The effects of the first and second industrial revolutions on vocational and technical education systems

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Abstract

The First Industrial Revolution, which started with mechanization in England in the 18th century, widespread the factory system, while largely eliminating manufacture production. The mechanization and factory system have caused institutional vocational-technical education systems to replace the classical master-journeyman-apprentice system in manufacture. The First Industrial Revolution reached a higher stage with the Fordist system in which Taylorist methods applied in the factories and this process created the Second Industrial Revolution. In the Fordist system, vocational-technical education institutions and education programs have taken on a diverse and gradual structure. These schools have also been the institutions where national education policies implemented. In this study, First and Second Industrial Revolutions have discussed in terms of their emergence and development dynamics, and the transformations created by industrial revolutions on vocational-technical education institutions have outlined.

Keywords: Industrial revolutions, mechanization, Fordist system, vocational and technical education

Introduction

The enlightenment revolution, which realized in Europe and left its mark on the last 400 years of human history, followed a parallel process with the developments in scientific, technological and social fields. In particular, developments in scientific and technological fields formed the baseline, first, of the First Industrial Revolution with mechanization, later, of the Second Industrial Revolution with new discoveries.

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The First and Second Industrial Revolutions have made fundamental transformations necessary in all areas of social structures, especially economic structures, in accordance with their own dynamics. Vocational-technical education was one of the areas where these transformations took place most radically.

The effects of the changes caused by the First and Second Industrial Revolutions on vocational-technical education systems still continue, although a long time has passed since their time and Third Industrial Revolution has been going on for nearly 40 years.

Putting forth the effects of the First and Second Industrial Revolutions on vocational-technical education systems and making a comparison in terms of the dynamics of the Third and Fourth Industrial Revolution with them will enable countries, to recognize the lefted behind aspects of the existing education systems and also to develop alternative models more realistically.

This study aims to provide a theoretical basis for both to develop new vocational-technical education models suitable for today's developments and educational studies on Third and Fourth Industrial Revolutions.

The First Industrial Revolution

The transformations made by Western civilizations in the field of science and technology with the Renaissance caused a new age of enlightenment. The age of enlightenment that followed the Renaissance, while providing the widespread of scientific observation and experiment approach, also created the basis for scientific developments in fields such as physics, chemistry, mathematics, mechanics and thermodynamics. Because of these developments, scientific knowledge, while creating the conditions to eliminate the manufacturing type production based on large-scale work force, went beyond its own theoretical framework and formed the basis for new technological inventions and mechanization.

The mechanization, which started at the beginning of the 18th century, gradually abolished the manufacture type production based on manual labor and led to the formation of factory production based on machine systems that realized with the organic composition of the machines that complement each other in different stages of the production process (Çağlar Öncesinden…, 1982: 65). The transition from manufacture to factory system was the beginning of the First Industrial Revolution, which first took place in England in the period from the middle of the 18th century to the last quarter of the 19th century, brought about radical changes in work processes and organization of production (Pamuk, 1996: 9). Britain, the center of the First Industrial Revolution, greatly benefited from Europe's scientific and technological knowhow.

There was a great deal of migration of European artisans and professional people into Britain during the 15th/16th/17th centuries bringing their superior skills and technological methods. There was evidence of exchange and transfer of ideas, skills and technologies between Britain and Europe for many centuries before the first industrial revolution (https://technicaleducationmatters.org/2009/05/13 / chapter-2...).

Manufacturing type production was carried out under the relative autonomy of the craftsman or profession, who dominated all processes of production, such as the quantity, quality, sale of the product produced as a result of the work, and the conversion of the income obtained into new goods. The factory-type production organization, which develops in parallel with the expansion of markets and the forcing of economic and social conditions, has started to destroy the manufacture that produce low-efficiency and non-standardization within the master-journeyman-apprentice hierarchy. Factory system has created a structure, where the work turns into increasingly simplified routine work, the standardization of production became possible, many workers work together and the relations between the employee and the employer completely changed.

The most radical change created by the machine system in the organization of the production process has been the creation of the technical division of labor. In this way, it has become more possible to apply scientific methods in order to increase the labor productivity, the quality and the quantity of the products.

The First Industrial Revolution started with mechanization in the textile, mining and metallurgy sectors. The steam engine that patent by James Watt in 1775 has been the beginning of an important leap forward in industrialization. Because the steam engine has provided a great increase in efficiency by replacing muscle power, especially in operating production machines and then moving transportation vehicles (steam ship, steam locomotive) (Çağlar…, 1982: 64). The steam engine was initially adapted and used to provide power for a whole series of machines and as a result was in many ways the most important enabling technology of the time and as a result made the major contribution to the first industrial revolution (https://

technicaleducationmatters.org/2009/05/13/ chapter-2...). Steam-powered machines have developed over time and adapted for many areas, mainly textile, mining, iron and steel industries. Because of this evolution, it became possible to operate complex machines such as lathes, agricultural machinery and transportation vehicles.

The development of machinery, machine tools and energy machines in the factory system has initiated basic processes that reduce costs by replacing the expensive, skilled but low-capacity workforce, which based on handicrafts with an unqualified, cheap but higher-capacity workforce thanks to the machine.

The factory system created by the First Industrial Revolution realized the continuous production of a homogeneous commodity such as cotton yarn and weaving, which were the basic products of British industry, in a group of machines that initially powered by steam energy. The fact that the product produced is not in many pieces has not yet made it necessary to organize the production and assembly on the conveyor belt. In addition to the technical division of labor that occurs in a relatively small number of stations due to the small amount of the products produced, the division of labor between the brain and manual labor started to become clear. The labor of the workers directly involved in production and the engineers, who developed the energy design and manufacturing methods of looms, improved the production methods in the factories, turned scientific developments into technology; began to diverge with clear lines. In this system, the artisans who carried out manufacturing production within the old guild systems (artisans' organizations) could not survive in the face of the mechanized production of capitalism rising on the industrial revolution and formed the potential workers of the factories together with the cheap labor migrating from the villages to the citties.

The Second Industrial Revolution

Mechanization and factory production, which first started in the textile sector with the First Industrial Revolution, started also to become widespread in the production of goods such as transportation vehicles, war vehicles and materials, consumption vehicles outside textile sector. Towards the end of the First Industrial Revolution, the blockage in steam technology accelerated the developments in internal combustion engines and electrical energy.

At the beginning of the 20th century, the production organization set forth in Frederick Taylor's studies on the "principles of the organization of scientific enterprise" includes the production in which the work is divided into as small pieces as possible with time and motion studies and is made on a continuously sliding assembly line using single-purpose machines and unqualified labor. The Taylorist system was first apply extensively in Henry Ford's "T" type automobile manufacturing plant in the United States. (Ansal, 1986: 160). This production organization named as Fordist system was the beginning of the Second Industrial Revolution.

The Fordist system replaced the weaving loom, which left its mark on the Ist Industrial Revolution, with looms and machine looms performing special operations, but continued the factory structure where the looms were been operated massively with the developed energy machines. Because of the closer relations between the USA and German industries with the developments in basic sciences, significant technological leaps have occurred in the internal combustion engines, transportation vehicles, electrical devices, communication equipments, chemistry, iron and steel, and weapons industries. Increasing demand during and after World War 1 was the driving force behind these leaps.

Mass production emerged in the nineteenth century as an outgrowth of the Industrial revolution (1770-1800). At that time, it featured three basic characteristics: division of labour, interchangeable parts and mechanization. Although the pursuit of “perfect interchangeability” remained a challenge throughout the 19th century known as the American system of manufacturing became the symbol of industrialization. As early, as 1850, it began to impose itself as the dominant mode of manufacturing and by 1890; it was solidly establishe in the USA (Skinner, W. 1985, cited by Duguay C. R.; Landry S. and Pasin, F., 1997).

The Fordist system, based on a production line where special purpose machines are lined up one after another, has established a structure where each worker constantly performs a routine job defined on the basis of detailed division of labor, and there is a constant relationship between machine and worker. The Fordist system has created a technical basis in which standard processes, in which different rhythms and different processes are coordinated and transformed into many standard products with the support of quality control (Yentürk, 1990:43-44). This technical basis has allowed the work to be concentrated by increasing the flow rate of the production line, thereby increasing the production.

Bureaucratic and Taylorist organizational structures separated the management and design function from the execution of the business by establishing rules and procedures, and designing the works scientifically. Thus, the efficiency and management control over the workers has been increased by all information about the job has placed in the management (Bartol and Martin, 1991, cited by Dyer, 1998).

In the Fordist system, work has vertically organized, the work to done throughout the working day has been determined and piece rate and premium system has been introduced. The information on how fast the work, and how much production can be done has been taken from the hands of the worker and made a mandatory principle to be followed. It has revealed a form of inflexible organization in which the control over the workforce is constantly increasing, its powers and decisions has centralized in the hands of the management of the enterprise and therefore the brain and manual labor has clearly separated from each other (Gülsever, 1989:166).

The increasing complexity of scientific developments and technologies has led to a detailed division of labor among scientists and engineers responsible for design and technology production, beyond the division of labor where even the smallest movements in the production line has taken into account. In this system, the transformation of the work done by the worker into very simple repetitions because of the detailed division of labor brought about the unqualification of the job and therefore the worker. Hence, even people with no vocational training or skills have formed masses of labor that could easily introduced into the Fordist production process. However, this de-qualification did not cover the whole of a hierarchical level consisting of worker, forman, quality control personnel, production engineer, design and development personnel and senior managers in the vertical organization of production. Generally, all levels after the worker were required to have professional-technical qualifications to the extent of their responsibility. For example, the task of restoring the machine that malfunctions or deteriorates in the workflow has assigned to the forman. Because it is inevitable that a machine that fails in the Fordist production line will affect other stations with which it related, causing a huge production loss.

The First and Second Industrial Revolutions, which emerged with the reflection of scientific and technological developments on the production system, while ensured that capitalism, which is a new and advanced social formation, gradually dominated the world, they also led to significant changes in social, economic and political institutions. The most important of these changes is the acceleration of the nationalization process and the emergence of nation states.

The Dynamics of the First and Second Industrial Revolutions in terms of Vocational Technical Education Systems

Industrial revolutions have brought about important changes in the structure of vocational technical education maintained in a master-journeyman-apprentice relationship throughout human history. The master, who knows and applies all stages of handicraft production within the guild organization, gradually transfers all his knowledge and skills to the apprentices he works with, and ensures that they become first journeymen and then masters as a result of long-term observation and skill tests. The capitalist system, which became dominant with the industrial revolution, abolished manufacturing production and the old vocational-technical education form, and created mass education institutions that would respond to its own structural needs.

In order to transform the people living in the newly formed nation states and in the increasingly crowded cities within the boundaries of this state, in line with the policies of the new social structuring, there was a need for organized school-type organizations that provide mass education. This process resulted in the emergence of vocational-technical schools that initially established in large factories and later became independent schools throughout the country, instead of classical master-journeyman-apprentice training in vocational-technical education. These schools have become official schools where basic sciences has taught in addition to providing vocational education in order to train the workforce required by increasing scientific and technological developments and diversified professions.

Education levels in vocational-technical schools have begun to diversify in line with the responsibility and skill levels expected of the employees in the Fordist production hierarchy. For example, various levels of school and education established ranging from a few-week courses for workers to do simple, fragmented jobs on machines and sliding line to training programs that train engineers to work in research laboratories.

Instead of the artisan who knows every stage of production in manufactory production and even realizes practical inventions himself, the type of human being trained in narrow specialties at various levels of knowledge and skill and employed accordingly has emerged. As an example, USA and Germany, which were the pioneers of the Second Industrial Revolution and widely implemented the Fordist system, have implemented the short-term vocational course and school-based apprenticeship system, as well as established universities that are the forerunner of very important scientific and technological developments.

The vocational-technical education system, which has become organized and massive in the industrialization process, has emerged in two basic systems depending on the industrialization level and characteristics of the countries:

A. The system in which vocational-technical education predominantly carried out at workplaces: This system has adopted in advanced industrialized countries, especially in the USA and Germany, and public and private industrial enterprises has formed the driving force of education. It includes modern apprenticeship, journeyman and mastership training, which combines national training programs and vocational-technical training in the workplace. In this system, occupational standards and documents are prepared in cooperation by the state and employers and workers organizations. According to these standards, applied education is carrying out in the workplace, and theoretical education in the vocational-technical school provided by the state (Baloğlu, 1990: 51). In this system, which called the dual system, universities are also in close ties with industrial organizations.

B. The system in which vocational-technical education carried out in schools: In this system, vocational-technical education is completely carry out in the school with state funding. Workshops and laboratories in schools are equipped according to training programs. The equipment should renewed depending on the developments in the programs and technological field (Baloğlu, 1990: 149). Education expenses quite high compared to the other systems. It mostly used in countries that have not entered the industrialization process yet or are industrializing. It has adopted in order to provide technical staff and technology support to industrial enterprises that have not yet developed in terms of technological level and size, from schools and universities established with government support.

The Crisis of the Fordist System, End of the Second Industrial Revolution

The Fordist system, which had a great development in the 25-year period following the Second World War and experienced its golden period in the 1960s, entered into a deep crisis in the 1970s, which manifested itself as the oil crisis and then the world economic crisis. It is necessary to explain why the Fordist system, which left its mark on the fastest 50 years of world industrialization, entered a crisis with the combination of many factors originating from inside and outside. We can list these reasons as follows:

A. Fordist system, which produces for the demand for a large number of standard and cheap goods; faced with the collapse of the large and stable markets that sustain it due to the saturation of consumer preferences for standard cheap goods and the shift of demand to specific types of goods (Suğur, 1994:103). Inelastic supply-oriented Fordist mass production has been unable to keep up with the small demand-centered markets created by varying consumer preferences (Suğur, 1994: 124). The reason why the Fordist system is not flexible in the face of rapidly changing demand is that it is very time consuming and expensive to switch to a new process because the machinery, looms and equipment operating in the sliding production line are specifically designed for a single process. Related to this, the very long payback period of Fordist technology delays the application of new technologies and the increase in productivity.

B. The following reasons accelerated the blockage of Taylorist methods and the Fordist system: Excessive control over the labor force arising from the vertical organization of production (Suğur, 1994: 124). Work intensification is limited to the physical and psychological stamina of the worker. The inability of the worker who constantly does the same job in the production flow to achieve stable productivity. The demoralization and indifference experienced by employees who lost their knowledge and control over production and became alienated from their work (Lordoğlu, 1986: 221). Actions such as strikes and slowdowns that have become easier in mass production.

C. Inevitably, unevenly dense work at the production points placed on the sliding production line leads to coordination disorders, causing backlogs at some points and waiting in others (Yentürk, 1990:45). The productivity loss caused by the waiting of the machines and workers on the line, increases the production time of the product and increases the cost. The loss of time between production points is a major cause of inefficiency.

For example, in the US automobile industry, 25% of the working time has spent with waiting due to imbalance between workstations. Semi-finished goods have traded in machines only 5% of the real time between their entrance to the factory and their exit (TMMOB, November 1993: 12).

Problems caused by any machine or worker on the line adversely affect the entire line. The fact that the quality control is carried out by separate units at the exit of the line, instead of at the production point, causes faulty production to be noticed too late, and the production of faulty goods in large batches. In this case, a part of the final products either scrapped or repaired. Carrying out works such as quality control, maintenance, repair, mold replacement by separate units, increases inefficiency.

Besides, the fact that the system has to work with excess stocks increases both dead capital and storage costs, and requires supply-oriented production based on stocks rather than demand (Yentürk, 1990: 46).

As seen, the crisis of the Fordist system, it is the result of the combination of problems arising from the market, labor and its own technical structure. In summary, the Fordist system has reached a critical point where productivity cannot increased by more mechanization in the technical composition of capital and intensification of work with more detail.

At this point, it can pointed out that the Fordist system has to go through two basic sets of changes: The first is to move towards a production structure that can respond to low and unstable demand and can increase productivity by changing the in-workshop technical division of labor. The second is with the emergence of an automation effort and a systemic integration of decision and execution, it is the emergence of a new production organization that aims both to respond to different demands and to overcome the inefficiencies caused by the Fordist organization (Yentürk 1990: 47).

The economic dynamics that emerged from the crisis of the Fordist system began to form the main basis of new production organizations based on "flexible production systems". The radical transformations created by the new production organizations have named as the Third Industrial Revolution.

Conclusion

Mechanization, which started in England in the 18th century, abolished manufacturing production and formed the basis of the transition to the factory system, and this process named as the First Industrial Revolution. The mechanization and factory system have created radical transformations in labor and work processes, and in vocational-technical education, the education system based on master-journeyman-apprentice relationship has replaced the mass education system based on the school. In this process, the schools where staff employed in narrow specialties trained rather than masters who know all stages of production have become widespread.

The First Industrial Revolution, which first started in the textile sector, reached a higher level with the application of Taylorist methods to the sliding assembly line in the factory system at the beginning of the 20th century, under the name of Fordist system. In the Fordist system, where production is based on a detailed division of labor with special purpose machines, vocational-technical education institutions and programs have transformed into a diverse structure in accordance with the responsibility and skill levels expected from employees in the Fordist production organization. At the same time, these schools have undertaken the function of serving the nationalization process as institutions where national education policies implemented.

The Fordist system, which showed great development until the 1960s, faced a crisis in the following years, and efforts to overcome the crisis of the Fordist system led to the emergence of "flexible production systems." With the help of high technology, flexible production systems, which have a production organization that can respond to variable market demands and led to the Third Industrial Revolution, have brought about significant changes in the qualifications expected from the workforce, and required a fundamental change in the objectives expected from vocational-technical education systems depending on the need for flexible labor.

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