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SOCIOLOGICAL PERSPECTIVE TO THE INDUSTRIAL ENGINEERING PROFESSION IN TURKEY

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Multidisciplinary Journal With Arbitration Committee

CURRENT SCIENCE

Prof. Samantha Lewes

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OBJECTIVE

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Based on keeping this article present, an evaluation of the past, current situation and future of Industrial Engineering (IE) in Türkiye should be a basis for different evaluation studies to be carried out.

METHODOLOGY

A literature review was conducted, and recommendations were developed based on the experience and knowledge of the authors in the field by evaluating the available statistics.

RESULTS

In this article, it is revealed based on statistics that "INDUSTRIAL ENGINEERING is among the most preferred professions in Turkey and finds a wide range of applications". In accordance with the rapid change experienced today, how to ensure the sustainability of this position of Industrial Engineering Department has been examined. Areas open to improvement, for example, Attention was drawn to issues such as University-Industry cooperation, Industrial Engineering Department taking its place in the field of digitalization, renewing education and training programs taking into account the Z-generation, and returning the tendency towards the service sector to the manufacturing sector. In addition, it was discussed how to train Industrial engineers who are aware of global problems such as hunger, health, education, entrepreneurship-innovation (innovation), sustainability, peace and democracy, economic development.

Keywords: *Industrial Engineering, Globalization, Digitalization, Industry 4.0, Generation Z, Sociological Perspective*

Abstract

From a sociological perspective, the industrial engineering profession in Türkiye is examined. In this article, the profession of "INDUSTRIAL ENGINEERING" is examined from a sociological perspective in the context of the country's history, culture and economic development, and it is revealed on the basis of statistics that the Industrial Engineering profession is among the most preferred professions in Türkiye and has a wide range of applications. In line with the rapid changes taking place today, the sustainability of this position of the Department of Industrial Engineering is examined. Areas open to improvement, such as University-Industry cooperation, the Department of Industrial Engineering taking its place in the field of digitalization, renewal of education and training programs taking into account Generation Z, the tendency of the service sector to return to the manufacturing sector, have been pointed out; how to train Industrial Engineers who are aware of global problems such as hunger, health, education, entrepreneurship-innovation (innovation), sustainability, peace and democracy, and economic development have been discussed.

Industrial engineering is a relatively new field in Türkiye, as the country's economy underwent a significant transformation from an agriculture-based economy to an

industrialized economy in the mid-20th century. As Türkiye has become a major player in the global manufacturing industry, the importance of the profession has increased. However, like many other professions in Türkiye, industrial engineering is not immune to challenges such as social inequality, political instability and economic insecurity. The profession is also affected by broader societal trends such as globalization, urbanization and technological change.

One of the main challenges facing industrial engineers in Türkiye is the lack of investment in research and development. This prevents the profession from keeping pace with the latest technologies and developments in the field. In addition, there is a shortage of qualified personnel in the sector, leading to a lack of competitiveness and low productivity. Another problem is the unequal distribution of wealth and opportunities in Türkiye. Despite the country's economic growth in recent years, many industrial engineers struggle to find jobs, and those who do often face low wages and poor working conditions. This is especially true for women, who are underrepresented in the field and face discrimination in the workplace.

Overall, the industrial engineering profession in Türkiye reflects the broader social and economic conditions in the country. Addressing the challenges facing the profession requires a comprehensive approach that addresses not only the technical aspects of the field, but also the social and political factors that have shaped the development and growth of the profession.

Keywords: *Industrial Engineering, Globalization, Digitalization, Industry 4.0, Generation Z, Sociological Perspective*

Introduction

Industrial Engineering, which is one of the popular professions of today, is actually one of the oldest engineering in the world. After the first engineering fields that emerged before the first world war, construction, machinery, electricity and chemistry, it was born with the change that started with the Industrial Revolution and has continued its development since the 1900s as a natural result of the mass production process. The first Industrial Engineering program in the world was opened in Pennsylvania State and Syracuse universities in 1908. However, the program opened in Syracuse was closed in a brief time and then reopened in 1925 (Turner et al., 1978: 18-19). When the history of Industrial Engineering is examined, it is seen that it has continued its development rapidly since 1920.

When we look at the development of Industrial Engineering in our country, it is seen that the "Operation Research" branch was first established in 1956 under the Turkish Armed Forces

General Staff (Kara, 2012). The studies carried out in this branch led to the development of Operations Research (OR) and pioneered the development of Industrial Engineering. In this context, courses were opened under the titles of "Operational Research" or "Activity Research" in some of our universities, the first of which was at Istanbul Technical University (ITU) in 1961 (Soysal, 1983), (Kara, 2012). With the development of Operations Research between 1940 and 1970, and the interaction of Operations Research and Industrial Engineering (Turner et al., 1978: 2-4), Industrial Engineering has become one of the most preferred professions of today.

THE DEVELOPMENT OF INDUSTRIAL ENGINEERING IN TURKEY

The first Industrial Engineering program in Türkiye was established in 1965 within the Mechanical Engineering Department of the Middle East Technical University Engineering Faculty, and the first OR unit was established within the Turkish Scientific and Technological Research Council (TÜBİTAK) the same year. This program was included in Türkiye's first Industrial Engineering department in 1969. In the same year, another department was opened in ITU under the name of Industrial Engineering. In 1980, although there were 20 universities in Türkiye, the number of Industrial Engineering departments was limited to 4. In 1984, Türkiye's first foundation university, Bilkent, was established and in the same year, an Industrial Engineering Department was opened within the Faculty of Engineering. The number of Industrial Engineering departments reached 12 in 1990, and a rapid increase was observed in the following years. Today, the number of Industrial Engineering departments actively carrying out education and training activities is 90 (Figure 1). In this rapid increase, it is thought that the capital mobility provided by Türkiye's transition to a free market economy after 1980, the liberalization of the import regime and the changes such as customs union and the opening of the enterprises to competition on a world scale are thought to play a key role.

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In the same years, product and service diversity increased, investments in areas such as quality, cost and flexible production technologies accelerated and the need for industrial engineers increased. This increasing trend has continued as a natural consequence of globalization, paralleling the growth in the national economy. In the same period, the growth in the service sector (banking and finance, information technologies, logistics, health, tourism, transportation) led to the acceleration of developments in the field of Industrial Engineering. Parallel to the growth of the service sector, the diversity within the sector increased and qualified manpower was needed. Therefore, in the 2000s, many industrial engineers found employment opportunities in the service sector, especially in banking, finance and information technologies. Increasing competition, uncertainty and the impact of the 2008-2012 global economic crisis in these years increased the demand for industrial engineers who can work interdisciplinary, with a flexible and holistic system perspective in the labor market.

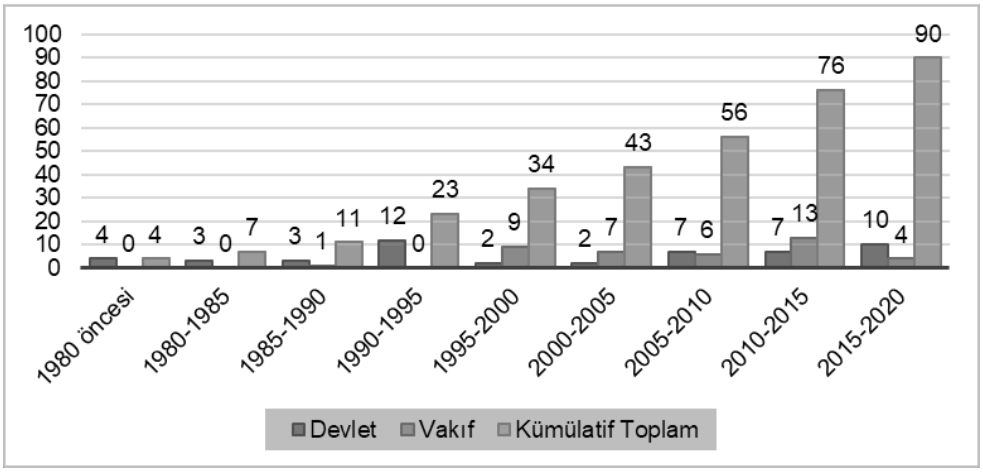


Figure 1. Number of INDUSTRIAL ENGINEERING departments established according to years

According to the Higher Education Council (YÖK) data (2021), the total number of Industrial Engineering departments in our country has increased over the years and reached 138. 90 of them continue their active education and training activities. Education and training activities are carried out in these departments, which were opened under different names such as "Industrial Engineering", "Management Engineering", "Industrial Engineering", "System Engineering", "Industrial and Systems Engineering", and industrial engineers who are in need of today's society are trained.

In this development process, Industrial Engineering also accelerated its organizational development and strengthened its organic bond with Operations Research with the participation of the academic and business world. Parallel to these developments, the first Operations Research/Industrial Engineering "OR/IE" Congress, which has an especially prominent place among the national academic activities of Industrial Engineering, was held at Boğaziçi University in 1975 under the name of "National OR Congress" (Kara, 2012).

A total of 40 National OR/IE congresses held to date have brought together universities, the public, industry and practitioners, thus creating great interaction and synergy.

Another crucial factor in the development of Industrial Engineering is the national journals published in this field. The first journal related to Industrial Engineering is the journal that was published by the ITU Industrial Engineering Department in 1982 with the name "Industrial Engineering" and continued to be published as "Industrial / Industrial Engineering" in 1984 with its changed name. The journal "Operation Research", which has been published since 1980 by the Operations Research Association, which was founded in 1975, has played a key role in the development of both Operations Research and Industrial Engineering in our country by continuing its publication life as "Operation Research Journal" since 1993.

ACADEMIC DEVELOPMENT AND STUDENT PROFILE

Industrial Engineering Departments and Programs: Undergraduate and Graduate

As of 2020, there are a total of 203 universities in Türkiye, of which 129 are state universities and 74 are foundation universities. According to the Higher Education Information Management System data created by YÖK (2020), there are Industrial Engineering departments in 138 universities, 86 of which are state and 53 are foundations. There are 112 undergraduate, 57 graduate and 36 doctoral programs in these departments. These programs differ in terms of education-teaching languages as 100% Turkish, 100% English and 30% English. In some universities, education activities are carried out with two different programs, 100% Turkish and 100% English. There are also two Industrial Engineering programs in two universities, one in German and the other in French.

Engineering programs in our country, as in the world, have given importance to accreditation especially for the last 20 years. Bilkent University Industrial Engineering program is the first Industrial Engineering program to be accredited by the Accreditation Board for Engineering and Technology (ABET) in 2006. Today, the Engineering Education Programs Evaluation and Accreditation Association (MÜDEK), which is a national organization, also carries out the accreditation of engineering programs.

MÜDEK was accepted by YÖK in 2007 as a national institution accrediting engineering programs. As listed in the list of undergraduate programs accredited by MÜDEK (2007), Gazi University Industrial Engineering program was the first Industrial Engineering program accredited by MÜDEK in 2004. Today, a total of 34 Industrial Engineering programs, 16 of which are in state and 18 in foundation universities, have MÜDEK accreditation and EUR-ACE label. EUR-ACE is an accreditation system that shows that the standards of engineering programs in Europe are provided at high quality.

Within the scope of the ERASMUS Program, Industrial Engineering students can continue their education and training for one or two semesters in various universities in Europe and in the world depending on agreements, and in Mevlâna and Farabi exchange programs at home or abroad. Students coming from abroad can receive education and training from Industrial Engineering programs for one or two terms within the scope of these programs.

The distribution of state and foundation universities with Industrial Engineering departments by provinces is given in Figure 2. When the map is examined, it is seen that the Industrial Engineering departments are mostly concentrated in Istanbul, Ankara and Izmir. This situation shows parallelism with the distribution of the Turkish economy on a provincial basis.

Figure 2. Distribution of Industrial Engineering departments by province

2.2. Students

In the 2019-20 academic year, there are more than 4.5 million students enrolled in the Turkish Higher Education System. 91% of them are in state universities and 9% are in foundation

universities. The share of Industrial Engineering in the total is 0.69%. In addition, there are 3516 students enrolled in Industrial Engineering graduate programs, 952 of which are doctoral students. Every year, approximately 2.5 million students apply to the Republic of Türkiye Assessment, Selection and Placement Center. According to these data, 16.2% of the students who applied in the 2019-20 academic year were placed in undergraduate programs. The number of students entering Industrial Engineering programs is over 6400. It is seen that the number of students at the undergraduate level is remarkably close to each other in the female-male distribution among the students, and this distribution increases in the direction of females at the graduate level and in the direction of males at the doctoral level. According to YÖK Atlas (2020), there is an increase in the number of undergraduate students compared to the previous year, a decrease in postgraduate studies, and a slight increase in doctoral studies (Table 1).

Table 1. Total number of students in Industrial Engineering departments

	Undergraduate Student			Graduate Student			PhD student		
Academic Year	**M**	**F**	**T**	**M**	**F**	**T**	**M**	**F**	**T**
2019-20	15746	15356	31102	1162	1402	2564	503	449	952
2018-19	14863	15026	29889	1718	1616	3334	535	405	940
2017-18	13938	14469	28407	2178	1780	3958	583	404	987
2016-17	12745	13535	26280	2375	1866	4241	605	386	991
2015-16	11432	12836	24268	2086	1708	3794	576	370	946

M: Male F: Female T: Total

When the general preference tendencies of the most successful students in the YÖK Atlas (2020) are examined, it is seen that the industrial engineering program ranks 3rd among the most preferred engineering programs after medicine and dentistry (Table 2).

Table 2. Distribution according to the departments preferred by the students in the first 20 thousand success rankings

Sections	First 20 thousand	%
Medicine	13384	66,92
Dentist	964	4,82
Computer Engineering	786	3,93
Electrical Engineering	649	3,25
Industrial Engineering	525	2,63
Mechanical Engineering	562	2,81
Molecular Biology and Genetics	91	0,46
Aeronautical Engineering	78	0,39
Chemical Engineering	76	0,38
Civil Engineering	72	0,36
Others	2813	14,07

2.3. Instructors

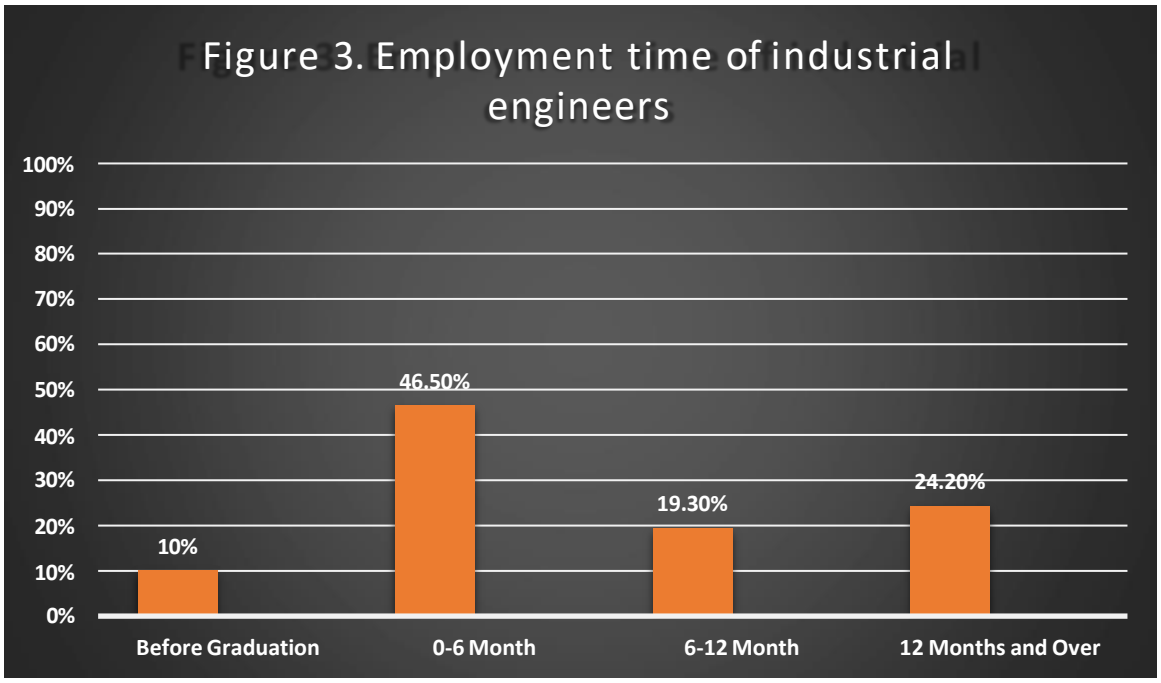
According to the Higher Education Information Management System data created by YÖK (2020), there are 230 professors, 153 associate professors, 459 Dr. academic staff, 32 lecturers, a total of 874 lecturers and 363 research assistants (Table 3). Considering a total of 90 active Industrial Engineering departments, an average of 9.7 faculty members works in a department. The number of students per faculty member is 35.6. This figure is reported by the National Center for Educational Statistics (2020) as an average value of 18:1. Considering that the demand for Industrial Engineering will increase in the coming years, a planning should be made to meet the supply-demand balance by training faculty members in the Turkish Higher Education System.

	Professor			Associate P			Dr.Instructor Member			Instructor			Research Assistant		
Type	**M**	**F**	**T**	**M**	**F**	**T**	**M**	**F**	**T**	**M**	**F**	**T**	**M**	**F**	**T**
State	98	48	146	67	37	104	154	106	260	9	8	17	113	160	273
Foundation	64	20	84	31	18	49	120	79	199	8	7	15	26	64	90
Total	162	68	230	98	55	153	274	185	459	17	15	32	139	224	363

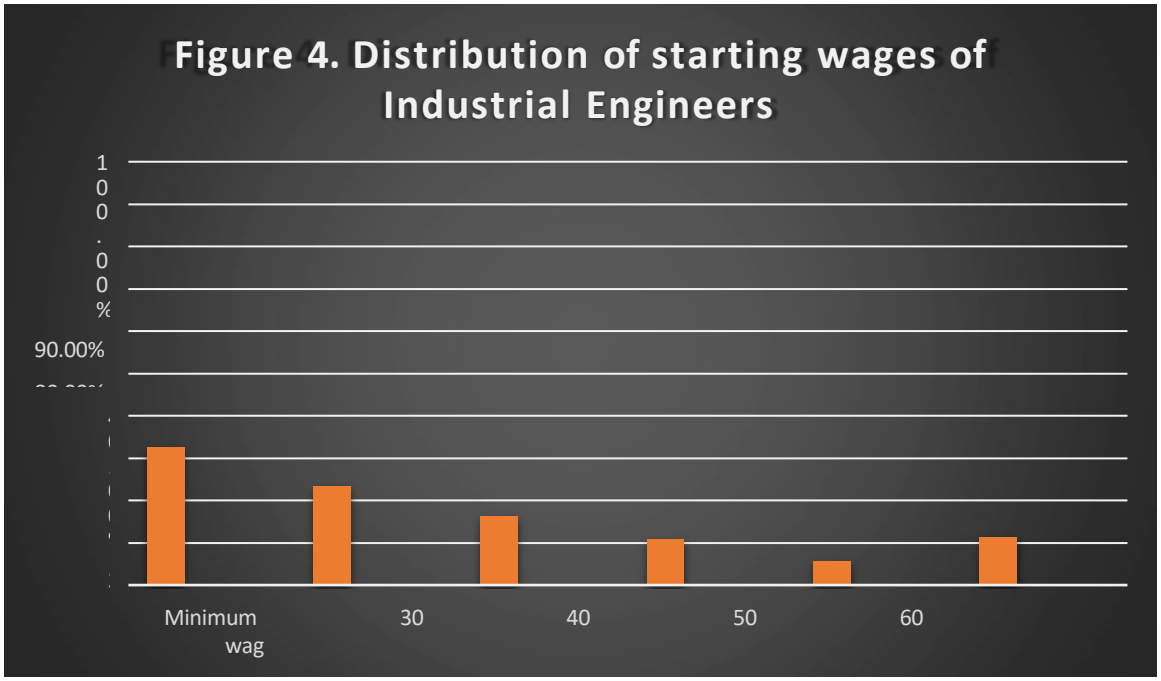
Table 3. Number of 2019-2020 academic staff in Industrial Engineering Departments

JOB AND CAREER OPPORTUNITIES

According to YÖK Atlas (2020), the total number of undergraduate formal education graduates in Türkiye in the 2019-20 academic year is 307608. 1.66% of this number are Industrial Engineering graduates. According to Uni-Veri (2019) data prepared by the Presidential Human Resources Office, 10% of industrial engineers in Türkiye can find a job before graduation and 65.8% within the first year, according to employment data in recent years (Figure 3).). According to the Career and Talent Management Association data, while the rate of those who find a job within the first 6 months after graduation is 34%, this rate for industrial engineers is 39.14%, which is well above the average of Türkiye.



According to the Uni-Veri (2019) data prepared by the Presidential Human Resources Office, the distribution of the starting wages of Industrial Engineering graduates is given in Figure 4. From this figure, it is seen that the rate of industrial engineers who start working with a wage above the minimum wage is 67.5%, and that a part of the total, close to 30%, started to work with an extremely high wage.

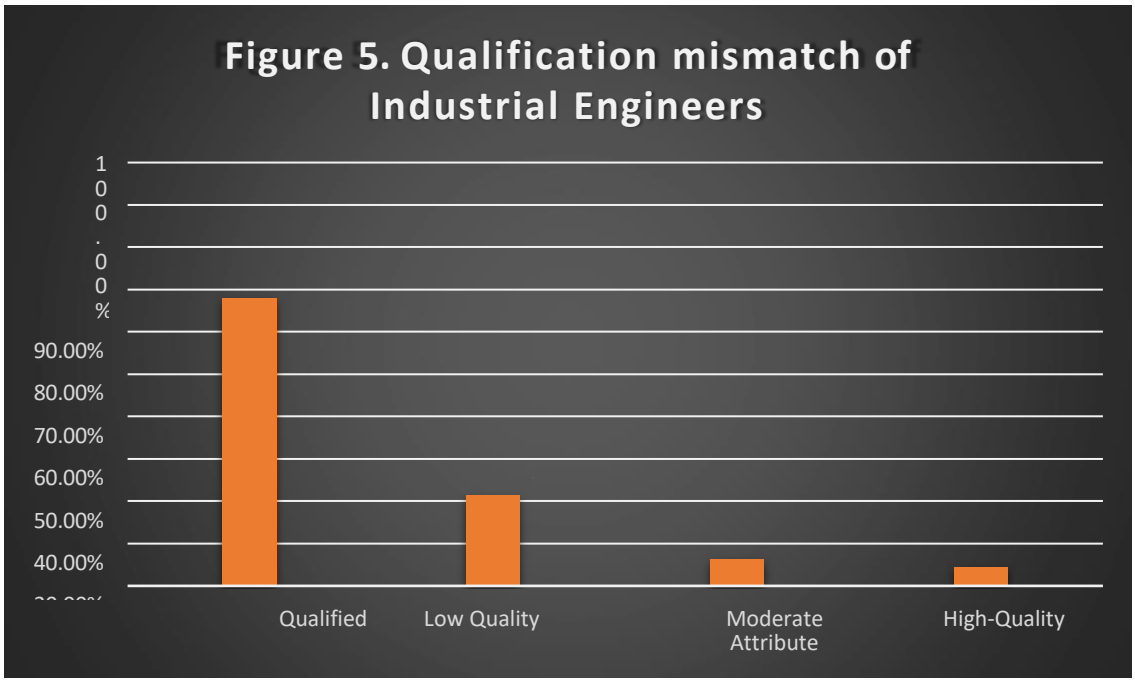


According to International Labor Office (2018) data, it is known that skill mismatch and qualification mismatch are among the crucial factors of unemployment problem. The "skills mismatch" between the expectations of the employer and the qualifications of the graduates is one of the critical issues on the world's agenda. Youth unemployment, which has increased rapidly in recent years, has become a global problem.

However, skill mismatch is not an easily calculable measure. Qualification mismatch occurs when jobs require lower or higher qualifications according to their education level. The qualification mismatch indicator in Employment Projections (2020) published by The Bureau of Labor Statistics and UniData Method (2020) announced by the Presidential Human Resources Office is based on

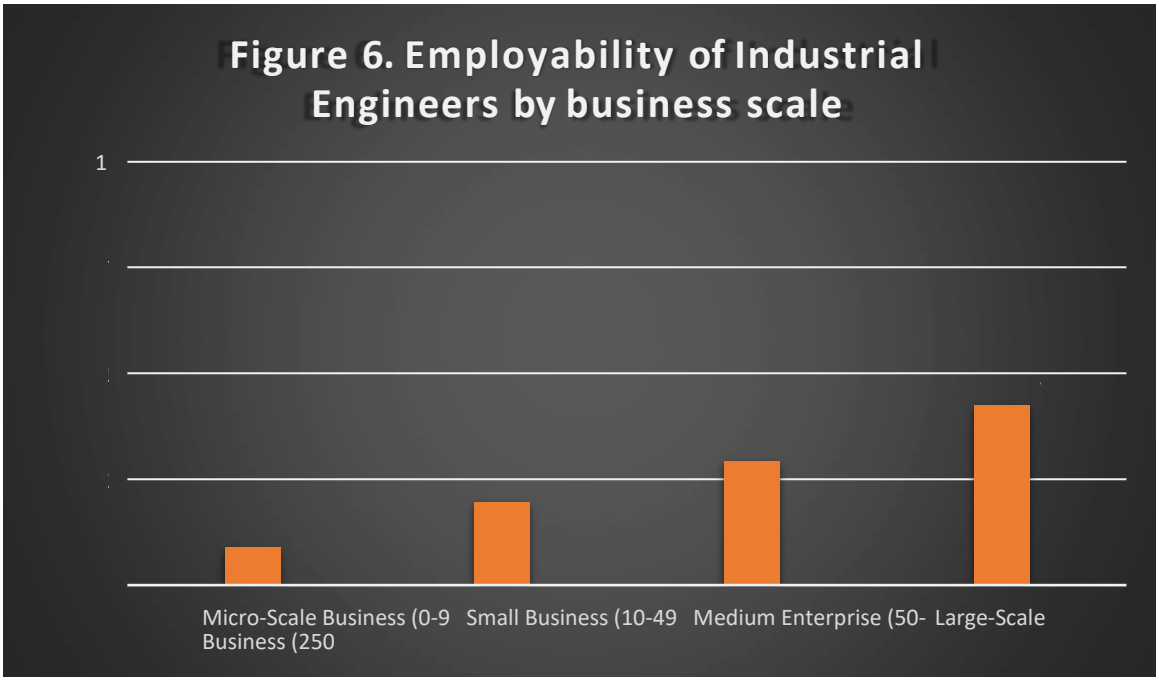
education and employment information and is based on the International Labor Organization (ILO) standard occupation (ISCO) and skills are calculated by the set's classification.

Figure 5, prepared according to the data of Uni-Veri (2019) prepared by the Presidential Human Resources Office, shows the data on the qualification mismatch for industrial engineers. Industrial engineers are among the lucky group, and they are one of the professions with the lowest level of qualification mismatch. In our country, industrial engineers do not experience a talent mismatch with a high rate of 68%. This shows that the education standard is provided at a particularly proficient level. On the other hand, industrial engineers are one of the professions most preferred by companies, public institutions and non-governmental organizations, as they have many of the 21st century competencies with their acquired social skills due to their professional formations.

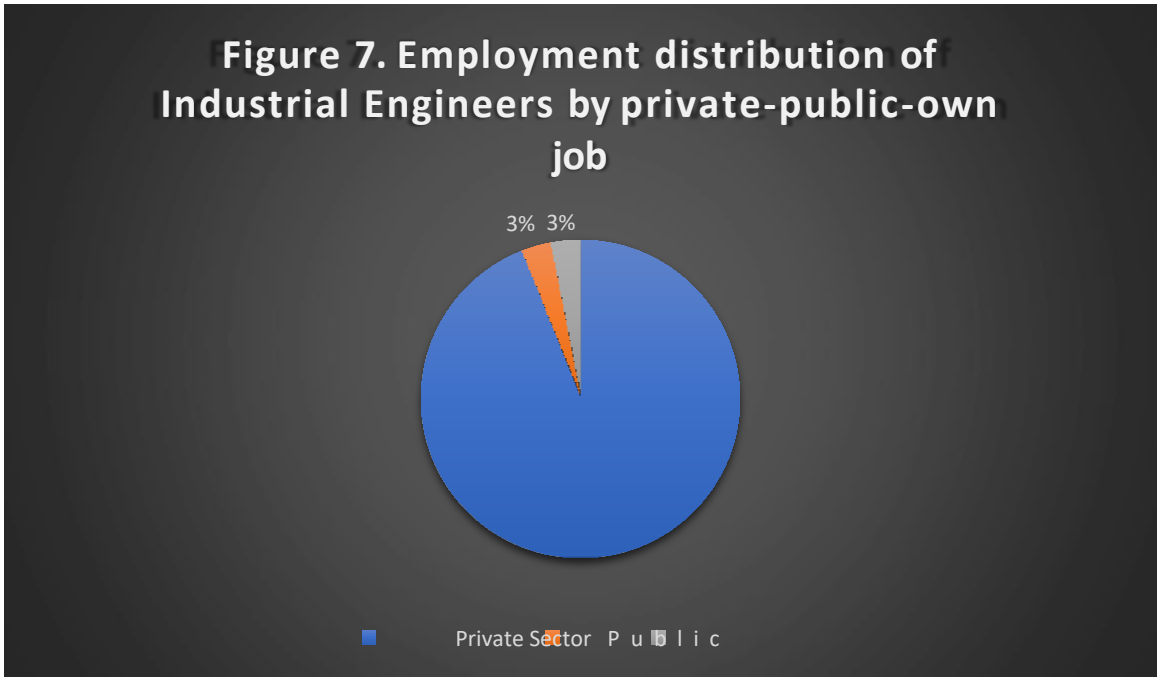


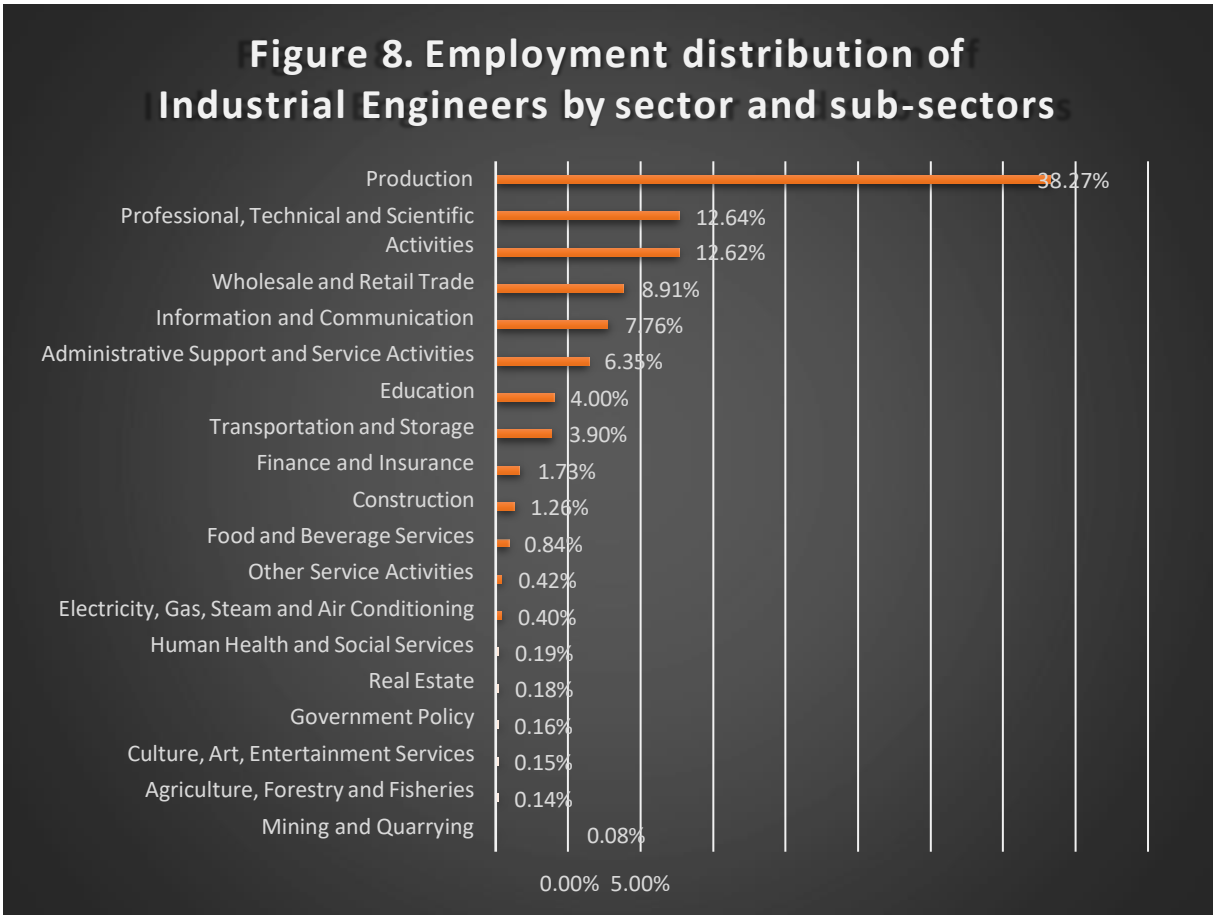
According to the Uni-Veri (2019) data prepared by the Presidential Human Resources Office, according to the distribution of the type of enterprises industrial engineers work in according to the scale of the firm (Figure 6), 8.8% are in micro-scale enterprises, 48.7% are in Small Enterprises and Medium Sized Enterprises, 42.5% of them work in large enterprises. This table: It shows that the developed or developing large-scale enterprises of our country are aware of the added value of

hiring industrial engineers, and therefore industrial engineers have a profound influence on the development of these companies.



When the Uni-Veri (2019) data prepared by the Presidential Human Resources Office is examined, it is seen that 94% of industrial engineers work in the private sector, while the rest equally work in the public sector or as entrepreneurs, in a classification made according to private sector, public and self-employed employees. (Figure 7) According to another evaluation made in Uni-Veri (2019), taking into account the sector-based distribution of enterprises, 38% of industrial engineers are in the manufacturing sector, 59% are in the service sector, and the rest are in construction, agriculture-forest-fishing, mining, works in sectors such as water and sewage waste management (Figure 8). It can be said that more employment of industrial engineers in the service sector depends on their preference due to their flexible professional formations.





THE FUTURE OF INDUSTRIAL ENGINEERING

In her article in the Financial Times, Pilita Clark (2020) states that in our world, where a momentous change is experienced due to digitalization, the demand for new business areas in all sectors will increase in the future with the effect of Covid-19. Among these works, Employment Projections published by The Bureau of Labor Statistics, data analysis and research, artificial intelligence and machine learning, big data analysis, digital marketing and strategy development, process development, business development, digital transformation, specified within the scope of Future Jobs Studies prepared by the Higher Education Institution. We can say that some professions will come to the fore in this changing job composition and one of them is Industrial Engineer. Industrial engineers have a human-oriented, holistic system perspective and flexible professional

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formation; suggest that it will play a key role in the above-mentioned new business areas in this process. In addition, deep optimization knowledge and analysis capability will give them a great advantage in modeling and solving increasingly complex systems and big data today. In the current conjuncture, the steps to be taken in order to take advantage of these opportunities and the strategy and policy recommendations related to these steps are given below:

Z-Generation: Industrial Engineering is one of the preferable professions that designs, installs and manages systems that are human-centered due to its natural nature. In order to make this situation sustainable, it has to better understand the Z-generation and their expectations. As generations change, it is an inevitable necessity to renew education and training programs. Entrepreneurship, cultural awareness, globalization, sensitivity to social values and the environment are among the prominent features of the Z-generation. At the same time, the expectation of the society from this generation and the change in the competencies of this generation should be taken into account. In other words, it is important to redesign the education and training programs of Industrial Engineering by revealing the strengths and weaknesses of the Z-generation. In this context, new courses should be designed, teaching methodologies based on active learning should be developed, and measurement and evaluation systems should be updated. Therefore, learning outcomes and program outcomes should also be redefined. Thus, the contribution of Industrial Engineering graduate programs and post-doctoral research to society and science will be increased.

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University-industry cooperation: Although it has been discussed for many years, university-industry cooperation, which has not reached the desired level, should be put into practice in real terms. Due to the lack of necessary structural reforms in higher education, education and research activities are carried out in a disconnected manner from each other and from life. In particular, the pressure of publication on faculty members, the fact that enterprises do not devote sufficient time and budget to R&D by focusing on daily issues prevent university-industry cooperation from reaching the desired level. Due to the different expectations and perspectives of both parties, many techno parks and technology transfer offices established in our country in recent years have not been able to contribute to the development of cooperation at a sufficient level. Another observation is that the share of Industrial Engineer in existing R&D projects is exceptionally low. One of the main reasons for this is that R&D is perceived as more product-oriented in our country. R&D studies on production processes have not reached a sufficient level. Therefore, the chance of industrial engineers to take part in such R&D activities decreases. Existing collaborations are mostly limited to the application studies carried out within the scope of graduation projects of senior students. It is necessary to create R&D awareness in the subjects of "process design" and "process improvement" in order to develop the culture of mutual benefit between industry and university in Industrial Engineering as well. Handling reproducibility and recycling together in product designs, especially in order to ensure sustainability and reduce carbon footprint, has become one of the priority issues that the world attaches importance to on a global scale. In this context, new opportunities may arise for industrial engineers in R&D and P&D studies in the near future.

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Return to production: The Covid-19 outbreak has revealed how important domestic production and self-sufficiency are in a country's economy. The share of the manufacturing sector in the country's economy is expected to increase in the coming years. Considering that some of the trend that has shifted to the service sector today will return to the production sector, it would be appropriate to take this situation into account in the renewal of the above-mentioned curricula. Supporting Industrial Engineering programs with new courses on product and process design in digital environments will strengthen the role of industrial engineers in the manufacturing sector.

Entrepreneurship and innovation: In Industrial Engineering programs, as one of the areas open to development, the entrepreneurial spirit and innovation culture should be gained increasingly effectively. Thus, we can train graduates who can turn their creative ideas into highly valued start-up companies. Therefore, we must systematically sprinkle critical thinking, critical thinking and creative thinking competencies into Industrial Engineer programs. In this context, it should also include “disruptive innovation” projects that can be carried out with interdisciplinary and teamwork.

Digitalization: We are in a period in which a lot of information is produced, consumed and technology changes rapidly. While the 21st century is called the 'information and technology age', we are also experiencing the industry 4.0 revolution in this period. The possibilities provided by digital technologies carry the world to various places globally. Can industrial engineers stay out of this reality? On the other hand, the Covid-19 outbreak has accelerated the digitization process. It is inevitable for industrial engineers to take their place in this virtual world. In this context, it is necessary to update the Industrial Engineering programs and to establish and use new types of laboratories (digital twins, augmented reality, virtual reality, Industry 4.0, simulation, etc.) in education. While existing business models are being redesigned in accordance with digital transformation, new business models may arise and the need for industrial engineers will increase in this process.

Global problems: Industrial engineers have moved away from the global problems that the world has been experiencing and waiting for a solution for a long time and have focused more on micro-scale problems based on profit optimization of enterprises. In line with the "Sustainable Development Goals" of the United Nations, global problems that all countries of the world are trying to solve with an interdisciplinary perspective; for example hunger, health, education, innovation, sustainability, peace and democracy, economic development etc. have remained off topic. By making the necessary arrangements in Industrial Engineer programs, raising graduates who are aware of these global problems of the world, who can develop analysis and solution methods and who will contribute to the society should be among the main goals in the future. Thus,

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it will be possible for industrial engineers to find wider job opportunities in the public sector and non-governmental organizations.

CONCLUSION

In this article, the development, current situation and future of Industrial Engineering from its emergence in Türkiye to the present are evaluated. Today, Industrial Engineering is among the most preferred professions in Türkiye. In order to increase the sustainability of this situation, the areas open to improvement that need to be worked on are also shared in this study.

First of all, today's change and transformation process need to be read and analyzed well. In this framework, together with stakeholders from all parts of the society (student, parents, graduates, academia, business / industrial world / public / non-governmental organization representatives), Industrial Engineering's missions (missions) of contribution to the society, especially education and research, and to the needs of the age have been reviewed. It has become inevitable to develop and implement appropriate strategies and policies.

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Prof. Dr. Kürşat Şahin YILDIRIMER*, a Sociology graduate, completed theses on Family Effect on Spouse Selection, Bipolar Disorder, and Suicide in Clinical Psychology for his MA degrees. His Doctorate focused on Psychological Factors. As an Assoc. Prof. of Clinical Psychology at St. Clements University, he holds a Doctor of Letters (Social Psychology) and a Professorship in Psychology. With 80+ international articles and books like "Psychological Factors of Suicide," he earned a Professorial Diplomate from St. Clements University. Contact: kursatsahinyildirimer@gmail.com.

Prof. Dr. Derya YENTÜR*, Istanbul University graduate in Archaeology and History of Art, holds a master's in Archaeology, specializing in Prehistoric Figurine Interpretation. Her PhD from Northwest University focuses on International Migration and Brain Drain. Fluent in English, French, and German, she boasts certificates from various institutions, enhancing her linguistic prowess. With diverse educational backgrounds, including International Journalism, Media Law, Training of Trainers, Educational Technology, Social Psychology, Management, Leadership, and Natural Stones and Minerals, she pursued programs at renowned universities. As a certified trainer in various fields, she brings practical experience. Beyond her academic achievements, Assoc. Prof. Yentür is a documentary producer, copywriter, and columnist. She founded NGOs, served on scientific organizations' boards, authored 50+ international scientific articles, nine books, and edited over 30 publications. Connect with her at [deryayentur@gmail.com].

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