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Transformations Created by the Third Industrial Revolution on Vocational Technical Education Systems

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Abstract

The First Industrial Revolution replaced manufacture production with the factory system and created radical transformations in production systems. Depending on these transformations, the master-journeyman-apprentice structuring has gradually left its place to institutive vocational and technical education (VTE) systems.

Fordist system, which is based on the Taylorist methods, formed the basic dynamics of the Second Industrial Revolution. The Second Industrial Revolution started to transform VTE systems into multi-level and diverse structures.

In the 1970s, due to crisis of the Fordist system, "flexible production systems" have come to the fore with the contribution of technological developments. This process led to the emergence of the Third Industrial Revolution. Flexible production systems have increased the demand for higher quality and flexible labor.

In this study, First and Second Industrial Revolutions have been discussed in general terms and the internal dynamics and the effects on the VTE systems of the Third Industrial Revolution have been put forth.

Keywords: Industrial Revolution, Post-Fordism, Flexible Production, Vocational and Technical Education

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Introduction

Human history has generally been shaped by important leaps in scientific, social and economic fields. Especially in Europe in the last 400 years, the scientific and technological developments accompanying the enlightenment revolution has formed the basic dynamics of; the First Industrial Revolution with the mechanization and factorization process; the Second Industrial Revolution with the application of Fordist production techniques in factories; and after the 1970s, the Third Industrial Revolution with flexible production systems. Today, advances in fields such as informatics, communication, internet, cyber systems and artificial intelligence have begun to lay the groundwork for the Fourth or even the Fifth Industrial Revolution.

In the historical process, the leaps that occurred with the industrial revolutions take place in the form of, the previous one creates the next from within, and the continuation of the previous one for a while in the process of the next one becoming dominant.

All industrial revolutions made radical transformations inevitable in all social areas, especially in production structures, depending on their own conditions and internal dynamics. Vocational and technical education (VTE) structures are one of the areas where industrial revolutions necessitate the most comprehensive transformations.

The invention of the steam engine in the 18th century has provided a great increase in productivity by substituting the machine for the muscle power used in production for thousands of years. The factory system, which enables mass and standard production with machines, and then the Fordist system based on mass production, where Taylorist methods were applied, have started to destroy manufacture production that has no chance to compete with them. In the same period, while the training model based on the master-journeyman-apprentice system in manufacture lost its importance, with the effect of the nationalization process, school-based mass education models diversified in the extent of the complexity of the division of labour in the production process began to come to the fore.

The deep crisis because of, the Fordist system, which forms the basis of the Second Industrial Revolution, could not respond to the changing market dynamics after the 1970s created the conditions for the emergence of flexible production systems. In this process, demands of the markets to almost personalized products and services instead of standard products formed the main reason for the transition to flexible production systems. Beside, technological developments in fields such as automation, computer, internet and microelectronics have made possible this transformation, which is called the Third Industrial Revolution. The production, which became flexible depending on the variability of the markets, has brought forward the necessity for; diversification, flexibility and rapid change of the qualities of the labour force, which is the basic element of production. This radical transformation has created a great change pressure on the VTE systems organized according to the Fordist system requirements. Today, while the Third Industrial Revolution is over and the Fourth Industrial Revolution is being carried out, it is seen that the VTE systems of many countries cannot provide the transformations in accordance with the requirements of even the Third Industrial Revolution. One important reason for this situation is that some countries continue to produce mostly Fordist systems, and the other is that decision makers and implementers in VTE systems have not grasped the requirements of the Third Industrial Revolution, although it has been nearly 50 years since its emergence.

Putting forth the effects of Industrial Revolutions on VTE systems together with their basic dynamics; determining the differences between these dynamics and effects will make it easier to identify the insufficient aspects of existing VTE systems and to create alternative models that can serve new training requirements.

This study aims to create a theoretical basis for the studies on making VTE systems responsive to current and future developments.

Problem

The enlightenment revolution, which left its mark on the last 400 years of human history, followed a parallel process with the developments in scientific, technological and social fields. Particularly, developments in scientific and technological fields have formed the basis of all industrial revolutions up to the present.

Industrial Revolutions, in accordance with their own dynamics, have made fundamental transformations necessary in all areas of social structures, especially in economic structures. VTE is one of the areas where these transformations are felt most deeply. The problem of this study is to reveal the effects of the current developments characterized by economic fields and industrial revolutions on VTE systems based on the 3. Industrial Revolution.

The Aim of the Study

The aim of this study is to reveal the effects of the 3rd Industrial Revolution, which rose above the 1st and 2nd Industrial Revolutions, on VTE systems in general terms. This study also focuses on the development of VTE models suitable for today's developments and it also aims to form a theoretical basis for VTE studies carried out against the 4. Industrial Revolutions.

The Importance of the Study

Revealing the effects of the 3rd Industrial Revolution on VTE systems on the basis of the 1st and 2nd Industrial Revolutions will enable the deficiencies of the existing VTE systems to be noticed, the development of alternative models and the construction of future-oriented models in the process leading to the 4th Industrial Revolution. The importance of the study is that it aims to reveal the basic principles to be followed in the studies of making VTE systems flexible and preparing them for the future.

The First Industrial Revolution

With the Renaissance and reform process in Europe, significant advances in the field of science and technology accelerated the mechanization process in production and paved the way for energy machines first with steam engines and then with internal combustion engines. The steam engine, which James Watt patented in 1775, was the cause of an important leap forward in industrialization. Mechanization first started in the textile, mining and metallurgy sectors. The steam engine, which allows the production machines to work collectively in the factory environment, has quickly begun to replace the low-efficiency muscle power. Mechanization, which started mainly in England in the 18th Century, created the conditions for the elimination of hand-based manufacture production, and caused the gradually increase in factory production. The systematic combination of standard machines designed to undertake sequential and interrelated tasks at different stages of the production process has formed the basis of factory production. Energy machines have been used to operate production machines on the one hand, and to be used for moving transportation vehicles on the other hand. The radical transformations brought about by mechanization in the fabric of production and labour processes created the First Industrial Revolution. The First Industrial

Revolution, which started in the UK, quickly spread to Europe and then to the USA, Japan and other parts of the world.

Production of low-efficiency manufacture, which is based on manual labour within the master-journeyman-apprentice hierarchy, which is far from standardization, has entered the process of extinction by being unable to compete with machines and factories in the face of the expanding market conditions. Masters (artisans), who had a command of all the processes of manufacture production, began to lose their jobs and create potential labour masses of factories, along with the journeymen and apprentices they employed, in parallel with the decrease in manufacture production. Machines designed to perform routine work in the factory system have greatly increased productivity and reduced costs, while also reducing the quality of labour that it routinates and simplifies.

In the Factory system created by the First Industrial Revolution, production has organized in consecutively arranged stations, although the products produced have not yet multipartite. This kind of production organization has begun to SME highlight the separation between the brain and manual labour with the technical division of labour. The labour of, the managers; the engineers who design products, machines and production systems, and workers who do routine, simple tasks have begun to separate sharply.

The First Industrial Revolution has brought to the fore organized and mass education models in line with its own structural needs instead of the VTE model which has been carried out for thousands of years based on the master-journeyman-apprentice in manufacture production. In the emerging nation states, as a requirement of new social and economic structures, school-type institutions that provide mass education and have a relatively centralized organization model have arisen. In this process, schools that gave education in the field of VTE emerged, first in factories and then throughout the country. These schools, in accordance with the policies of the nation states, have become official schools where general information have taught as well as provided VTE.

The Second Industrial Revolution

In the face of the deficiencies in steam technology, which constitutes the basic dynamics of the First Industrial Revolution, with the support of the developments in basic sciences, great technological advances have been made in areas such as transportation, electricity, communication, iron, steel, chemistry and war industries. Increasing demands during and after World War I has also accelerated these advances. In this process, new studies on production organization started to emerge.

At the beginning of the 20th Century, Frederick Taylor, in his studies called "The Principles of Organization of Scientific Business", predicted that the work should be divided into as small parts as possible with time and motion etudes. Taylor's system, which is based on a production organization made on a continuously sliding assembly line with single-purpose machines, using unqualified labor, was implemented for the first time in Henry Ford's "T" type automobile manufacturing plant in USA (Ansal, 1996:160). Unlike the factories with relatively few production stations in the First Industrial Revolution, production in the Taylorist system has organized on a sliding line where the number of stations increased much more. The Taylorist production organization, also known as the Fordist system, formed the beginning of the Second Industrial Revolution with the great productivity leap it created.

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 labour, and there is a constant relationship between the machine and the worker. The Fordist system has created a technical basis in 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). With the production organization created by the Fordist system, it has been possible to raised concentrate the work and productivity via increase the speed of the production line.

Bureaucratic and Taylorist organizational structures has been designed to strictly control productivity and management over workers by, creating rules and procedures, separating the function of scientifically designing the works from the execution of the business, and placing all business related information in management (Trans. from Bartol and Martin, 1991, by Dyer, 1998).

The Fordist organization of production, with its elaborate division of labour, has created detailed divisions within these two basic types of labour, while separating mental and manual labour with certain lines. While the division of labour has diversified in the manager and engineer sections, a detailed division of labour has been created for the manual workers. In particular, the work of manual labourers has been simplified as much as possible. Thus, even people with no training or experience could easily be introduced into Fordist production as line workers.

The diversity of skills and responsibilities in the Fordist system's production hierarchy also diversified the demands from VTE systems. For example, these demands have been in the direction of training the workforce at all levels, from the workforce to do the simple, routine works on the sliding production line, to the top managers and research and development (R&D) engineers. This situation has reflected in all educational components such as schools organized at national level, education models and education programs. While the line worker could be put into production with a few weeks of training at most, the training of R & D engineers or top managers could take years. Institutions such as VTE high schools and vocational training centres (VTC), which popularized for the training of the labour force who mostly work in manual labour, have organized according to programs that designed according to narrow specialization areas and with poor general academic aspects. Similarly, in engineering education, curriculums, although has relatively high quality, have been squeezed into narrow profession fields. As a result, the USA, Germany and Japan, which were the pioneers of the Fordist system and the Second Industrial Revolution, were the countries that applied the journeyman-apprenticeship system integrated with the school system and short-term vocational training mechanisms most comprehensively. These countries have also established the best universities in the world. In consequence of these developments in the Second Industrial Revolution, two types of VTE models have emerged in the world: First, the model in which VTE is built mainly in the workplaces, integrated with schools; the second is the model in which VTE is mostly carried out in schools. The first model was used mostly in developed countries, while the second model was used in countries that have not yet completed its development. This differentiation continues to a certain forms today.

The Third Industrial Revolution

The Fordist system, which cannot be changed easily due to its nature, started stuck in the face of demand changes in market structures after the Second World War.

In the 1970s, it was observed that new forms of organization and technological transformations were made in the production processes in order to overcome the congestion of Fordism, which gradually turned into a world economic crisis (TMMOB, Kasım 1993:10). The flexible production systems (FMS), also defined as Post-Fordism, has formed the focus point of these transformations. Post-

Fordism, which accepted as the beginning of the Third Industrial Revolution, has been dominant especially after the 1980s.

In the flexible production system, instead of single-purpose operations machines and inflexible production line arranged according to the standard products in the Fordist system, it seen that, multi-purpose (CNC-Computer Numerical Control) machines equipped with computer and automation technologies. A flexible production line can produce much kind of products by way of switch from one product to another product in a very short time. Microelectronic technology and informatics-communication-organization technologies have played a very important role in making flexible production system possible. Advances in microelectronics technology are the technical predecessors of nanotechnology, primarily genetic engineering, which makes it possible to develop biocomputers (Göker, 1991:7).

The reason why microelectronics is described as the dominant technology of our age is not that it is frequently encountered in durable consumer goods such as TVs and music sets where this technology is applied. The main reason of, it is widely used in investment goods, production methods and business processes and radically changes the objects, methods and processes in which they are used. Programmable machine tools and process machines, industrial robots are examples of products of microelectronics in the field of investment goods (Göker, 1991: 7). The same technology has revealed the methods of Computer Aided Manufacturing (CAM), Computer Aided Design (CAD), Computer Integrated Management (CIM) and cybernetics in production processes. "Just in time" production (JIT) has also become possible with microelectronic technology. With the help of microelectronics and computer technology, the machines have been made multi-purpose by using technologies, such as electro-mechanic, hydraulic, pneumatic, highly advanced robots, and automated systems (process control) that take over the control of the production process.

Advances in microelectronics have resulted in robots replacing workers. However, automation has not limited to the production area, it has also started to include control, research and decision-making processes. In other words, not only ordinary workers but also the functions of the manager have become transferable to robots and machines (Şaylan, 2003: 164). In addition to, developments in the field of artificial intelligence have accelerated this process even more.

CNC benches and industrial robots can replace three or four conventional benches, as well as having the ability to produce another product or change a process in a very short time, so they can reduce sizes of the production areas and factories. At the same time, with the cell organizations in the flexible production system, two CNC machines are used by one operator, thus one operator is employed instead of six to eight (Ansal, 1996: 187). Thus, both the number of classical benches and the number of operators can be reduced with CNC machines.

With CNC machines and robots, working under computer aided design (CAD) and computer aided manufacturing (CAM) techniques, work interruptions have been minimized, the number of operations has been reduced, and zero defect production has been made possible with immediate uninterrupted quality control. The technological composition of this system provides the flexibility of production in the face of highly differentiated demands at low cost, while the system itself has gained a flexibility that can easily adapt to technological developments. The new technology revolution has also brought radical transformations in production, distribution, transportation and management processes.

Microelectronics-based automation, the pioneer of the Third Industrial Revolution, brought the opportunity to replace the labour force in production with capital largely, and reduced the rate of labour in production costs to less than 15% in many areas. Automation has, replaced the unskilled and semi-skilled workforce, on the other hand increased the need for a less but highly skilled workforce. This innocent-looking effect, while has led to a radical transformation all over the world, has led to social and economic problems such as increasing unemployment rates in central countries, collapsing welfare state, part-time working and subcontracting (Kazgan, 1997: 166).

The tools and technologies emerged by the developments in the field of microelectronics, while have enabled the localization of the production process, have ensured the centralization of the management with a high level of efficiency. The new production process has entered into a localization that will respond to market conditions in the best and fastest way, and use production factors in the most efficient way (Şaylan, 2003: 192). Post-Fordist developments have emerged in two main trends (Öngen, 1996: 183): The first is a flexible speciality system based on small and medium sized enterprises (SME) that emerged especially in northern Italy; the second is the flexible production system known as "Toyotizm" or "Lean Production", which was first implemented in Japan Toyota factories.

The flexible speciality system has spread to Germany, France and Denmark from northern Italy, where SMEs, which both compete with each other and cooperate in various ways by exchanging production information with each other. However, it should be stated that the relations of SMEs with each other are not independent from the coordination and interests of large-scale enterprises. This system has, started with the transfer of some stages and parts of the production process to subcontractors and gradually expanded with the spread of SMEs engaged in contract manufacturing depending on large and multinational companies (Ansal, 1996: 188). According to the characteristics of the market, SMEs have started to make flexible production with the help of new technologies in areas vacated by large companies.

The lean manufacturing system has emerged with microelectronic technologies making mass production flexible (Taymaz, 1993: 34). The relations of this system, which spread around the world as a Japanese model, with SMEs are not different from the flexible specialization system. The fact that these systems, which give the impression that they are two different models, actually produce the same results in all processes of production and relations between companies reveals that the flexible production system does not need to be examined under different headings.

The flexible production system has also brought about significant changes in the qualifications expected from the workforce. In flexible production, it is imperative to be able to use advanced technologies effectively and to benefit from the workers' capacities, production experiences and mental potentials at the highest level. Therefore, flexible production has revealed the need for workforce who, well trained; actively contribute to product renewal, quality increase and design processes; competent in computer programming, machine use, adjustment, maintenance and repair; flexible in the face of changing production conditions and skilled for foreign language. In flexible production, significant decreases are observed in the number of unskilled workers involved in the production process in workshops and factories. A study conducted in France shows that there is an average of 6% decrease in unskilled labour every year (Lordoğlu, 1989: 179).

Unlike Fordist production, the employee is given authority and responsibility in flexible production, and in case of any faulty production or breakdown, workers are expected to intervene immediately and solve the problem (Ansal, 1996: 188). Quality control does continuously carried out during production, as well as operations such as, maintenance, repair of machines, cleaning of the environment, and mold replacement always carried out by the same workers. In order to fulfil all these, workers are required to have a wide variety of skills therefore they are given intensive training including production knowledge in their workplaces. Even the acquisition of some skills has a direct effect on wage increases (TMMOB, 1993: 13). In addition, working groups are formed in teams or cells in order to increase the productivity of the workers.

In flexible production, techniques such as Quality Control Circles (QCC), Total Quality Management (TQM), Total Preventive Maintenance (TPM) has been created for, continuously development of the production technology by workers' knowledge, skills, work experience and suggestions.

The need to obtain the most efficiency from high-tech machines and robots and to ensure the continuity of the work brings radical changes in terms of both the employment structure and the composition of the workforce.

It is observed that high technology has a negative effect on employment in some areas. With the advent of automated production systems, many jobs that were previously done with human labour have begun to be done by robots and machines. However, while high technology has narrowed employment in some fields, it also led to the emergence of new jobs and new professions depending on the labour force categories that produce use and control high technology (Öngen, 1996: 184). Flexible production systems also have an effect on the removal of permanent employment in some professions. For example, positions such as production line supervisor, quality control staff and stocking staff in the Fordist system have eliminated. In addition, there are employees who come from time to time and take special actions. In labor types, there is a shift from manual labour to brain labour, in other words, an increase in the service sector.

The Third Industrial Revolution has not only increased the rate of manufacturing to trade in terms of value-added, but also shifted the scope of trade activities that have increased the wealth of nations throughout history from agricultural products and natural raw materials to manufacturing industrial products (Yenal, 1999: 29). For example, service jobs in Europe have already reached seventy percent of the total workforce. In most of the Western European countries, it is clearly observed that the basis of traditional sectors such as textiles, steel and heavy industry is disappearing and new sectors that produce microelectronics-based consumption and capital goods are developed, so new types of labour have replaced traditional types of labour (Öngen, 1996: 178). Even countries such as S. Korea and China have moved from traditional labour-intensive industries such as textiles and clothing to complex and technologically sophisticated industries such as computers, transportation vehicles and machinery. Even in the production of low value-added goods, with the developments in manufacturing technology, flexible production processes have replaced mass production based on the line system (Gereffi, as cited in 1994, Özuğurlu, 2008: 99).

Increasingly, organisations are focusing on the third choice, outsourcing, as a means to increase flexibility and generate high customer value. Outsourcing is a form of restructuring that often involves personnel reduction when it is used to replace a function that was once provided internally. Thus the outsourcing of both core and non-core tasks has become widespread in recent years (Trans. from Daugherty and Droge, 1990). Beginning with support services like catering and cleaning, the approach often develops rapidly to include central service functions such as personnel, accounting, and information systems, as well as traditional core operations including R&D, logistics, engineering, and manufacturing (Harvey E. Griggs, Paul Hyland, 2003).

The flexible production system has brought significant changes in issues such as organizational forms of companies, management systems, size strategies, relations with other companies and sub-industry organizations, information technologies they use, marketing and finance systems.

The radical changes in the organization of production and the use of information technologies in management required the redefinition of the levels in the managerial hierarchy pyramid. In the Fordist system, the administrative system is in the form of a classical central bureaucracy, based on a vertical flow of information, with formal rules of control and a chain of command from top to bottom. In flexible production systems, administrative structures have organisation that, enable horizontal and vertical flow of information, versatile communication network, includes the systematic network of units with unitary autonomy, self-control, participation and suggestion features and has more flattened pyramidal structure. This kind of relationship established between decision and production, while reduces the classical bureaucracy, it also make the bidirectional feedback mechanism work faster.

Information technologies have made enabling the companies to respond instantly to demand changes by make versatile and fast the communication between the units in the market and the company, as is the case with in-company communication,

Flexible production systems have also changed the companies' own network of relationships. It is seen that, with the acceleration of capital and information flow in the world related to the internationalization process of capital, companies go into strategic cooperation in order to protect or increase their competitiveness, and even large companies and multinational companies, known as archrivals, increasingly make technological cooperation agreements, especially in the most dynamic information-intensive sectors. In the face of increasing competition and the pressure created by R & D expenditures reaching very high levels, companies aim to protect their advanced technology with established partnerships, to create technological innovations and to set common standards. At that point, unlike classical company marriages, the main reason is sharing the costs and risks of producing information / technology instead of joint production.

Especially, the ability of innovations in advanced technologies to be easily implemented in different production areas strengthens the motivation for cooperation. For example, a new technology in the field of microelectronics can be easily used simultaneously in a medical device or a musical instrument. As a concrete example, Olivetti and Hitachi companies collaborated with Goldstar on software development (Göker, 1991: 14).

Small and medium-sized enterprises (SMEs) have become more important than before, as small and unstable markets based on variable demand put Fordist mass production into crisis. In the increase of this importance, SMEs' ability to produce flexible in the face of changes in demands, as well as the attempts of large companies to find solutions to the problems of Fordist production, which turned into crisis, had a large share.

With the Post-Fordist developments, about the SMEs gain importance in a way that they did not before, it is necessary to mention that, there are many external influences mainly the interests of large companies besides the flexibility that characterizes SMEs’ production structures. The fact that the importance given to SMEs has increased compared to the past does not show that the claims that they have become the alternative of large-scale companies are correct (Algan, 1994: 15). On the contrary, the field of activity of SMEs is limited to the areas vacated or transferred by large-scale companies and the framework drawn by large companies. The production of goods and services such as investment machinery and instruments, transportation vehicles, electrical and electronic devices and facilities, telecommunication systems, machine tools, hypermarket chains management, international tourism organizations are necessarily carried out by large-scale and international companies having great value-added shares in the world economy today, in terms of the size of the investment they require.

SMEs either produce goods and services in sectors where large-scale enterprises are emptied or operate in the position of sub-industry enterprises, subcontractors or subcontracting enterprises in areas where large enterprises produce. While large companies transfer certain parts of their production to SMEs, they also provide support improving product quality, improving shipping and communication systems, reducing costs, products design and technology development at certain levels. Large companies that place more responsibility on SMEs in production and design functions, find the opportunity significantly to reduce their investments in these areas. This is one of the most important effects enable SMEs to create more innovation than before.

Especially, it is seen that multinational companies transfer some of their R&D activities to SMEs in order to benefit from the characteristics of SMEs to establish more organic links with local markets. Because, the millions of SMEs scattered around the world, have great advantages and unique experiences due to their presence in markets with a wide range of demands and characteristics. For example, the seat designs of the cars that the Mercedes Benz automobile company will sell in the Far East are made by the local businesses in consequence of this requirement.

SMEs, which have to work in connection with other enterprises, cannot spontaneously create the kind of cooperation environment required by flexible specialization without the help of public institutions and large enterprises due to their sectoral diversity and geographical dispersion. SMEs are also dependent on large companies and public institutions in terms of providing the high technology they use in flexible production. Because the high technology, which forms the technical basis of the flexible production system, is under the control of large companies and public institutions that can carry out R&D studies that require large expenditures today.

While only 4% of companies employing less than 1000 workers in the USA are engaged in research activities; 90'1% of companies employing more than 5000 workers do research. In the USA, 80% of the industrial R&D activities are concentrated in 500 companies employing more than 5000 workers. Major companies that first four rank within the OECD realized 50% of the total R&D projects in the industry. R&D programs of 100 large companies within the same group of countries reach 80% of the total (Erdost, 1991: 28). In Turkey, according to the results of the Small and Medium Scale Manufacturing Industry Survey, 92.3% of small-scale companies and 85.1% of medium-sized companies do not have R&D units (Sarıkaya, 1995: 22).

The developments of SMEs, which gained relative importance in the face of large companies that stumbled with the crisis of Fordism in the 1970s, stopped towards the end of the 1980s and then began to decline.

Building on the work of Cooke et al. (1989), Blyton and Morris (1991) suggest that five broad trends are occurring in the re-organisation of industry that indicate forms of flexibility (Dyer, 1998):

- There is a tendency for vertically integrated organisations to use subcontractors.
- Internationalisation is occurring through the expansion into international markets to increase market share; and, through the forming of joint ventures, mergers, and acquisitions with corporations outside of the domestic sphere.
- There is an increase in investment in flexible automation machinery.

- There is a new focus on satisfying customers through quality improvement and adapting products and services to customer demand using total quality management (TQM) and just-in-time (JIT) methods
- Unskilled, semi-skilled and professional workers are increasingly required to take on a broader range of tasks, and there appears to be a move toward increasing the proportion of professional workers compared to semi-skilled and unskilled workers.

The Effects of the Third Industrial Revolution on Vocational Technical Education Systems

Due to the very short product cycles in flexible production, the duration required for the training of the workforce is very low.

In the Fordist system, apart from the training of qualified core workforce working in areas such as design, R&D and management, the VTE system, which mostly trains a workforce with the competence to do simple work in the production line, has started to become inadequate with the emergence of flexible production systems and faced the need for radical transformation. However, VET systems, which are predominantly among the functions of national states, could not keep up with these rapid developments in most of the industrialized countries and fell behind the current technological level. This situation has brought to the fore the VET model based on school-company cooperation, which is applied in various ways in all industrialized countries today. In addition, companies have started to make in-company training units more effective, which provide very intensive training in accordance with their own needs. Company training activities have begun to be perceived as a continuous firm function, and the workforce has started to be trained periodically depending on the phases in production. For these activities, companies have employed more master trainers, technical teachers and training experts who maintain their direct relationship with production. Firms regard the workforce graduated from classical VET schools as candidates for their special training and apply a second training program to this workforce. Because it is not possible to implement a curriculum suitable for all specific areas of business life and to equip students with appropriate qualifications for every business area in the education processes in schools. For this reason, it is obligatory to take the human resources to orientation training in the workplaces according to the characteristics of the enterprises. The duration and quality of training in workplaces vary according to the sector of the workplace and the characteristics of the jobs. For example, the table below shows the average training hours given by the companies in Europe to their employees on a sectoral basis.

Table1. Training Hours per Employee in European Firms in 2005 (Eurostat 2009)

Sector	Training Hours
Real estate, renting and business activities	10
Financial intermediation	20
Post and telecominications	13
Land transport, transport via pipelines, water…	9
Hotels and restaurants	4
Wholesale and retail trade, repair of motor…	6
Construction	6
Electricity, gas and water supply	15
Manufacturing	9
Mining and quarrying	9
Other community, social, personal service…	9

The duration of the training given by the companies to their employees increases depending on the level of scientific and technological composition of production. Since flexible production systems contain more technology than previous production systems, in-service training durations are higher. For example, the average per year for new workers in assembly plants in the automotive industry, 380 hours in Japan, 173 hours in Europe, 90 hours in Turkey and 46 hours in US are given of training (TMMOB, 1993: 26). Fiat, which is one of the first companies to adopt flexible production practice in the automotive sector, which is among the dominant sectors in the world economy, created new job definitions while liquidating some of the jobs included in the Fordist job description, and this situation immediately required the establishment of a new automation and training organization (Gülsever, 1989: 167). In fact, with the "Fire" (Fully Robotized Engine) initiative, which is the most important attack of Fiat's automation mobilization, an educational mobilization that cost 21 million dollars for 950 workers was supported. With "Fire" initiative, it was aimed, via mass training, both giving the workers a high skill combination, and replacing the existing workforce the youngest workers who can show high cooperation and are compatible. Also, Renault firm started a broad training campaign to re-skill the workforce in accordance with the flexible production philosophy. The most important feature of educational mobilization is realize the training organization within a flexible production systematic in a way that in a hierarchical stratification extending from top management to down workers (TMMOB, 1993: 47).

In parallel with the importance SMEs have gained in company relations in the face of changing market dynamics, it has become important to increase the education level of employees working in SMEs. The training support offered to SMEs has begun to be increased by the companies and government organizations they are associated with. Non-formal education institutions and main company training programs have been predominantly used in providing this support. These training programs have begun to be designed with flexibility to respond to changes in the market and production processes and with a specific target-oriented approach. While SMEs already had a very weak power against big companies, they started to weaken even more after the 1990s. That is why SMEs have become dependent on also VTE services due to their technological dependence on large companies. SMEs have become a crutch in the efforts of large companies, which have Fordist mass production to overcome the crisis and realize the flexible production. SMEs continue to be dependent on large companies in terms of technology and VET today.

The most important change created by flexible production technologies in VTE systems has been in the nature of training programs. From the training approach based on narrow specialization suitable for the production character of Fordist production system, there has been a transition to a modular education approach, which aims to provide a broad professional perspective and makes it possible to have a versatile, professional and inter-professional transition.

The training programs prepared as module groups in the modular education system have the feature of articulation or transition with similar modular programs. At the same time, new modular programs produced with new technologies are also complementary to sub-programs. UNESCO revealed this situation in 1974 as follows: "VTE should start with a broad base. Thus, horizontal and vertical connections between school systems and school and employment will be facilitated. Programs should be designed in such a way that the transition from one field to another within VTE is allowed" (Sönmez, 1995: 10).

At the “Proceedings of The European Symposium on Education, Training and Employment", it has been said: “Individuals should learn to adapt themselves to technological developments and learn as a result of greater responsibility and autonomy in their duties. It is not enough to master only one vocational branch"(As cited in Sönmez, 1995: 9). Similarly, in the "International Symposium on Dual Vocational Training", the new understanding is emphasized by saying like that: "A new development in recent years has been to give special appreciation to broad-based vocational training again. This is because new technologies have put an end to the specialization training that has been before. The broad-based basic education will ensure that employees adapt to near areas of specialization in the future” (As cited in Sönmez, 1995: 10).

The flexible production systems, which are the driving force of the Third Industrial Revolution, in parallel with their processes, started to demand high level and multiple qualifications from the workforce. The most important of these qualifications are the flexible qualifications with high scientific and technological content, rapidly changing and transferable between disciplines and with a wide range of competencies rather than a narrow scope. Demands for the qualifications expected from the workforce has create pressure to, extend the (pre) basic education periods required for VTE, increase the content levels of VET programs and continue to lifelong learning.

The Dynamics of the Transition from the Third Industrial Revolution to the Fourth and Fifth Industrial Revolution.

Today, developments in areas such as new generation software and hardware, bio-computers, internet of things, cyber systems, smart (dark) factories, robotic systems and artificial intelligence constitute the basic dynamics of the transition from the Third Industrial Revolution to the Fourth Industrial Revolution. The basis of the 4th Industrial Revolution was the real-time communication and autonomous control and optimization of systems, machines, devices and products, through developed software and networks, at all stages of production, with developing science and technology. The developments that formed this ground could be realized through Cyber-Physical Systems (CPS) and the internet that connects these systems. Cyber-physical systems connect the physical world with the virtual computing world with the help of sensors (sensors) and implementers (actuators).

The dynamics created by the 4th Industrial Revolution are expected to be as follows:

- Establishment of smart factories where machines and devices communicate with each other autonomously and determine their production activities.
- The ability of smart factories to instantly produce products suitable for individual requirements.
- Increasing global cooperation opportunities in R&D and design processes.
- Minimizing human intervention by making equipment such as buildings, transportation vehicles, household appliances, robots, machines smart.
- Redesigning services such as education, health, justice, security.
- Having radical transformations in all employment areas.

Nowadays, while the Fourth Industrial Revolution is being realize the emergence conditions of the Fifth Industrial Revolution in which the focus entirely on human, society and the environment are appearing almost simultaneously.

The 4th Industrial Revolution, rising above the scientific and technological combination created by the 3rd Industrial Revolution, revealed new dynamics in raising people suitable for radical transformations in business life and production. While the competencies expected from people in business life have diversified, their content has started to deepen. Competent human resources are needed in areas such as communication, design, software, autonomous systems, cyber-physical systems, virtual and augmented reality applications. With the diversification in the qualification sets, the transitions between these sets are also increasing. In terms of the competencies expected from human resources, it has begun to move from narrow-scoped structures to broad-range structures. The complexity of the work in business life, the increase in the types of tasks that the employees have to do, the prominence of flexible business models and teamwork methods constantly increase the types of competencies required in the workplace. Now, businesses tend to employ human resources who are not only doing routine work, but are creative and can easily adapt to change, can produce solutions to problems as soon as possible, bring new suggestions and make continuous learning a part of their lives.

The qualified workforce, which has started to replace the unskilled workforce, which has become a implement for reducing costs in traditional company management, is now seen as the most basic element of production and productivity increase. The training need of the qualified human resources, which is increasingly prominent in all social areas, especially in employment and production processes, forces educational organizations that have the task of educating this human resource to change. The dynamics of development emerging in social and economic structures increase the pressure of change on educational institutions. For this reason, reorganization of education systems becomes inevitable in order to meet the future needs of human resource qualifications. Along with the new developments, in parallel with the changes in the qualifications expected from human resources, radical transformations have started to emerge in education, such as curricula, learning and teaching methods, training environments, instructor qualifications, training tools and equipment, training periods.

Today, among the employability criteria, only vocational and technical competencies are not considered sufficient, features such as, being able to adapt quickly to changes, making the right decision, having creativity and problem-solving skills, having ethical values, taking responsibility in production, communicating in various types, adopting the principle of lifelong learning, being able to use up-to-date technology, being prone to teamwork, and knowing a foreign language are sought. VTE institutions are expected to provide individuals with these qualifications as well as professional qualifications. In summary, it is expected from VTE systems not only to provide individuals with certain professional qualifications, but also to offer broad-perspective education opportunities that will enable individuals to be successful and happy in all areas of social life.

Education as a whole is meaningful when it is defined in terms of the development of the human being and society together with the person. Education has a plurality of functions in terms of the developments which of, abstraction ability, skills in the artistic field, basic and social sciences, which are the main determinants of human existence. (Ercan, 1998: 152). These qualities given to people ultimately constitute the synergy of social development. In this respect, education does not only undertake a function that prepares people for business life. In today's world, the development of human beings in all aspects is a necessity for the persons themselves and for all areas of society. Business life is just one of these areas. For this reason, the conditions that today towards the Fourth and Fifth Industrial Revolutions emerged made it necessary for VTE systems to evolve from the goal of training only “labour force” to the goal of “raising“ people ”integrated with other educational organizations.

Conclusion

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 that have a production organization that can respond to variable market demands and that led to the Third Industrial Revolution, have brought about important changes in the qualifications expected from the labour force. It also, necessitated a fundamental change in the objectives expected from VTE systems depending on the need for flexible labour.

In flexible production, necessity of workforce who, well trained; able to use advanced technologies effectively; can actively contribute to product renewal, quality increase and design processes; competent in computer, machine use, adjustment, maintenance and repair; flexible in the face of changing production conditions; fluent in foreign languages; committed to ethical principles has come to the fore. The need for unqualified workforce in workplaces has begun to decrease. Depending on these requirements related to the increase in the scientific and technological composition of the professions, the trend of extending the basic education periods required for the transition to VTE and increasing the starting age of VTE gradually has become mandatory. Suggestions and approaches in the opposite direction of this tendency, although many years have passed since the emergence of the Third Industrial Revolution, unfortunately continues to be effective in determining education policies in countries, have not yet gotten out of both the Fordist system, and the production model of foreign-dependent, goods and services with low added value.

In the face of new developments, VTE systems in many countries could not keep up with rapid developments and fell behind the current technological level. This situation has highlighted the VET models based on school-company cooperation, which are implemented in various ways, and the companies have started to make in-company training units, which provide very intensive training in accordance with their own needs, more effective. In addition, training activities have started to be perceived as a permanent firm function.

The flexible production system has given importance to SMEs like never before. However, at this stage, SMEs have not emerged as an alternative to large enterprises; on the contrary, they have become enterprises that large enterprises benefit from in their production activities. For this reason, large enterprises have started to provide technology and training support to SMEs.

The need for qualified human resources, especially in employment and production processes, increases the pressure on educational organizations that have the task of raising this human resource. Changes in social and economic structures force educational institutions to change. Therefore, the reorganization of education systems, which will prepare human resources for the future, has become inevitable. In parallel with the changes in the qualifications expected from human resources, transformations are also required in subjects such as educational environments, curricula, training periods, learning and teaching methods, qualifications of trainers, training tools and equipment. In summary, VTE systems are expected to offer individuals not only vocational and technical qualifications, but also broad-perspective education opportunities that will enable individuals to be successful and happy in all areas of social life.

The world is today on the brink of, the Fourth Industrial Revolution and, according to some approaches, the Fifth Industrial Revolution. As in the previous Industrial Revolutions, the Fourth and Fifth Industrial Revolutions will require transformations in all social areas, especially in production and education processes, in accordance with their own dynamics. Societies that anticipate these transformations and prepare accordingly will undoubtedly be ahead.

References:

Algan, N. (1994). Küçük ve orta ölçekli sanayi işletmelerinde (kobi) etkinlik, verimlilik ve karlılık açısından bir değerlendirme. *Verimlilik Dergisi*, Ankara: MPM Yayını, 1994/3. (An evaluation in terms of efficiency, productivity and profitability in small and medium sized industrial enterprises (SMEs). *Journal of Productivity*, Ankara: MPM Publication, 1994/3.)

Ansal, H. (1996). İşgücünün niteliği ve eğitimde yeterlilik-teknolojik gelişme döneminde işgücünün niteliği. *TMMOB 1995 Sanayi Kongresi Bildiriler Kitabı 1-2*, Ankara: MMO Yayını, Yayın No: 186, Mart. (Quality of workforce and competence in education - quality of workforce in the period of technological development. *TMMOB 1995 Industry Congress Proceedings Book 1-2*, Ankara: MMO Publication, Publication No: 186 March.)

Dyer, S. (1998). Flexibility Models: A critical analysis. International journal of manpower. *MCB University Press*, Vol. 9, No. 4, pp. 223-233, 0143-7720.

Ercan, F. (1998). Eğitim ve kapitalizm. İstanbul: *Bilim Yayıncılık*, 1. Baskı, Haziran. (Education and capitalism. İstanbul: *Bilim Publishing,* First Edition, June.)

Erdost, C. (1991). Teknoloji üretiminin çağdaş özellikleri ve teknoloji üretiminde devletin rolü. *TMMOB Makine Mühendisleri Odası, 1991 Sanayi Kongresi Bildiriler Kitabı*, Ankara: MMO Yayını, Yayın No: 148/1, Kasım. (Contemporary features of technology production and the role of the state in technology production. *TMMOB Chamber of Mechanical Engineers, 1991 Industry Congress Proceedings*, Ankara. MMO Publication, Publication No: 148/1, November.)

Eurostat (2009). Training hours per employee in European firms in 2005.

Göker, A. (1991). Mikroelektronik ve buna bağlı teknolojilerin kazandığı olağanüstü önem. *TMMOB Makine Mühendisleri Odası 1991 Sanayi Kongresi, Elektronik Sanayi Sektör Raporu*, Ankara: MMO Yayını. Yayın No: 149/4, Kasım. (The extraordinary importance acquired by microelectronics and related technologies. *TMMOB Chamber of Mechanical Engineers 1991 Industry Congress, Electronics Industry Sector Report*, Ankara: MMO Publication. Publication No: 149/4, November.)

Göker, A. (1991). Yeni sanayileşen ülkelerde elektronik sanayi: G. Kore, Tayvan, Brezilya, Hindistan ve Singapur deneyimi*. TMMOB Makine Mühendisleri Odası, 1991 Sanayi Kongresi, Elektronik Sanayii Sektör Raporu*, Ankara: MMO Yayını, Yayın No: 149-4, Kasım. (Electronics industry in new industrialized countries: experience of S. Korea, Taiwan, Brazil, India and Singapore. *TMMOB Chamber of Mechanical Engineers, 1991 Industry Congress, Electronics Industry Sector Report,* Ankara. MMO Publication, Publication No: 149-4, November.)

Gülsever, T. (1989). Teknolojik gelişme enformasyon teknolojisi, esnek üretim ve esnek uzmanlaşma. *TMMOB Makine Mühendisleri Odası, 1989 Sanayi Kongresi Bildirileri I*, Bursa: MMO Yayını, Yayın No: 134/1. (Technological development information technology, flexible production and flexible specialization. *TMMOB Chamber of Mechanical Engineers, 1989 Industry Congress Proceedings I*, Bursa: MMO Publication, Publication No: 134/1.)

Griggs, H.E. and Hyland, P. (2003). Strategic downsizing and learning organisations. *Journal of European Industrial Training*, Vol. 27, No. 2/3/4, pp. 177-09-0590, Publication date: 1 March 2003, ISSN: 03.

İşler, H. (1997). *Sanayileşme ile mesleki teknik eğitim politikaları ilişkisi.* (Yayınlanmamış Yüksek Lisans Tezi). Türkiye ve Orta Doğu Amme İdaresi Enstitüsü, Kamu Yönetimi Lisans Üstü Uzmanlık Programı, Ankara. (*Relationship between industrialization and vocational technical education policies*. (Unpublished Master Thesis). Institute for Turkey and Middle East Public Administration, Public Administration Graduate Specialization Program, Ankara.)

Kazgan, G. (1997). Küreselleşme ve yeni ekonomik düzen, ne getiriyor, ne götürüyor, nereye gidiyor? İstanbul: *Altın Kitaplar Yayınevi*, Ekim. (What does globalization and new economic order bring, what does it take, where is it going? İstanbul: *Altın Kitaplar* Publishing House, October.)

Lordoğlu, K. (1989). Yeni teknolojinin yeni ürünü: emek sürecinde niteliksizleşme. *TMMOB Makine Mühendisleri Odası, 1989 Sanayi Kongresi Bildirileri,* Bursa: MMO Yayını, Yayın No: 134/1. (New product of new technology: dequalification in labor process. *TMMOB Chamber of Mechanical Engineers, 1989 Industry Congress Proceedings,* Bursa. MMO Publication, Publication No: 134/1.)

Öngen, T. (1996). Teknolojik gelişme döneminde işgücünün niteliği. *TMMOB 1995 Sanayi Kongresi Bildiriler Kitabı 1-2*, Ankara: Makine Mühendisleri Odası Yayını, Yayın No: 186, Mart. (The Nature of the workforce in the technological development period. *TMMOB 1995 Industry Congress Proceedings Book 1-2*, Ankara: Chamber of Mechanical Engineers Publication, Publication No: 186. March.)

Özuğurlu, M. (2008). Anadolu'da küresel fabrikanın doğuşu, yeni işçilik örüntülerinin sosyolojisi. İstanbul: *Kalkedon Yayınları*, 2. Baskı, Ocak. (Birth of global factory in Anatolia, sociology of new workmanship patterns. İstanbul: *Kalkedon Publications,* Second Edition, January.)

Sarıkaya, B., T. (1995). KOBİ'lerin Türkiye ekonomisindeki yeri, *İzmir Ticaret Odası Yayını*, Yayın No: 20. (Place of SMEs in the economy of Turkey, *İzmir Chamber of Commerce Publication*, No. 20.)

Sönmez, A. (1995). *Örgün ve yaygın mesleki eğitimin bütünleştirilmesi*. (Yayınlanmamış Doktora Tezi), M.E.D.A.Ü., Sosyal Bilimler Enstitüsü. (*Integration of formal and non-formal vocational education*. (Unpublished Doctorate Thesis), M.E.D.A.Ü., Institute of Social Sciences.)

Statista. [https://www.statista.com/statistics/739741/learning-hours-used-per-employee/]. Last access: 14.06.2022

Şaylan, G. (2003). Değişim, küreselleşme ve devletin yeni işlevi. Ankara: *İmge Kitabevi*, 2. Baskı. (Change, globalization and the new function of the state. Ankara: *İmge Publishing House*, Second Edition.)

Taymaz, E. (1993). Kriz ve teknoloji. *Toplum ve Bilim Dergisi*, İstanbul: Birikim Yayıncılık, Bahar 56-61. (Crisis and technology. *Journal of Society and Science*, İstanbul: Birikim Publishing, Spring 56-61.)

TMMOB Makine Mühendisleri Odası Bursa Şubesi. (1993). *Sanayi kongresi, Türk otomobil sanayii verimlilik analizi*, Bursa. MMO Yayını, Yayın No: 159, Kasım. (TMMOB Chamber of Mechanical Engineers Bursa Branch. (1993). *Industry congress, Turkish automobile industry productivity analysis,* Bursa. MMO Publication, Publication No: 159, November.)

Yenal, O. (1999). Ulusların zenginliği ve uygarlığı, eğitim boyutu. Ankara: *Türkiye İş Bankası Kültür Yayınları*, 1. Baskı. (Wealth and civilization of nations dimension of education. Ankara: *Turkey İş Bank Cultural Publications,* First Edition.)

Yentürk, N. (1990). Post-Fordist gelişmeler ve dünya iktisadi işbölümünün geleceği. *Toplum ve Bilim Dergisi*, İstanbul: Birikim Yayıncılık, Bahar 56-61. (Post-Fordist developments and the future of the world economic division of labor. *Journal of Society and Science,* İstanbul: Birikim Publishing, Spring 56-61.)