficult to be downsized; the overhead line shafts limited the mechanical efficiency and the distance of transmission; production was almost impossible to be arranged into a production line. Further industrial development required a more convenient power source; this became the breakthrough of the Second Industrial Revolution (Zhang and Yang, 2020).

Also, scientific base for the new era was electricity. In 1831, a British scientist, Michael Faraday, revealed the principle of electromagnetic induction (Zhang and Yang, 2020).

The first large two-phase AC generator was created by an English electrical engineer, James Gordon, in 1882 (Singer et al. 1958). Nikola Tesla, a Serbian American scientist, designed the first two-phase AC motor and patented it in 1891 (Zhang and Yang 2020).

In 1856, Henry Bessemer, a British engineer, invented a new steelmaking process with converter (the Bessemer process), the first industrial process for making steel directly from molten pig iron. The Bessemer process greatly improved the quality of steel and achieved mass production at low cost (Zhang and Yang 2020).

In the Second Industrial Revolution, electrical motors and internal combustion engines replaced steam engines, becoming the dominant prime movers. In the age of electricity, steam and hydraulic turbines were rapidly developed and widely used.

More and more new machines were invented and applied in many fields. Machines even began to enter people’s daily life. Machines tended to develop toward high speed, great power, high precision and light weight (Zhang and Yang 2020).

Great progress was made also in mechanical and hydraulic transmissions. Machine design entered a semi-theoretical and semi-empirical stage.

In this period, various precision machine tools, such as grinding machines and gear processing machines, were developed. Mass production appeared and modern management system was firstly established in machine building enterprises (Zhang and Yang 2020).

Power remained the most important keyword in the Second Industrial Revolution as it was in the First one. However, the old steam power stepped down, while new powers rose. (Goddard 2010; Williams et al. 1978a).

According to Mokyr (1998) The first Industrial Revolution -- and most technological developments preceding it -- had little or no scientific base. It created a chemical industry with no chemistry, an iron industry without metallurgy, power machinery without thermodynamics. Engineering, medical technology, and agriculture until 1850 were pragmatic bodies of applied knowledge in which things were known to work, but rarely was it understood why they worked.

It was in this regard that the inventions after 1870 were different from the ones that preceded it. The period 1859-1873 has been characterized as one of the most fruitful and dense in innovations in history (Mowery and Rosenberg, 1989, p. 22)

F. Taylor, who invented the high-speed steel, laid the foundation of scientific management. (…) From his many years practice, he recognized that the lack of effective management means was a serious obstacle to improve productivity. Beginning from the operation of a lathe worker, Taylor systematically investigated the detailed work components in the business, and the time needed for each component. Then, he tried to find ways to improve the efficiencies in each working component and tested in the factory. Gradually he formed the framework for the theory of scientific management (Williams et al. 1978b).

Taylor was the founder of scientific management, from which a new discipline, industrial engineering, grew out gradually. As such, Taylor is also regarded as the father of industrial engineering (Zhang and Yang 2020).

The new era where large machines and high quantity of products were produced need new way to manage such production which led to new styles of managing these processes. New discipline, management, later called Taylor’s scientific management, was becoming crucial to maintain high levels of productivity.

In 1913, Ford Motor Company developed the world's first assembly line, on which a total of 15 million of Model T were produced by 1927. This set a world record, until 45 years later surpassed by the Volkswagen Beetle (Brinkley 2004; Lewis 1987).

The dramatic increase of productivity helped lower the price of the Model T from $850 to $360. In 1914, Ford pioneered the worker daily wage of $5, which was almost double the rate for general factory workers at that time. Besides, Ford reduced the workday from 9 to 8 h, which allowed the factory to run 3 shifts a day instead of 2. Model T was seen then all over the world, and Ford was known as the "person who put the world on wheels" [5] (Brinkley 2004).

The assembly line also needed new ways to organize the entire producing processes and also all the following processes of acquiring materials and parts, selling the products and marketing.

According to some authors like Mokyr (1990), Mokyr (1998) and Hobsbawn (1987), the Second industrial revolution ended in 1914, while some other authors, like Zhang and Yang (2020), stretch the period of the second industrial revolution until the early 1940-thies, when most of the world entered or was already involved into the Second World War.

Formation of the classic school of management - The gamechanger

Jones and George (2016) wrote that the evolution of modern management began in the closing decades of the 19th century, after the industrial revolution had swept through Europe and America. In the new economic climate, managers of all types of organizations—political, educational, and economic—were trying to find better ways to satisfy customers' needs. Many major economic, technical, and cultural changes were taking place at this time.

[5] Although automobile is seen as the machine that symbolises high-speed movement of modern civilization, the railways were the first to do it. Schivelbush (1977) wrote that the railroad, the destroyer of experiential space and time, thus also destroyed the educational experience of the Grand Tour. Henceforth, the localities were no longer spatially individual or autonomous: they were points in the circulation of traffic that made them accessible. As we have seen that traffic was the physical manifestation of the circulation of goods. From that time on, the places visited by the traveller became increasingly similar to the commodities that were part of the same circulation system. For the twentieth-century tourist, the world has become one huge department store of countryside and cities.

Jones and George (2016) also noted that a famous economist of that time, Adam Smith, journeyed around England in the 1700s studying the effects of the industrial revolution. 4 In a study of factories that produced various pins or nails, Smith identified two different manufacturing methods. The first was similar to crafts-style production, in which each worker was responsible for all the 18 tasks involved in producing a pin. The other had each worker performing only one or a few of these 18 tasks[6].

By 1910 Taylor's system of scientific management had become nationally known and in many instances was faithfully and fully practiced (Litterer, 1986).

Scientific management brought many workers more hardship than gain and a distrust of managers who did not seem to care about workers' well-being (Pollard, 1974). These dissatisfied workers resisted attempts to use the new scientific management techniques and at times even withheld their job knowledge from managers to protect their jobs and pay. It is not difficult for workers to conceal the true potential efficiency of a work system to protect their interests (Jones and George, 2016).

It is important to note that Taylor was not an original thinker. Many of his ideas came from other thinkers, especially the Englishman Charles Babbage (1791–1871). Taylor's contribution was that he advanced a total system of management by uniting the ideas and philosophies of many others (Bright et al., 2019).

Two prominent followers of Taylor were Frank Gilbreth (1868–1924) and Lillian Gilbreth (1878–1972), who refined Taylor's analysis of work movements and made many contributions to time-and-motion study (Jones and George, 2016).

Max Weber (1864–1920) wrote at the turn of the 20th century, when Germany was undergoing its industrial revolution. To help Germany manage its growing industrial enterprises while it was striving to become a world power, Weber developed the principles of bureaucracy, a formal system of organization and administration designed to ensure efficiency and effectiveness (Jones and George, 2016).

Henri Fayol (1841–1925) was the CEO of Comambault Mining. Working at the same time as Weber, but independently, Fayol identified 14 principles that he believed essential to

[6] Smith included this into his book The Wealth of Nations, first published in 1776, for the purpose of writing this article, an edition from 1982 (Smith, 1982) was used.

increase the efficiency of the management process. We discuss these principles in detail here because, although they were developed at the turn of the 20th century, they remain the bedrock on which much of recent management theory and research is based (Jones and George, 2016).

According to Bright et al. (2019) a notable contributor to Taylor's methods was Henry Gantt (1861–1919), who developed the Gantt chart, which allowed for greater and more precise control over the production process.

If F. W. Taylor is considered the father of management thought, Mary Parker Follett (1868–1933) serves as its mother. Much of her writing about management (…) was a response to her concern that Taylor was ignoring the human side of the organization. She pointed out that management often overlooks the multitude of ways in which employees can contribute to the organization when managers allow them to participate and exercise initiative in their everyday work lives (Jones and George, 2016).

The management thought that started acknowledging the needs and the well-being of the workers is generally known as neo-classical school of management.

2.3 The third industrial revolution - Miniaturization, transistors and microchips

On December 16, 1947, the transistor was invented by William Shockley, John Bardeen, and Walter Brattain at Bell Telephone Laboratories. This was a big milestone in human history as it was the origin of the field of micro/nano electronics, which is now resulting in a super-intelligent society. The technological revolution that followed the invention of the transistor is astounding and has moved mankind forward in countless ways (Iwai and Misra, 2022). This new revolution is mostly known as the Third industrial revolution.

The Third Industrial Revolution (IR3) began in the 1950s and reached its peak in the dot.com era of the late 1990s, and it continues at present, 2021. It is expected that IR3 will end around 2030s. The IR3 is considered as the movement from mechanical and analogue electronic technology to digital electronics, such as green buildings, electric cars, and distributed manufacturing. It is based on energy transition and digital technologies, and the internet, and called "The Digital Revolution" (Bojanova, 2014).

In the IR3, great inventions were semiconductors, mainframe computer, microprocessors, MOS transistors, worldwide web, internet (an ultra-fast 5G communication

internet, a renewable energy internet, and a driverless mobility internet), renewable electricity, e-commerce around 1995, and later developed Smartphone (Gordon, 2012).

There is an enormous economic development in IR3, such as international trade has extended, economic institutions have widened, entrepreneurial activities have increased, the living standards of people has increased, and life expectancy has increased in every nation. During IR3 a new global economy is established based on computers, the internet, telecommunications, and entertainment (Conors et al., 2020).

Schwab (2016) wrote that the Third industrial revolution began a little later, in the 1960s.

In 1987 the UNESCO published the Number 146 of its scientific magazine Impact of science on society. This number called The third industrial revolution. In an article called The third industrial revolution: an economic overview its author Kahn (1987) wrote that the new industrial revolution may be defined as the increased and pervasive application of information technology in most advanced industrial societies and its penetration into the Third World.

Opposing most of the authors covering the topic on third industrial revolution, Jeremy Rifkin (2011) wrote a book called The third industrial revolution, How Lateral Power Is Transforming Energy, the Economy, and the World. In the book the author states that the third industrial revolution will start once the world shakes off the energy sector dependant on oil and its products and embraces the new green, renewable energy. The use of such energy will be joint with new IT and communications technologies such as the internet and internet communication.

Rifkin (2011) claims that today, we are on the cusp of another convergence of communication technology and energy regimes. The conjoining of Internet communication technology and renewable energies is giving rise to a Third Industrial Revolution (TIR). In the twenty-first century, hundreds of millions of human beings will be generating their own green energy in their homes, offices, and factories and sharing it with one another across intelligent distributed electricity networks - an intergrid - just like people now create their own information and share it on the Internet.

Following the end of the second industrial revolution, which, by some authors finished at the brink of the First World War and by others lasted almost until 1950 a new waves of management thoughts were crated. This new era of management started with the new technologies that, by some authors, started the Third industrial revolution. The 3rd revolution, so called “digital era” was a motive to reshape the old schools of management thoughts. Digitalization brought new communication possibilities to business which started spreading worldwide much easier than before.

To increase efficiency, they studied ways to improve various characteristics of the work setting, such as job specialization or the kinds of tools workers used. One series of studies was conducted from 1924 to 1932 at the Hawthorne Works of the Western Electric Company. This research, now known as the Hawthorne studies, began as an attempt to investigate how characteristics of the work setting—specifically the level of lighting or illumination—affect worker fatigue and performance. The researchers conducted an experiment in which they systematically measured worker productivity at various levels of illumination (Jones and George, 2016).

The experiment produced some unexpected results. The researchers found that regardless of whether they raised or lowered the level of illumination, productivity increased.

The researchers found these results puzzling and invited a noted Harvard psychologist, Elton Mayo, to help them. Mayo proposed another series of experiments to solve the mystery. The goal was to raise productivity.

Subsequently it was found that many other factors also influence worker behaviour, and it was not clear what was influencing the Hawthorne workers’ behaviour. However, this effect—which became known as the Hawthorne effect —seemed to suggest that workers’ attitudes toward their managers affect the level of workers’ performance (Jones and George, 2016).

Several studies after World War II revealed how assumptions about workers’ attitudes and behaviour affect managers’ behaviour. Perhaps the most influential approach was developed by Douglas McGregor. He proposed two sets of assumptions about how work attitudes and behaviours not only dominate the way managers think but also affect how they behave in organizations. McGregor named these two contrasting sets of assumptions Theory X

and Theory Y (Jones and George, 2016). The Theory X and Theory Y, and its opposite statements, can be seen in Table 1.

Table 1
Management theory X versus theory Y.

Theory X	Theory Y
The average employee is lazy, dislikes work, and will try to do as little as possible.	Employees are not inherently lazy. Given the chance, employees will do what is good for the organization.
To ensure that employees work hard, managers should closely supervise employees.	To allow employees to work in the organization's interest, managers must create a work setting that provides opportunities for workers to exercise initiative and self-direction.
Managers should create strict work rules and implement a well-defined system of rewards and punishments to control employees.	Managers should decentralize authority to employees and make sure employees have the resources necessary to achieve organizational goals.

Source: McGregor, 2006

Based on their assumptions about human nature, managers could organize, lead, control, and motivate people in different ways. The first set of assumptions McGregor examined was Theory X, which was to represent the ‘‘traditional view of direction and control.’’

Managers who accepted the Y image of human nature would not structure, control, or closely supervise the work environment. Instead, they would attempt to aid the maturation of subordinates by giving them wider latitude in their work, encouraging creativity, using less external control, encouraging self-control, and motivating through the satisfaction that came from the challenge of work itself (Wren and Bedeian, 2009).

One of the most influential views of how an organization is affected by its external environment was developed by Daniel Katz, Robert Kahn, and James Thompson in the 1960s. These theorists viewed the organization as an open system —a system that takes in resources from its external environment and converts or transforms them into goods and services that are sent back to that environment, where they are bought by customers (Jones and George, 2016).

2.4 The fourth industrial revolution

The fourth industrial revolution had started somewhere in the second decade of the 21st century. In this part, the start of this new era is elaborated.

Mindful of the various definitions and academic arguments used to describe the first three industrial revolutions, I believe that today we are at the beginning of a fourth industrial revolution. It began at the turn of this century and builds on the digital revolution. It is characterized by a much more ubiquitous and mobile internet, by smaller and more powerful sensors that have become cheaper, and by artificial intelligence and machine learning. Digital technologies that have computer hardware, software and networks at their core are not new, but in a break with the third industrial revolution, they are becoming more sophisticated and integrated and are, as a result, transforming societies and the global economy. This is the reason why Massachusetts Institute of Technology (MIT) Professors Erik Brynjolfsson and Andrew McAfee have famously referred to this period as "the second machine age"[7], the title of their 2014 book, stating that the world is at an inflection point where the effect of these digital technologies will manifest with "full force" through automation and the making of "unprecedented things" (Schwab, 2016).

In Germany, there are discussions about "Industry 4.0", a term coined at the Hannover Fair in 2011 to describe how this will revolutionize the organization of global value chains. By enabling "smart factories", the fourth industrial revolution creates a world in which virtual and physical systems of manufacturing globally cooperate with each other in a flexible way. This enables the absolute customization of products and the creation of new operating models.

The fourth industrial revolution, however, is not only about smart and connected machines and systems. Its scope is much wider. Occurring simultaneously are waves of further breakthroughs in areas ranging from gene sequencing to nanotechnology, from renewables to quantum computing. It is the fusion of these technologies and their interaction across the physical, digital and biological domains that make the fourth industrial revolution fundamentally different from previous revolutions (Schwab, 2016).

The fourth industrial revolution is more than just technology-driven change. Rather, it is powered with disruptive innovation to positively impact our core industries and sectors, such

[7] Brynjolfsson and McAfee (2014) are describing this term in their book The Second Machine Age: Work, Progress, and Prosperity in a Time of Brilliant Technologies.

as education, health and business. In education, with the previous industrial revolutions, the focus of education changed. With the first industrial revolution, education was focused on standard modes of learning, such as the McGuffey reader. With move toward mass production in the second industrial revolution and standardized testing. Education is service oriented and with the move into the third industrial revolution we come to see students under a customer learning model. Now in the fourth industrial revolution, technologies really blur the lines between physical, digital and biological spheres. Disruptive innovation makes its way into higher education in which it redefines the conventional ways universities deliver their content to students. New modes of curriculum and teaching arise, and the focus changes from modes of teach to modes of learning. Alternative curriculums are being constantly developed. Disruptive innovation also reshapes how businesses operate. Thinking has really moved outside of the box. New markets are created, and new products are defined. Netflix is competing with traditional television. Taxis must compete against Uber and Lyft. These offered similar product offered to customers in new ways. You could watch your shows from your home or get a ride somewhere. With the Airbnb alternative overnight accommodations are competing against traditional hotels and motels (Jules 2017).

The fourth industrial revolution affected the world significantly. First, a large portion of people around the world are likely to use social-media platforms to connect, learn, and change information. Second, a variety of innovative producers and competitors will have easy access to digital platforms of marketing, sales, and distribution, thereby improving the quality and price of goods and services. Third, consumers will be more and more involved in the production and distribution chains. The main effects of this revolution on the business environment are the impact it will have on consumer expectations, product quality, the move toward collaborative innovation, and innovations in organizational forms (Xu et al., 2018).

2.5 Management of the future - Managing the new technologies

Several new management practices arose in the second half of the 20th century and are still being in use today. One of such practices is Total Quality management or TQM.

TQM (Total Quality Management) is one of the best-known methods for constantly enhancing processes and has a key influence on organizations by putting the customer at the center of quality decisions and advancement (Johnston et al., 2012). Quality is an important factor that supports organizations to do better than their competitors. Ethics, integrity, trust, teamwork, training, leadership, communications, and recognition are the elements that will guarantee the success of TQM (Milosan, 2014).

The key benefits of TQM (Charantimath, 2011) include improved efficiency, customer satisfaction, and better organizational development. It will also establish a good corporate culture where the customer is the main concern of the business rather than the department and improve the performance of employees through training provided by the company, which will increase productivity and efficiency. In addition, TQM will improve the process effectively and eradicate common problems in work systems, lowering the cost and creating flexibility in arranging personnel. Moreover, TQM focuses on major areas that need changes, redundant tasks and processes, and worthless operations.

Porter (1985) conceptualized a value chain that pertains to a firm that disaggregates into its purposely relevant activities so that the behavior of costs and the present and future basis of segregation would be understood. The most important characteristic of the service value chain is the integration of all functions that influence a company's ability to provide service to its customers, such as sales & marketing, and customer service. The key intention of the value chain is incorporating the value chain partners to enhance the efficiencies that would result in value creation for the stakeholders (Ilyas et al., 2006).

Wade (2014) presented how management has evolved over the ages showing several stages, where each stage is identified by a colour. The first stage was described as a “wolf pack” characterized by division of labour and command authority. The last stage was referred to as a “living organism” that has an evolutionary purpose, is self-managed, and is holistic.

As Industry 4.0 will radically transform the competence profiles of workers, it will be necessary to provide the appropriate training strategies and to prepare universities for triaging students for meeting the job needs in 4th industrial revolution society (Oh, 2020). The rise of 3-D printing will negate the need for manufacturing skills that workers needed in the past. 3-D printing is now used for creating human organs to use as a testbed for drugs, all different types

of materials (glass, metal, brick), and also is being used to create chocolate. In response to this, what is needed by workers will be what has come to be known as "soft skills". "Soft skills" is the term given to people's ability to handle the human side of business such as influencing, communicating, team management, delegating, appraising, presenting, and motivating. This is now recognized as key to making businesses more profitable and an essential skill for new employees. Increasingly, companies aren't just assessing their current staff and future recruits on their business skills. They are now assessing them on a whole host of soft skill competencies around how well they relate and communicate to others (Shaturaev, 2022).

Schwab (2016) wrote that the companies need to adapt to the concept of "talentism[8]". This is one of the most important, emerging drivers of competitiveness. In a world where talent is the dominant form of strategic advantage, the nature of organizational structures will have to be rethought. Flexible hierarchies, new ways of measuring and rewarding performance, new strategies for attracting and retaining skilled talent will all become key for organizational success. A capacity for agility will be as much about employee motivation and communication as it will be about setting business priorities and managing physical assets.

Mahmood at el. (2023) researched the usefulness of artificial intelligence in project management and concluded that in the demonstrated case studies show that there is a need for AI in the implementation of new business management. Artificial intelligence can be defined as the machines that are created to simulate human intelligence to do and learn as a brain of human do (Mentzas, 1994). These machines can perform multi-tasks in intelligent ways by adapting to several situations. AI has the potential influences on the project management field in a positive way. Implementing AI in the project management field will help in a wide range of missions and tasks, such as increasing automation, productivity, help in making intelligent decisions, solving complex problems, managing repetitive missions and tasks, enhancing lifestyle, and assisting in complex analysis (Jiang et al., 2017; Ribeiro et al., 2021).

[8] Schwab (2016) also wrote that the emerging operating models also mean that talent and culture have to be rethought in light of new skill requirements and the need to attract and retain the right sort of human capital. As data become central to both decision making and operating models across industries, workforces require new skills, while processes need to be upgraded (for example, to take advantage of the availability of real-time information) and cultures need to evolve. This is what he calls – talentism.

3. CONCLUSION

It is evident that all the industrial revolutions brought significant changes to the societies in the last 300 years. First industrial revolution ended one dominantly agriculture era and shifted craftsmanship into the production, which lead to a wide scale industrialization, at first in Britain, and then in many other European countries. It was already clear that new technology may allow manufacturing goods on a much larger scale than before. It was also clear that the machines for production need new spaces and new ways of organizing the production in order to reach this potential level of production. These new spaces were factories and new organization needed workers with specialized skills for each part of the production which introduced the division of labour as new and much more efficient way to quickly produce larger quantities of products. As Kapas (2008) wrote that the factory itself was the major novelty in the British industrial revolution which had an enormous effect on the development of economies. Further on, the factory replaced the putting-out system that was based on the "family firm" craft-shop. By most authors, the first industrial revolution in Britain started around 1760 and ended somewhere between 1840 and 1850. These processes of early industrialisation stared later in other countries like Germany, France, the Netherlands, etc. In most of these countries that era also ended later than in Britain.

In comparison with the first industrial revolution that was based on technology and the inventions in machinery, the second industrial revolution was much more based on science and technology driven by scientific discoveries in chemistry, physics, electromagnetism and machinery as well. The first industrial revolution was also driven by coal as a primary source of energy, while in the second industrial revolution coal was gradually replaced by electricity.

The improvements of the steam engine, primarily the ones done by James Watt, allowed a stable source of kinetical energy that was used for the machinery in the factories, but it also revolutionized transport by allowing the installation of stable sources of power on vehicles. This allowed the production of (steam) locomotives that started the railway era, and steamboats that started the era of modern seafaring and modern transportation by rivers and canals also.

Second industrial revolution also introduced some new materials which revolutionized the machine engineering and the production of the machinery. The Bessemer process allowed the refining of iron into high-quality steel. This also allowed huge advantages in civil

engineering and construction. Generating electricity through coal power plants and hydro plants allowed large scale electricity usage.

It was evident that without huge improvements in management, the usage of new technologies and reaching high productivity numbers would not have been possible. One of the first modern economists, Adam Smith, observed many new management practices for the 18th century Britain's factories.

But it was not before the last quarter of the 19th century that management as a discipline was born and started to develop. One of the first notable people that researched relations between tasks and people, and did that very systematically and methodically, was Frederick W. Taylor. He was a manufacturing manager who eventually became a consultant and taught other managers how to apply his scientific management techniques. He claimed that the way to create the most efficient division of labour could best be determined by scientific management techniques rather than by intuitive or informal rule-of-thumb knowledge. Many more followed his footsteps, like Frank and Lillian Gilbreth, Mark Webber and Henri Fayol. One of the prominent thinkers when it came to planning was Henry Gantt. He used inventive planning methods in order to improve the production. His Gantt chart is a graphic planning tool still very often used to this day.

It was evident that using only machinery in the first industrial revolution would not increase the production significantly. New organisation of production had to be applied also, which lead to the formation of factories. In the second industrial revolution new schools of management thoughts helped boosting the production as well. But the new ways to organize the production also led to the invention of new machinery. For example, assembly lines first used by Ford Motor Company were designed, both organisationally and technically, to increase productivity by using strict division of labour. This links the division of labour from first factories (First industrial revolution) with Taylor's more sophisticated scientific management (Second industrial revolution) which resulted in creating assembly lines which additionally boosted productivity. In the end, Ford Company got more efficient and managed to produce more cars which were cheaper while simultaneously raising the workers' wages for double the amount.

After the two world wars the developed world entered a new industrial era were automation and miniaturization started developing on a rapid scale. Electronic machines quickly developed into computers and many other sophisticated electronical devices. At the end of 20th century, the internet started developing and smart devices, like smartphones, became dominant at end of the first decade of the 21st century.

This resulted with modern school of management with thinkers like Douglas McGregor and his development of Theory X and Theory Y.

An interesting book by Jeremy Rifkin, called the Third Industrial Revolution, wants to put the start of the third industrial era on the beginning of the 21st century, being driven by clean energy and new eco-based technologies. However, Rifkin is rather alone in his claims that third revolution era didn't start with transistors and computers later.

Huge development of modern technologies that were backed by big data, smart devices and artificial intelligence was, by many authors, the start of even newer era, the one that the modern society is still currently in – the Fourth industrial revolution. This era is marked by another modern term – the Industry 4.0. This modern industry sector is also based on the same technological advances as the Fourth industrial revolution.

The latest industrial eras in the second half of 20th and at the beginning of 21st century influenced new approaches to the management thought. Some of the most interesting management practices were Total Quality Management and Data-driven decision making. The first one is based on methods for constantly enhancing processes and has a key influence on organizations by putting the customer at the center of quality decisions and advancement. The second one is based on Artificial Intelligence solutions as a main tool for decision making in project management and other management practices.

The answers to several research questions are the following:

- How did industrial revolutions affect the birth of management schools?

  This research showed that inventions and technological advancements lead to possible improvements in production which would not have been possible if certain improvements haven't been done in organising and managing the production processes.
- How did management schools affect the creation of new technologies and possibly new industrial revolutions?

This vice-versa process didn't occur at a similar scale as the one described after the previous question. But new schools of management also opened doors to creativity and many new inventios.

- How did new technological advances affect new advances in management?

As partly explained before, new technological advances influenced the development of new machinery and new tools that lead to higher productivity. But this would not have been fully possible if no new ways of organizing the processes of production had not been developed. To fully utilize new technologies for higher productivity, efficient management of energy, machinery, sources, workers and labour was necessary.

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