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The Uses of Industry 4.0 Technologies in Underground Mining Activities Evaluation In Terms Of Occupational Safety

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This study is derived from the doctoral thesis on "4.0 Applications in terms of Occupational Safety". Also, Developing Trends In Interdisciplinary Research And Practice At The 4th International New York Conference 2021 2-4 Presented as a Summary Paper at the New York City Symposium in Manhattan, 2021.

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I. INTRODUCTION

Mines provide a contribution that is being completed in terms of social, project and economic aspects of human beings.The use of steam power in the emergence and development of the first industrial revolution has increased the importance of mines. In this period, large factories were built and the transition to mechanical production was made. With the machines starting to replace the workforce, production was carried out in a fast, high quality, flexible and cheap way and there was an increase in productivity. On the other hand, explosions, mining accidents, steam boiler explosions have occurred as a result of poor working conditions and inadequate occupational health and safety conditions.In order to create a safer working environment, regular maintenance of the machines and equipment has started. In the second industrial revolution, electrical accidents, traffic accidents, explosions and factory accidents occurred with the use of electricity in industry. Machine guards and rollers have been developed to prevent these accidents. With the use of electronics in industry in the Third Industrial Revolution, accidents such as elevator accidents, major industrial accidents, and human-machine collisions were experienced. In order to prevent these accidents, automation systems (PLC) are included in the production processes. In Industry 4.0-Fourth and last Industrial Revolution, with the use of internet technologies (IT), past accident types, cyber attacks, robotic errors, unmanned machine accidents etc. Various accidents are expected due to various reasons (URL-1).

The Fourth Industrial Revolution, unlike the three industrial revolutions in the past, is expected to emerge in the near future with the integration of new technologies into the manufacturing industry and industry, the adaptation of employees to the new process, and unpredictable advanced technological risks.Industry 4.0, which reflects today's world, is about many connected technologies that are expected to affect the conditions of our age and the future in the near future. Although national level research on Industry 4.0 content has increased recently, this rate has not been at the expected level (Demiral, 2019:193-194). Mining is one of the most dangerous business lines. Compared to many other sectors, the use of new technologies in the mining industry can take serious time.The most important reason for this is that the risks brought by advanced technological applications have not been proven in terms of occupational safety. Today, it is known that Industry 4.0 and its components have started to be used in the mining sector (real-time tracking systems, artificial intelligence supported systems, wireless communication with remote access system, etc.). Employees' perspectives on new technologies are just as important as the integration of technology into the business. Developing the workforce of businesses that want to keep up with the harsh global competitive conditions will make businesses a strategic power in terms of accelerating the change process.

This study is a study to measure the perception levels of Industry 4.0 applications in terms of occupational safety of employees in an underground metal mining operation. The questions used in the study were prepared by taking the opinions and suggestions of experts. Considering the answers given by the participants and the literature research, a number of solution suggestions were presented for businesses on the way to Industry 4.0 as a result of the study. The study is expected to fill the existing gap in terms of its application both to the literature and to other sectors such as the mining industry.

INDUSTRY 4.0 AND ITS TECHNOLOGIES

The concept of industry means obtaining products using mechanical and automatic methods. The most

basic technological breakthroughs from the period of industrialization to the present are defined as industrial revolutions (Lasi vd., 2014). The concept of Industry 4.0 has been defined differently in different economies. For example, it has been defined as Industrial Internet (EI) in the USA, Industry 4.0 in Europe, and Society or Internet 5.0 in China. The purpose of using the name Industry 4.0 conceptually in this way is to be defined as an extension of the industrial revolutions experienced in the past (Banger, 2016). Industrial revolutions have a very important role in the development of countries.

This process, which connects England with the other industrial revolutions, attracted the attention of many countries and contributed to the industrialization of countries by investing in this direction (Bulut ve Akçacı, 2017:70)

The industrial revolutions from the past to the present and the change experienced in this process are briefly summarized below.

First Industrial Revolution: Mechanization-1780-1870s began with the introduction of mechanical production using water and steam power (Spath vd., 2013: Pollard, 1981).

The Second Industrial Revolution: Mass Production It began with the production of cheap steel, invented by English inventor Bessemer between 1870 and 1970. It has become widespread with the use of electricity and chemical techniques. It became more common with the use of electricity in factories and houses in 1882 (Spath vd., 2013: Pollard, 1981).

Third Industrial Revolution: Automation-1970-2010 The use of electricity is accepted as the beginning of this revolution. The developments in computer technology and the development of the internet have made this period known as the information revolution (Çeliktaş vd.,2015:1).

Fourth Industrial Revolution: Smart Factories-2011-This revolution, also known as Industry 4.0, is known as the use of technologies such as visualization, personalization and hybridization in industry with production based on cyber-physical systems (Brettel, Friederichsen, Keller & Rosenberg, 2014).

The combination of some components with the development of Industry 4.0 necessitated the emergence of new concepts and new technologies. Some of these technologies are briefly summarized below.

3D 3D Printers: This technology first appeared in 1984. But it did not receive the expected attention. With the Reprap project, which started in 2006, it started to attract attention and reached large masses (EBSO, 2015:10). Traditional production is made in the form of subtractive production. In other words, the raw material is cut and finally combined to be converted into the final product (Rifkin, 2015: 98-99).

IoT Internet of Things: This concept refers to technologies that transfer data of all kinds of living and non-living objects connected to the local network and the Internet (Köroğlu, 2015:1). Sensors, machines, cabling systems and computers form the components of the system. The internet of things is a technology that facilitates the instant tracking of many real-time data by integrating it into the production processes in the industry.

Smart Factories: Smart factories are a form of intelligent organism that integrates the physical world with the virtual world, and can perform data exchange and smart production. Compared to today's factories, it increases the use of resources, reduces product distribution, decreases storage, increases the production speed, while reducing waste (Wan ve Zhou, 2015:136).

Augmented Reality: Augmented reality refers to the animations in the digital environment that can bring the data obtained from technologies such as video, audio, GPS or graphics to levels that affect people's senses (URL-2).

Big Data: This concept is a phenomenon that provides an alternative to traditional solutions based on data analysis and database. This phenomenon is not just about storing or accessing big data.At the same time, it is aimed to make sense and interpret the data (Koseleva ve Ropaite, 2016, 545).

Cyber-Physical Systems (SFS): Cyber-physical systems, sensing and commanding the physical world with digital data are defined as SFS. (Zezulka vd., 2016). SFSs bring together the virtual-digital and real-physical worlds (Jirkovský vd., 2017). Industry 4.0 focuses on manufacturing and service innovation that includes SFS (Pal vd., 2009). SFSs are expected to provide an advantage in competitive conditions by increasing quality, efficiency and flexibility in the manufacturing sector, as in the cloud computing system. Industry 4.0 is not just about the communication of machines with each other. It can be said that it is comprehensive in a way that affects many scientific fields from information processing technology to genetics. The difference of Industry 4.0 from previous industrial revolutions is that the technological change is intertwined by affecting each other, acting in connection and developing by being affected collectively (Schwab, 2016: 17).

MINING ACTIVITIES AND OHS

Mining has been one of the main business lines that have shaped civilizations throughout history. In

today's world, it is difficult for human beings to survive without mining activities. Because almost everything we use in our daily life is obtained as a result of mining activities (Bilim vd., 2015). The mining industry is one of the important business lines that contribute to the economic development and employment of countries. However, due to its nature, it contains many risks and is in a very dangerous business line. It is often not possible to assess and prevent these risks and hazards. For a safe and sustainable work production, it is necessary to establish, implement, supervise and continuously improve the occupational health and safety system (Bilim vd., 2018). Occupational health is a state of complete well-being, not only physically, but also physically, mentally and socially.

In this respect, the concept of occupational health can be defined as a medical science that aims to eliminate the negative effects of the employees in the business ecosystem and to achieve harmony between the work and the worker (Yiğit, 2013:2). Occupational safety is the application that includes technical rules to eliminate possible risks and dangers for employees and the business. (Tozkoparan ve Taşoğlu, 2011:183). Occupational health and safety covers not only the employee and the business, but also all kinds of elements. In addition to improving working conditions, it includes many issues such as vocational training, social security, a qualified healthy life, employee rights, institution and institutionalization culture. (Taşdemir ve Öztürk, 2019:24). In this respect, occupational health and safety includes the studies to predict and evaluate risks and hazards and to completely eliminate these risks or reduce them to acceptable levels (Özkılıç, 2005:5).

When the historical development of occupational safety in Turkey is examined, it can be seen that the 1865 Dilaver Pasha Regulations, the 1869 Regulations of the Ministry, the 1876 Mecelle, the Law on the Law of Ereğli Havza-i Fahmiye Mining Workers, 1923 İzmir Economics Congress, the General Public Health Law No. 1593, dated 1930, and the Law No. The Labor Law No. 3008, the Labor Law No. 4857 in 2003 and the Occupational Health and Safety Law No. 6331 in 2012 were adopted. Occupational Health and Safety Law No. 6331 also covers mining workplaces. In order to support this law, the Regulation on Occupational Health and Safety in Mining Workplaces numbered 28770 was published on 19.09.2014. With this regulation, a safer working environment for mining activities is aimed.

Table 1: *Mining Occupational Accidents and Death Rates for the Years 1990-2020 (Mining Engineers Chamber, 2010-2020 Report)*

Place	**History**	**Type of Win**	**Number of Deceased**
Yeni Çeltek	1990	Firedamp	68
Kozlu	1992	Firedamp	263
Sorgun	1995	Firedamp	37
Aşkale	2003	Firedamp	8
Ermenek	2003	Firedamp	10
Bayat	2004	Firedamp	3
Küre	2004	Fire	19
Gediz	2005	Firedamp	18
Dursunbey	2006	Firedamp	17
M. Kemalpaşa	2009	Firedamp	19
Dursunbey	2010	Firedamp	17
Karadon	2010	Firedamp	30
Elbistan	2011	Slope Shift	11
Kozlu	2013	Methane Degauss	8
Soma	2014	January Fire	301
Ermenek	2014	Flooding	18
Şirvan	2016	Landslide	16
Şırnak	2017	Landslide	7
Milas	2019	Block Shift	3
Soma	2020	Dent	3

In Table 1, mining occupational accidents and death rates between 1990 and 2020 are given. Considering the causes of the accidents and the number of deaths, the most fatal accident is the Soma mining accident that occurred in 2014 and caused the death of 301 miners. When the occurrence of the accidents is examined, it is seen that they are caused by reasons such as firepit, slope slide, methane discharge, quarry fire, landslide, flood, block slide, dent.

II. LITERATURE

In the literature, studies have been carried out in many different areas in order to measure the perception levels of employees towards changes. For example; Safar et al. (2020) conducted a study to measure Industry 4.0-South India awareness. Torun and Cengiz (2018) applied the technology acceptance model to evaluate the Industry 4.0 perspective from the students' perspective. Yasım (2020) examined the change of Industry 4.0 in working life and the effect of this change in terms of social security. Mahlberg et al. (2021) investigated the impact of the Fourth Industrial Revolution on the development of future occupations in Australia. Golosinski (2001) investigated the impact of the change in information technologies and the widespread use of the internet, mining and other sectors. Özdağoğlu and Yılmaz (2020) conducted a study to measure Industry 4.0 awareness of some businesses in Manisa and İzmir. In the study, it was determined that Industry 4.0 was the most known term with 23.36%, while the internet of things was 17.52%, factory layout with 16.06%, and big data with 16.06%. Doğan and Baloğlu (2020) developed a scale to measure the Industry 4.0 awareness of university students. Kamber and Bolatan (2019) investigated the issue of Industry 4.0 Turkey awareness.202 participants employed in the manufacturing industry were included in the study, and the sectoral differences in the perspective of Industry 4.0 were determined and the opinions of the participants were taken according to their level of knowledge. Akkuşcu (2019) examined the effect of Industry 4.0 on working life in the example of Bursa.As a result of the study, it was determined that the awareness of Industry 4.0 is high in Bursa, but the use of new technologies is not at the expected level. Hamzeh et al. (2018) conducted an internet-based survey for companies located in the New Zealand region.In the study, some results were obtained by considering the feedback from medium and small-sized enterprises in the manufacturing industry.They proposed the ARPPAD implementation model for manufacturing companies to implement and guide Industry 4.0 at different levels. Kolberg and Zühlke (2015) investigated the positive and negative aspects of lean manufacturing systems in their study.In order to eliminate the negative aspects, they investigated the effects and benefits of the usability of the technologies within the scope of Industry 4.0 on the process. Schlechtendahl et al. (2015) investigated what kind of issues should be done in order for the production systems to be ready for Industry 4.0.The study mentioned that there should be an integrated structure (horizontal integration) in order to integrate Industry 4.0. Soyöz (2019) conducted a study on the awareness of Industry 4.0 in SMEs and universities. 351 different operating personnel participated in the study.351 different operating personnel participated in the study.According to the results of the study, the awareness of the enterprises was determined as 76.35%.However, the answers given to the questions about the existence of the application were quite low.The same study was applied to 184 academicians, and according to this analysis, it was determined that 25% of the participants had a study on Industry 4.0.

PURPOSE AND EXHİBİTİON OF THE RESEARCH

In the study, the effect of Industry 4.0 on occupational safety has been tried to be evaluated from the perspective of mine workers. Mining is a profession that includes many risk factors. Production method, structure of ore, presence of employees, technology used, environmental factors etc. situations are some of these risks. The industry is always distant to technologies whose risks have not been proven. The most important reason for this is that new technologies are not wanted to be included in possible risks. With Industry 4.0, many elements such as technological advances, globalization, demographic dynamics, mass privatization have become much more variable and complex in this process. As a reaction to the business environment, in order to keep up with the exponential technological change and make it sustainable, many micro and macro scale enterprises have had to develop this process with different strategies. (Ramsauer, 2013).Businesses that want to provide competitive conditions on a global scale, a good analysis of Industry 4.0 and its components will be of great importance for the future of businesses. Every business will soon need to conduct a baseline analysis, including aspects such as business infrastructure, employee competency, capital status, and technological infrastructure. The adoption of a new technology, business model or application by employees is of great importance for the future of the planned change. It is known that Industry 4.0 and its components have been integrated into the mining sector and started to be used in the field.The study was carried out in an underground mining operation, which is one of the sub-branches of mining. The effect of technologies within the scope of Industry 4.0 on occupational safety has been evaluated from the perspective of underground mining workers.

III. RESEARCH OF METHOD

This study is a study to measure the perception levels of underground mine workers towards Industry 4.0. A descriptive model with a screening model consisting of 29 questions was applied to the participants. Employees of an underground metal mine operating in Gümüşhane were determined as the research sample. The prepared questionnaire was applied to 167 employees through face-to-face interviews. However, since 7 participants answered the survey questions incorrectly, these answers were not included in the study. For this reason, the data obtained from 160 employees were taken into account within the scope of the research.

Frequency analysis of the obtained data was made using SPSS 21 program and descriptive statistics were reached. The research questions consist of demographic information, multiple choice (5) questions and open-ended (1) questions, taking into account the opinions and suggestions of experts in the field.

IV. Research Findings

The results of the survey conducted to determine the awareness of the employees towards Industry 4.0 in the company where the research was conducted are given in the tables. There are also findings such as demographic findings of the participants, their level of awareness towards Industry 4.0, work accidents and occupational diseases they have experienced throughout their professional life.

Table 2: *Employee Demographic Information*

Demographic Information of Participants					
Gender	**Number (n)**	**Percent**	**Marital status**	**Number (n)**	**Percent**
Male	160	100	married	106	66,3
Woman	0	0	single	54	33,7
Total	**160**	**100**	**Total**	**160**	**100**
Age	**Number (n)**	**Percent**	**Number of children**	**Number (n)**	**Percent**
16-18age between	1	0,6	no	60	37,5
19-23age between	5	3,1	1-3 between children	93	58,1
24-28age between	30	18,8	4 child and above	7	4,4
29-33age between	50	31,3	**Total**	**160**	**100**
34-38age between	34	21,3			
39-43age between	28	17,5			
44-48age between	10	6,2			
49 years and older	2	1,2			
Total	**160**	**100**			

According to Table 2, 31.3% of the participants are between the ages of 29-33, 21.3% are between the ages of 24-38, 18.8% are between the ages of 24-28, and 17.5% are 39. -43 years of age, 6.2% between the ages of 44-48, 3.1% between the ages of 19-23, 1.2% between the ages of 49 and over, and 0.6% between the ages of 16-18 found to be in the age range. 66.3% of the participants are married, 33.7% are single, 58.1% have 1-3 children, 37.5% have no children, 4.4% ü stated that they have 4 or more children.

Table 3: *Information on whether the spouses of the participants are working, their educational status and the duration of their profession*

Variable	**Number (n)**	**Percent (%)**
Employment Status of Spouses		
Yes	29	18,1
No	131	81,9
Total	**160**	**100**
Education Level of Employees		
Primary education	12	7,5
secondary education	82	51, 3
Associate Degree	21	13,1
Licence	41	25,6
Degree	4	2,5
Doctorate	0	0
Total	**160**	**100**
Time Spent by Employees		
1-5 year	73	45, 6
6-10 year	55	34,4
11-15 year	28	17,5
16-20 year	3	1,9

21 year and above	1	0,6
Total	**160**	**100**

In Table 3, the participants were asked whether their spouses were working, 81.9% of them stated that their spouses were working and 18.1% of them were not working. The participants answered the question about their educational background, 51.3% of them secondary school, 25.6% undergraduate, 13.1% associate degree, 7.5% primary school, 2.5% graduate stated. To the question about the time they spent in their profession, 45.6% answered between 1-5 years, 34.4% between 6-10 years, 17.5% between 11-15 years, 1.9% Between 16-20 years, 0.6% stated that they have worked for 21 years or more.

Table 4: *Information on the Positions of the Participants in the Workplace and Their Work in Different Occupational Fields*

Variable	**Number(n)**	**Percent (%)**
Positions of Employees		
İşçi	107	66,9
Employee	7	4,3
foreman	3	1,9
Engineer	26	16,2
Technical personnel	14	8,8
Job security specialist	2	1,3
Other	1	0,6
Total	**160**	**100**
Professional Experience		
Yes	68	42,5
No	92	57,5
Total	**160**	**100**

In Table 4, the participants answered the question about their position, 66.9% workers, 16.2% engineers, 8.8% technical staff, 4.3% sergeants, 1.3%. occupational safety experts stated that 0.6% of them work in other jobs. The participants were asked whether they had worked in different professions before, 57.5% of them stated that they were working and 42.5% of them were not working.

Table 5: *Information on What Kind of Risks the Employees Have Due to the Structure of the Job They Are Doing*

Variable	**Number (n)**	**Percent (%)**
Information About Risk		
Yes	146	91,3
No	5	3,1
No idea	9	5,6
Total	**160**	**100**

In Table 5, the participants were asked whether they had any information about what kind of risks are involved due to the nature of the work they are doing, 93.3% answered yes, 5.6% had no idea, and 3.1% answered no.

Table 6: *Information on Whether Employees Have Information on Work Accidents and Occupational Diseases*

Variable	**Number (n)**	**Percent (%)**
Work Accident and Occupational Disease Information		
Yes	134	83,8
No	26	16,2
Total	**160**	**100**

In Table 6, when the participants were asked whether they had information about work accidents and occupational diseases, 83.8% stated that they had knowledge and 16.3% had no knowledge. As a result of the findings, it was concluded that the majority of the participants had knowledge about work accidents and

occupational diseases. It is known that trainings are given periodically in the enterprise. However, as a result of the research, it is thought that the number of employees who do not have knowledge about work accidents and occupational diseases is undeniable.

Table 7: *Information on whether the Employees Have a Work Accident in their Existing Workplaces and Work Life*

Variable	Number (n)	Percent (%)
Work Accident in the Existing Business		
Yes	39	24,4
No	121	75,6
Total	**160**	**100**
Occupational Accident in Professional Life		
Yes	43	26, 9
No	117	73,1
Total	**160**	**100**

In Table 7, the participants were asked whether they had a work accident at their workplace, 73.1% stated that they had not had a work accident, and 24% stated that they had a work accident. When the participants were asked whether they had ever had a work accident in their work life, 73.1% stated that they had not had a work accident, and 26.9% stated that they had had a work accident.

Table 8: *Information on Whether Employees Have Occupational Diseases in Their Work Life*

Variable	Number (n)	Percent (%)
Occupational Disease at Work		
yes	9	5,6
no	151	94,4
Total	**160**	**100**

In Table 8, when the participants were asked whether they had an occupational disease in their working life, 94.4% stated that they did not have an occupational disease, and 5.6% stated that they had an occupational disease. As a result of the findings obtained, it was determined that the majority of the employees who participated in the study did not have any occupational disease in their business life. According to the Social Security Institution (SGK) data, the number of insured employees who received permanent incapacity income as a result of occupational disease was 88 in 2015, 163 in 2015 and 197 in 2016. (Makine Mühendisler Odası, 2018). It is known that the rate of occupational diseases worldwide is between 4 and 12 per thousand. In 2013, the ILO stated that occupational diseases are the most common hidden epidemic in the world. Every year, thousands of workers around the world suffer from occupational diseases. The fact that the rate of occupational diseases in Turkey is well below expectations brings to mind whether notification and regular records of occupational diseases are kept. (Keçeci, 2019).

Table 9:*Information on Whether Employees Witnessed a Near-Miss Incident in the Workplace*

Variable	Number (n)	Percent (%)
Information on the Near Miss Incident		
Yes	94	58,8
No	66	41,2
Total	**160**	**100**

In Table 9, the events that occur in the working environment but do not harm the employee, the enterprise or the environment are called near misses. The participants were asked whether they had ever witnessed a near miss incident in their workplace, 58.8% of them stated that they were witnesses and 41.3% of them stated that they were not.

Table 10: *Information on the Most Important Issue(s) Causing the Occurrence of Work Accident*

Variable	**Number (n:160)**	**Percent (%)**
Causes of Work Accident		
High self-confidence of employees	103	35,3
Lack of on-the-job training of employees	48	16,4
Inadequate employees and not being selected for the job	67	22,9
Employees are not aware of the dangers of their work.	56	19,2
Failure to provide the necessary personal protective equipment of employees	18	6,2

In Table 10, the participants were asked what could be the causes of the occupational accident (multiple choice), and 35.3% stated that it was due to the high self-confidence of the employees. According to the research conducted by A.Ş., it has been determined that employees with unnecessary self-confidence do not show enough attention and care in their work, and it is predicted that this may cause work accidents. 22.9% of the participants stated that the employees were insufficient and were not selected for the job, 19.2% of them were not aware of the dangers of their jobs, 16.4% were not given on-the-job training to the employees, 6.2% were the employees with the necessary personal protective equipment. stated that it was due to the lack of equipment.

Table 11: *Information on Knowledge Levels of Employees on Information Technologies*

Variable	**Number (n)**	**Percent (%)**
Knowledge Levels of Employees		
Very low	16	10
low	16	10
Middle	69	43,1
Good	41	25,6
Very good	18	11,3
Total	**160**	**100**

In Table 11, employees were asked about their level of knowledge about information technologies, 43.1% moderate, 25.6% good, 11.3% very good, 10% low, 10% very low. indicated level. As a result of the findings, it was concluded that nearly half of the participants had a medium level of knowledge about information technologies.Banger (2016) determined that the biggest obstacle in front of Industry 4.0 and the technological applications it will bring will be the lack of qualified workforce in fields such as informatics and communication. According to another research (IAB, 2016), it is stated that the creation of a business model based on digitalization (creation of high-quality jobs) can be achieved by meeting the needs of employers and competent personnel.

Table 12: *Knowledgeable about Integration of Automation Systems in Employees' WorkplacesInformation on whether or not they are*

Variable	**Number (n)**	**Percent (%)**
Information About Integration		
Yes	116	72,5
No	44	27,5
Total	**160**	**100**

In Table 12, to the question of whether they have information about automation equipment in the workplace and their integration with each other, 72.5% stated that they had knowledge and 27.5% had no knowledge. In the light of the data obtained, it has been determined that the majority of the employees participating in the research have knowledge about automation equipment and their integration with each other.

Table 13: *Information on Whether Industry 4.0 Awareness Trainings Are Given to Employees in Existing Workplaces*

Variable	Number (n)	Percent (%)
Whether they received education or not		
Yes	55	34,4
No	105	65,6
Total	**160**	**100**

In Table 13, employees were asked whether awareness training was given within the scope of Industry 4.0 in the workplace, 65.6% stated that no training was given, and 34.4% stated that awareness training was given. As can be seen from the findings, it was determined that more than half of the participants did not receive awareness training about Industry 4.0.

Table 14: *Information on Whether Employees Have Knowledge About Industry 4.0*

Variable	Number (n)	Percent (%)
Whether They Have Information		
Yes	75	46,9
No	85	53,1
Total	**160**	**100**

Industry 4.0 is the digitalization of production by integrating information and communication technologies into all areas of the industry. The participants were asked whether they had any information about Industry 4.0, 53.1% of them stated that they did not know, and 46.9% of them stated that they had knowledge.

Table 15: *Information on the Most Important Problems to Experience in Industry 4.0 or Transition to Autonomous Systems*

Variable	Number (n:160)	Percent (%)
Top Issues		
Insufficient current management	49	14, 9
Preference for traditional production methods	74	22,6
High initial investment costs	34	10,4
High investment costs	83	25,3
Difficulties in finding specialist personnel	60	18,3
Lack of support from business management	28	8,5

In Table 15, the participants were asked what the most important problems that may be experienced in Industry 4.0 or the transition to autonomous systems (multiple choice) were asked, 25.3% of the participants preferred high investment costs, 22.6% preferred traditional production methods, 18% 0.3% stated that it would be difficult to find expert personnel, 14.9% stated that the current management did not have sufficient vision, 10.4% stated that the initial investment costs were high, and 8.5% stated that the workplace management would not provide support.

According to a study conducted by Yüksel (2019), businesses need to make significant investments in the long term for Industry 4.0 technologies. As a result of the researches made on Industry 4.0 in Turkey and around the world, it is expected that the most important difficulty expected to be experienced in this process will be financial and economic. For this reason, it is recommended that every business conduct a current situation analysis study before investing. As positive returns are received from the investments made, it is predicted that the enterprises will be more willing for the investments they plan to make in the future.

Table 16: *Information Regarding Whether Employees Have Knowledge About the Business Plan Prepared within the Scope of Industry 4.0 at Workplaces*

Variable	Number (n)	Percent (%)
Whether there is a Business Plan		
Yes	65	40,7
No	66	41,3

It is planned to be implemented in the short term	29	18
Total	**160**	**100**

In Table 16, when asked about whether there is a business plan prepared within the scope of Industry 4.0 in the workplace, 41.3% stated that they did not know, 40.6% had knowledge, and 18% stated that it is planned to be implemented in the short term.

Table 17: *Information on Whether There Are Technical Personnel With The Competence To Use Industry 4.0 Up-to-Date Technological Equipment in the Workplace*

Variable	**Number (n)**	**Percent (%)**
Competent Staff		
Yes	69	43,2
No	50	31,2
Partially exists	41	25,6
Total	**160**	**100**

In Table 17, employees were asked whether there are technical personnel who have the competence to use Industry 4.0 up-to-date technological equipment in the workplace, 43.2% stated that they did, 31.2% did not, and 25.6% stated that they were partially present. According to a study conducted by BDC in Canada in 2017, the most common challenge in Industry 4.0 implementations is the lack of qualified employees with a rate of 42%. (BDC, 2017). For this reason, it is foreseen that the most important issue is meeting the needs of the labor market in the short and long term, increasing the existing workforce competencies and developing a new qualified workforce profile. (Doğru ve Meçik, 2018).

Table 18: *Information on the Advantages of Industry 4.0 Applications*

Variable	**Number (n:160)**	**Percent (%)**
Advantages of Industry 4.0		
Increases production speed	92	25,5
Increases production quality	74	20,5
Provides Occupational Health and Safety	110	30,5
Provides economic gain	61	16,9
There is an increase in employment	24	6,6

In Table 18, the participants were asked what the advantages of Industry 4.0 applications could be (multiple choice), 30.5% provide occupational health and safety, 25.5% increase production speed, 20.5% increase in production quality. 16.9% of them provide economic gain, 6.6% of them stated that there will be an increase in employment. According to a study by Kagerman et al., (2013), machines and integrated systems compatible with workplaces are expected to minimize employee roles, ways of doing business and employee safety concerns.In today's world where Industry 4.0 has become inevitable, the fact that Industry 4.0 accelerates mass production, minimizes production costs, and creates serious developments especially in ensuring worker health and safety is one of the most important and positive developments of this process. (Dikkaya vd., 2018). For example, the organization of advanced automation processes (Doğru and Meçik,2018) such as autonomous organization, dynamic routing, comprehensive connections and big data will be carried out under the supervision of these people.

Table 19: *Information on the Disadvantages of Industry 4.0 Applications*

Variable	**Number (n)**	**Percent (%)**
Disadvantages of Industry 4.0		
Unemployment rises	97	32,4
There is an increase in energy consumption	86	28,8
Increase in occupational accidents and occupational diseases	43	14,4

There is an increase in the demand for consumable energy sources.	73	24,4

In Table 19, the participants were asked whether Industry 4.0 applications had disadvantages (multiple choice), and 32.4% stated that there would be an increase in unemployment. Erdinç (1999) stated in her study that the automation brought by high technology and its use in the industry are factors in the increase in unemployment. While 28.8% of the participants stated that there will be an increase in energy consumption, 24.4% stated that there will be an increase in the demand for exhaustible energy resources. Toker 2018) thinks that with 4.0, fossils buy less in production processes, instead it will become more important about future-energy and the idea about short thinking.14.4% of the participants answered that there is an increase in occupational accidents and occupational diseases.

Some participants stated that these applications (fans, autonomous doors, gas monitoring system, etc.) frequently cause system failures and therefore they had to intervene manually.

Table 20: *Information on Whether Industry 4.0 or Current Technological Applications Create Risk in terms of Occupational Health and Safety in Production Processes*

Variable	**Number (n)**	**Percent (%)**
Whether Industry 4.0 Contains Risks		
Yes	23	14,4
No	96	60
Partially	41	25,6
Total	**160**	**100**

In Table 20, the participants were asked whether Industry 4.0 or current technological applications pose a risk in terms of occupational health and safety in their production processes, 60% stated that they do not pose a risk, 25.6% poses a partial risk, and 14.4% poses a risk.

Table 21:*Information on the Sources of Occupational Health and Safety Problems That May Be Experienced in Industry 4.0 and Transition to Automation System*

Variable	**Number (n)**	**Percent (%)**
Sources of Problems		
Lack of training of employees	93	23,4
Employee inexperience	100	25,2
Complexity of equipment used	67	16,9
Lack of warning sensors	41	10.3
Failures in maintenance and repair	69	17,4
Top management indifference	27	6,8
Total	**160**	**100**

In Table 21, the participants were asked what the sources of occupational health and safety problems might be in the transition to Industry 4.0 and automation (multiple choice). 'maintenance and repair malfunctions, 16.9% said that the equipment used was complex, 10.3% stated that the warning sensors were insufficient, 6.8% stated that the top management was indifferent.

Some participants stated that the applications frequently malfunction, which puts employee health and safety at risk during the production process. According to a study, the current industrial transformation changes work environments and job profiles, necessitating a more experienced and innovative workforce. (Prifti vd., 2017; Liere-Netheler vd., 2017). In cases where technological workforce competence is insufficient, some helpful applications can be implemented.For example, with the use of IoT-based wearable technologies equipped with sensors that transmit information about the physical conditions of people working in very dangerous conditions such as mines to the necessary units, and in addition to this, integrating them into smart mobile devices. (Dijital Dönüşüm ve Madencilik, 2019) workplaces can make safer for employees. According to a worldwide study conducted by Stanton Chase in 2017, it has been determined that with Industry 4.0, business managers avoid taking risks even though they are aware of the importance of the new process. The most important reason for this situation is that the benefit of the investments cannot be predicted clearly and the earnings cannot be put forward as a numerical value. (Stanton Chase, 2017; Banger, 2016).

Table 22: *Information on the Hazard Dimension of the Equipment Included in the Production Process within the Scope of Industry 4.0*

Variable	Number (n)	Percent (%)
Hazard Dimensions of Equipment		
security	84	52,4
Very security	35	21,9
hazard	8	5
Very hazard	2	1,3
No idea	31	19,4
Total	**160**	**100**

In Table 22, 52.5% of the participants were safe, 21.9% answered the question about the danger dimension of the equipment (automatic doors, control of fans, remote-controlled systems, etc.) included in the production process within the scope of Industry 4.0 in terms of employees, businesses and the environment. ' very safe, 19.4%' I have no idea, 5% dangerous, 1.3% stated that it is very dangerous.

Table 23: *Information on Occupational Safety in the Production Process of Industry 4.0*

Variable	Number (n)	Percent (%)
Reliability in the Production Process		
No effect on security	8	5
Increases your security	115	71,9
No idea	37	23,1
Total	160	**100**

In Table 23, the participants were asked about the effect of Industry 4.0 on occupational safety in the production process, 71.9% stated that it increased occupational safety, 23.1% did not express any opinion, and 5% stated that it had no effect on occupational safety.

V. DISCUSSION AND CONCLUSION

With the implementation of Industry 4.0 in the industrial industry, the contribution of this process to production, employer, employee and capital is still a matter of debate. Among the reasons for this uncertainty, there are issues such as the fear of being unemployed, the high initial investment costs, the shortage of competent employees, and the lack of infrastructure. The general perception is that unmanned production will become more dominant in this process and the demand for labor will decrease. Industry 4.0 is focused on the process of executing all kinds of elements by artificial intelligence supported algorithms, thanks to the internet of things and connectivity. It is a fact that the need for labor will decrease at some point. However, in an enterprise where all kinds of elements are interconnected, there is a continuous data flow; It is also obvious that many new professions such as data analyst, cloud account specialist, cyber security specialist, information networks specialist, analyst will be needed soon.This will open the door to new employment in business life. Actors in businesses can turn this process into an advantage by implementing encouraging practices in the industry 4.0 transformation process of employees. Employees' competence and motivation can be increased by providing internal and external trainings on issues such as maintenance, repair, debugging, interpretation and data analysis. This will also contribute to the adoption of technology by the employees and the sustainability of production and occupational safety. For example, people working in very dangerous conditions such as mines can make workplaces safer for employees by using IoT-based wearable technologies equipped with sensors that transmit information about their physical conditions to the necessary units, and in addition, by integrating them into smart mobile devices. Wearable smart technologies, augmented reality and virtualization can make the work easier and safer to use with the support of advanced technological applications. In this way, they can contribute to increasing work efficiency, reducing worker costs, and reducing many negative effects caused by work accidents and occupational diseases in the face of harsh global competition conditions.

In the literature, there are many studies on Industry 4.0 and its components. However, studies on Industry 4.0 and the perspective of employees on these technologies are still insufficient. It is recommended for future researchers to do this in other very dangerous business lines and by reaching a larger sample size.

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