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A Study on Industry 4.0 Awareness of Universities in Turkey

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Abstract

Industry 4.0, which emerged in Germany in 2011, attracted the attention of countries. Since 2011, companies and researchers in various countries have conducted researches to understand the advantages, disadvantages, contributions to their countries, and transition stages of Industry 4.0. In this study, the awareness of Industry 4.0 in the academic world was investigated. An online survey was prepared within the scope of the research. Questions were sent to the academicians working in the departments of engineering faculties and business administration of universities via an online survey platform. Although the awareness of the academicians in the departments where the study was applied is high, their studies in the field of Industry 4.0 are very few.

Keywords: industry 4.0, awareness, survey analysis, a case study, component of industry 4.0.

1. Introduction

Countries have changed for various reasons since ancient times. Some of the changes affected all the world. People migrated from one place to another. As a result of this spread, revolutions have taken place. One of these revolutions was Industry 4.0, which emerged in 2011. German authorities put forward 10 projects which they think will improve the German firm and contribute to the national economy [1]. Industry 4.0 technologies are included in these projects [2].

This term which first appeared at Hannover Fair attracted the attention of the countries. In other countries, such as Germany, did research on this issue. As a result of the researches, the benefits of Industry 4.0 to the enterprises were discussed. In light of these studies, the benefits of industry 4.0 were given below:

- To minimize production costs.
- Optimizing area usage.
- To minimize energy usage.
- Ensure high-speed production.
- Ensure safe production.
- To minimize production errors caused by personnel.
- Using machine power instead of manpower.
- Production follow-up and analysis.
- Receive instant error notifications.
- Maximizing machine utilization rates.
- To use the capacity of enterprises in the most efficient way.

These benefits have caused researchers to turn to Industry 4.0. The researchers' studies on Industry 4.0 are as follows:

Firat and Umit Firat [3] explained Industry 4.0 and its subheadings in detail in their studies. In Industry 4.0, they talked about robotic systems to provide automation. They also presented the robotic systems

and their analysis to the literature. In their study, Kolberg and Zühlke [4] mentioned the advantages and disadvantages of the concept of lean production, which is one of the important issues of the 3rd industrial revolution, and proposed what framework can be done in the case of combining lean production with industry 4.0 to prevent the disadvantages.

There are quite a several theoretical articles in the literature, especially related to big data and its analytics, which is the subheading of Industry 4.0. For example, Hazen et al. [5] provided theoretical data for the big data and sustainable supply chain and studied how this information will be shaped in the future. Rozados and Tjahjono [6] also mentioned the use of big data and analysis in supply chain management. They divided the supply chain into 4 levels: marketing, procurement, storage, transportation, and presented the major problems at these levels and solutions and techniques for the concept of big data and analytics.

Leveling et al. [7] gave general information about big data analysis in supply chain management and mentioned the developing technologies within this scope. Tuncel et al. [8] demonstrated the necessity of Industry 4.0 applications to increase capacity utilization rates and productivity in the furniture sector in our country. They pointed out the benefits of the implementation of Industry 4.0 in the furniture sector. Bhargava and Ranchal [9] talked about the possible problems that may occur in the digital supply chain regarding cyber security, which is one of the most important issues in ensuring the continuity of Industry 4.0, and made recommendations to the literature on how to ensure security.

Issa et al. [10] contributed to the literature by conducting an application-oriented study. In Industry 4.0, they created a roadmap for digital transformation. In this study, a formula is presented to determine the level of Industry 4.0, and results are evaluated for the enterprises. In their study, Kocak and Diyadin [11] determined criteria for the transition to Industry 4.0 and found the relationship levels between these criteria, and in this study, it was revealed that the most important factor in the transition to Industry 4.0 is big data management.

In the research articles, it is frequently mentioned that the contribution of Industry 4.0 to supply chains will be high, and especially the concept of the digital supply chain has been mentioned a lot in the literature. For example, Buyukozkan and Gocer [12] gave extensive information on digital supply chains in a study and they made a great contribution by presenting their contents to the literature by classifying the published articles about the digital supply chain in many aspects by searching the literature.

In a different study, the same researchers identified 6 criteria for a company's supplier selection about the digital supply chain and evaluated 5 suppliers with an extension between multiple criteria decision-making methods [13]. At the same time, they included information about the digital supply chain in a different study and made a selection of suppliers using a Moora extension method [14]. Tsai and Lu [15] provided a framework for planning and controlling carbon tax production through Industry 4.0 related technologies. In this context, a mathematical programming model was created. The parameters of the mathematical programming model were periodically updated from the large data set.

In recent years, researchers from different countries have been conducting surveys to see the application areas of Industry 4.0 in the world or their countries to determine the application rate and present the results to the literature.

In this context, Schumacher et al. [16] developed a maturity model for Industry 4.0 and identified 9 main headings in this model. A total of 62 questions belonging to these 9 main headings were presented to the facilities producing plants and the results were evaluated. In Oztemel and Gursel's [17] studies, a questionnaire was prepared to investigate the effects of Industry 4.0 on logistics management and 90 questionnaires were evaluated through SPSS.

Hamzeh et al. [18] have designed and installed a web-based research system in New Zealand. They randomly selected among the companies included in this system and asked questions on Industry 4.0 awareness and evaluated the responses statistically. Dalenogare et al. [19] investigated the effects of industry 4.0 on the performance of companies. In this context a large-scale survey of 27 industrial sectors representing 2225 companies of the Brazilian industry. At the end of the study, the positive and negative effects of Industry 4.0 technologies are given.

Mittal et al. [20] conducted a study on industry 4.0 maturity levels of small and medium-sized companies. They determined 17 criteria to measure maturity levels and they clustered these 17 criteria under 9 classes. At the end of the study, it was determined that the maturity level of the SMEs was low but could be improved. Frank et al. [21] examined industry 4.0 technologies in the manufacturing sector. In this context, 92 companies were examined. Big Data, analytics, and the implementation of flexibilization are the main challenges for companies.

Dutta et al. [22] emphasized that the use of industry 4.0 technologies will make a great contribution to the country's economy. In this context, they conducted a study to measure the industry 4.0 maturity level of small and medium-sized companies in the manufacturing sector. Ozyoruk and Soyoz [23] conducted a study to determine the awareness of the concept of industry 4.0 for students. Industrial engineering students were preferred in the study. At the end of the study, it was determined that the awareness of the students was low in general. However, it was determined that 3rd and 4th-grade students had better knowledge than 1st and 2nd-grade students. In this context, it was emphasized that this information should be transferred to the students by ensuring the cooperation of industry and university. A brief list of literature research is given in Table 1.

Table 1: Literature Survey of Industry 4.0

Author(s)	**Year**	**Country**	**Subject**	**Method**
Bhargava et al.	2013	USA	Syber Security	Review
Rozados and Tjahjono	2014	UK	Big data and analysis	Review
Leveling et al.	2014	Germany	Big data and analysis	Review
Kolberg and Zühlke	2015	Germany	Industry 4.0	Review
Schumacher et al.	2016	Austria	Industry 4.0	Survey Analysis
Hazen et al.	2016	USA	Big data and analysis	Review
Firat and Umit Firat	2017	Turkey	Robotic Systems	Review
Buyukozkan and Gocer	2017(a)	Turkey	Digital Supply Chain	MCDM
Buyukozkan and Gocer	2017(b)	Turkey	Digital Supply Chain	MCDM
Issa et al.	2018	Germany	Industry 4.0	Study Case
Tuncel et al.	2018	Turkey	Industry 4.0	Review
Kocak and Diyadin	2018	Turkey	Industry 4.0	Review
Hamzeh et al.	2018	New Zeland	Industry 4.0	Survey Analysis
Buyukozkan and Gocer	2018	Turkey	Industry 4.0	Review
Tsai and Lu	2018	Taiwan	Industry 4.0	Study Case
Oztemel and Gursel	2018	Turkey	Industry 4.0	Survey Analysis
Dalenogare et al.	2018	Brazil	Industry 4.0	Survey Analysis
Mittal et al.	2018	USA	Smart Manufacturing	Survey Analysis
Frank et al.	2019	Brazil	Industry 4.0	Cluster analysis
Ozyoruk and Soyoz	2019	Turkey	Industry 4.0	Survey Analysis
Dutta et al.	2020	India	Industry 4.0	Survey Analysis

Survey analysis on industry 4.0 was generally conducted for companies in the manufacturing sector. However, the education of people who will work in this field is an important factor for the implementation of industry 4.0 technologies. Curriculum and trainer knowledge is important for schools where people receive an education. For this reason, the industry 4.0 awareness of the academicians in the departments of engineering faculty and business administration was evaluated in this study.

2. Industry 4.0

Industry 4.0 is defined as automation systems that are continuously integrated, on the one hand, production systems that respond to constantly changing customer demands [24]. Knowing the sub-components of this concept is important for understanding industry 4.0. Sub-components of industry 4.0 are as follows:

- Internet of things

- Cloud computing
- Horizontal-vertical integration
- Augmented reality
- Cyber-physical systems
- Big data and analysis
- Autonomous robots
- Additive production
- Cyber security

2.1 Internet of things

The internet of things is defined as the machines used in the business are communicating with other machines via the internet. In this way, companies can monitor their machines in production sites remotely and have the opportunity to measure their performance. The Internet of Things has recently been introduced not only in production sites but also in various fields such as energy systems, home automation, logistics, health, and agriculture.

2.2 Cloud Computing

The production of large volumes of data raises the problem of where and how the data is stored. In the past, devices with high storage capacity were required to store large volumes of data. However, increased storage capacity means extra costs for businesses and individuals. Nowadays, regardless of device capacity, the data storage system is established over the internet thanks to Cloud Information technology. Storing data on the Internet allows operators and individuals to access their information whenever and wherever they want, regardless of the device they use.

2.3 Horizontal-Vertical Integration

One of the most important elements of Industry 4.0 is the continuous data flow and continuous communication between the units. For this reason, investments in horizontal and vertical integration are important. Horizontal integration, suppliers, customers, distributors, other enterprises, and so on in the supply chain network. It is a kind of integration that provides uninterrupted flow between.

Vertical integration includes sensors, actuators, etc., which are used in the enterprise. It is a kind of integration that works on providing uninterrupted communication and flow in the infrastructure of technologies. Based on all these definitions, horizontal integration is based on the ability to see instantaneous data inside and outside the enterprise while vertical integration is based on preparing the infrastructure of the technologies used in communication with each other and integration between them.

2.4 Augmented Reality

Augmented reality, is defined as the living and indirect physical appearance enriched with. Nowadays, this concept is used in the education sector especially. At the same time, more pleasant environments are created for the players through devices by using augmented reality in computer games.

2.5 Cyber-physical Systems

Cyber-physical systems are intelligent systems in which constantly changing data is connected simultaneously in a virtual cloud system [24]. Cyber-physical systems consist of two important elements. As the name implies, one is the physical environment and the other is the virtual environment. Virtual environment consists of simulating the simulation model of the objects in the physical environment. Cyber-physical systems are one of the main components of Industry 4.0 and it would be

very beneficial to implement them in enterprises. With these systems, both efficiency and quality of the products will be improved due to the reduction of errors. At the same time, detection of errors will be accelerated and easier. Because cyber-physical systems are run over computers, it is an important requirement for firms to develop themselves in terms of computers and software.

2.6 Big Data and Analytics

As the name implies, the concept of big data refers to the collection and storage of large volumes of data. However, although the formation of big data seems beneficial for enterprises, it is important to decompose and make it available. At different times, the presence of data generated by different units will be very cumbersome for those who use them, and this sometimes leads to the conversion of data into incorrect information. For this reason, big data and analytics are interested in collecting, storing, and analyzing high volumes of data and decomposing them into meaningful data.

2.7 Autonomous Robots

One of the biggest developments in Industry 4.0 for automation is autonomous robots. For years, ideas have been put forward that robots will be used in production, but their applications have come up with Industry 4.0. The use of autonomous robots in production and service systems will both reduce labor use and help reduce human errors. According to the researches, autonomous robots are mostly used in the automotive and supply industry. In the future, it is predicted that autonomous robots will be employed more in the mentioned areas and may even update their software. Nowadays, enterprises apply to robots especially in jobs that require unqualified labor and require much effort. Enterprises that want to create a competitive advantage plan to invest in robots by evaluating their investment power.

2.8 Additive Manufacturing

Additive manufacturing is defined as providing the final products to be produced in a very short time by accumulating layers with the help of some techniques. Today, due to the developing technology, the possibilities in production systems have increased and the cycle times of the produced products have been affected by this situation and decreased considerably compared to the past. All of these have increased customer demands considerably and have now started to announce the name of customized production all over the world. At this stage, the additive production technology brought by Industry 4.0 will provide advantages to the enterprises. In addition to this, prototype testing can be carried out with this technology and this will allow the opportunity to reduce the design costs which are high in terms of cost in the production of new products.

2.9 Cyber Security

Cyber security is an important factor to ensure the continuity of Industry 4.0. If precautions are not taken, risks such as viruses, etc. will be dangerous. All this disrupts the integrity of data and flow and even leads to the destruction of the production system. While this is a driving force of Industry 4.0, investment decisions and practices to be made for the security measures to be made by the conscious enterprises in these areas will ensure the continuation of the operation.

3. A Study on Industry 4.0 Awareness of Academicians

In this section, a test has been prepared to determine the awareness of academicians about Industry 4.0. In this context, a link was created for the survey questions prepared on the website www.onlineanketler.com and a study was prepared to be answered only by the academicians. The study was held in the system for two months and the identity of the participants was not shared by the site because personal information was not shared with third parties. At the same time, to prevent the participants from participating in the survey more than once, the credentials of the browsers they logged on were locked and allowed to participate only once. Questionnaires are given in Annex 1.

3.1 Population and Sample of Research

This section is located within the universe of the engineering faculty research universities in Turkey and includes academics working in the business section. The departments are detailed below. (The number of participants is 184.) (Figure 1)

- Computer Engineering (32)
- Electric and Electronic Engineering (30)
- Industrial Engineering (49)
- Business Administration (37)
- Machine Engineering (25)
- Mechatronics Engineering (11)

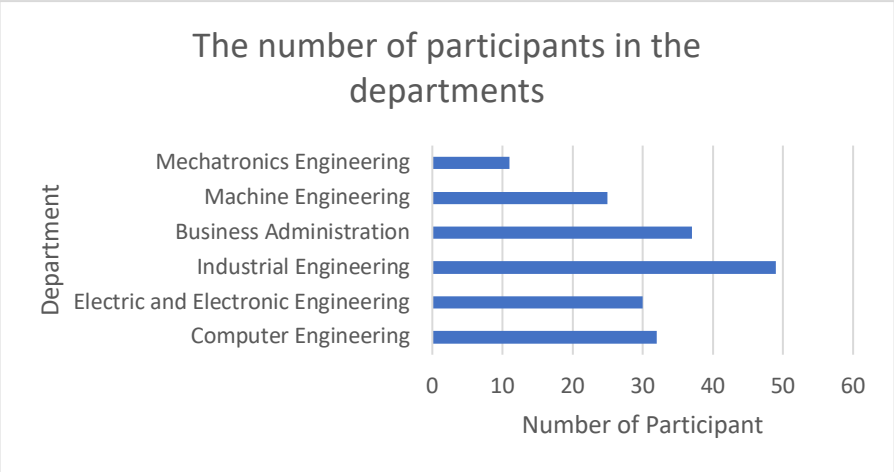

Figure 1: The Number of Participants in the Departments

3.2 Formation of Survey Questions

While examining survey questions, first of all, in the literature search related to Industry 4.0, Industry 4.0 technologies were dealt with and test questions where one of these technologies was identified as the correct answer was created.

Questions directed to academics are theoretical questions for Industry 4.0. In a part of the study, demographic questions were asked to the participants. After the questions were prepared, they were examined by different people. After the examinations, it was determined that some of the questions were very detailed and long, so that the response time would be low and the questions were redesigned to be short as the fact that the survey questions were so long would increase the time spent by the participants.

3.3 Determination of Sample Size

In this study, 25 universities have been selected, which generally include all of the aforementioned departments. Since the Department of Mechatronics is a newer department than the other departments, the universities which include the mentioned department have been considered as the priority in the university selection. Cekici [25] proposed Equation 1 for calculating the sample size for cases where the population size is specific.

$$n = (N.p.q.Z^2/[(N-1).d^2 + p.q.Z^2] \quad (1)$$

N= Population size

n= Sample size

Z= A value for normal distribution double-sided test

p= Probability of occurrence

q= Probability of an invisible event

d= Tolerance

The size of the population is estimated to be approximately 3850. In this case, the sample size was determined as 93 with 90% confidence. In this calculation, p and q values were taken as 0.5 to maximize the sample size.

3.4 Data Input

After the survey questions were created, the department was sent to the departments formed by the target audience via the e-mail addresses defined on the official website of the academicians working in the relevant departments of the selected universities via www.onlineanketler.com. The participants then answered the questions and completed the questionnaire.

3.5 Evaluation of Answers to Survey Questions

In this section, the distribution of information about the questionnaire questions used in this thesis and the answers given by the participants to the questions will be given. For this reason, the questions were evaluated individually. A total of fourteen questions were asked to the participants. Six of the questions are related to the participant himself/herself, and eight are intended to measure Industry 4.0 technologies. At the same time, one of the questions is a question where more than one option can be selected. All of the questions are given in Annex 1.

The first question is to measure the gender of the participants. 122 of the participants are male and 62 are female (Figure 2).

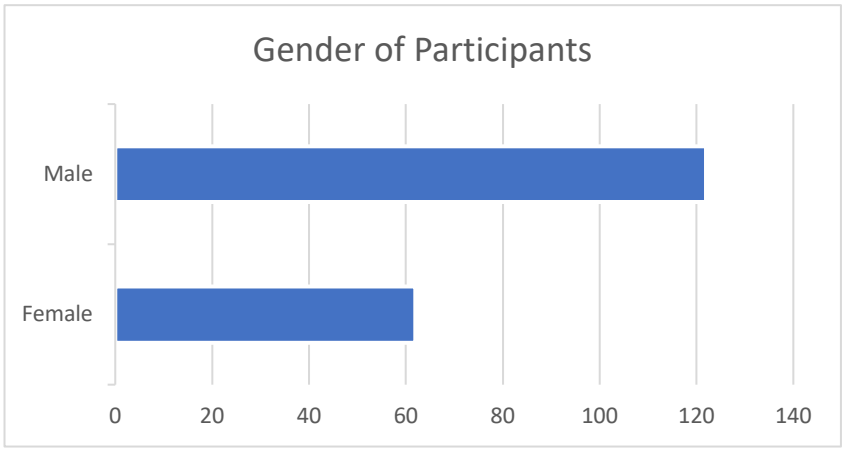

Figure 2: Gender of Participants

The second question concerns the participants' titles. Of the participants 32 are professors, 22 are associate professors, 30 are assistant professors, 8 are lecturers and 92 are research assistants (Figure 3).

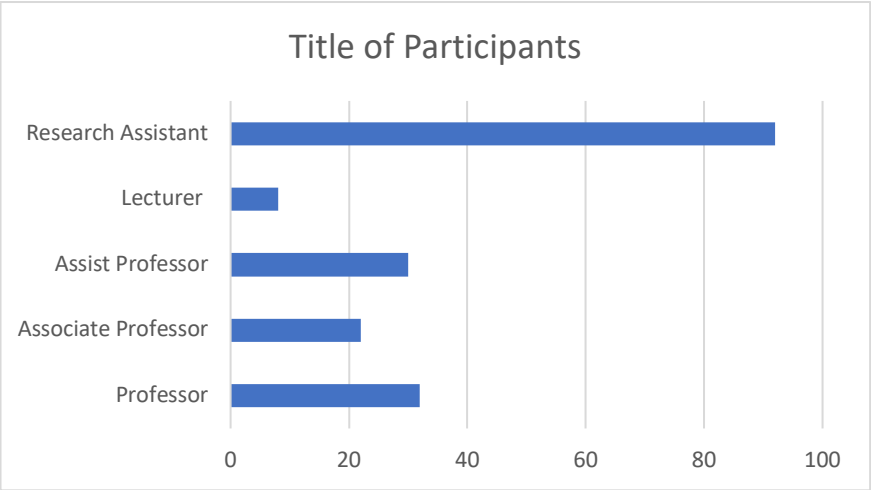

Figure 3: Title of Participants

The third question is about the department where the participants worked. 49 of the participants are working in industrial engineering, 37 in business, 32 in computer engineering, 30 in electrical-electronics engineering, 25 in mechanical engineering, and 11 in mechatronics engineering (Figure 4).

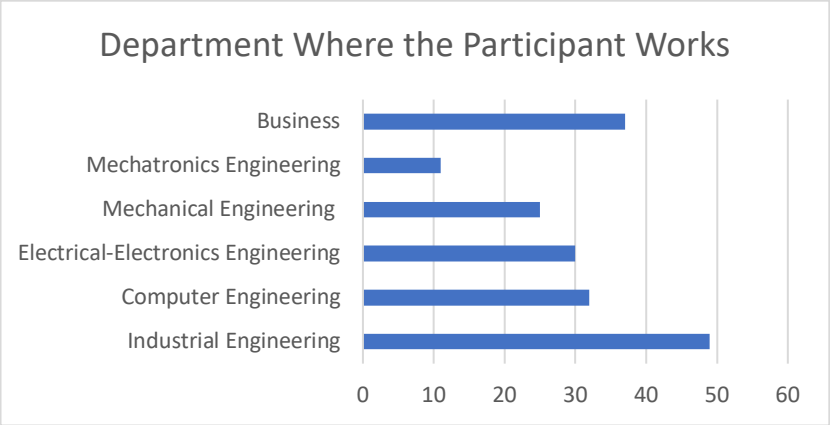

Figure 4: Department where the participant Works

The fourth question asks whether the participants know Industry 4.0. All participants answered yes to this question.

The fifth question concerns participants' knowledge of the Internet of things from Industry 4.0 technologies, cloud computing, augmented reality, horizontal integration, vertical integration, big data and analytics, autonomous robots, additive manufacturing, cyber security, cyber-physical systems (Figure 5). 42 of the participants are six, 30 are seven, 27 are ten, 21 are eight, 19 are five, 19 are four, 8 are three, 6 are nine, 6 are two, and 5 are one of which indicated that they have information about Industry 4.0 technology. When the responses of the participants are evaluated, the most known technology is cloud computing, followed by the internet of things, autonomous robots, big data and analytics, cyber security, augmented reality, cyber-physical systems, horizontal integration, additive manufacturing, and vertical integration.

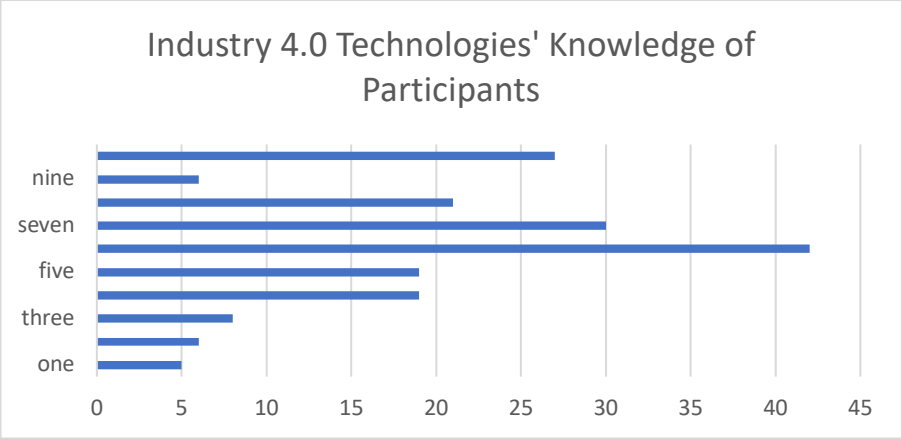

Figure 5: Industry 4.0 Technologies' Knowledge of Participants

The sixth question concerns participants' knowledge of cloud computing technology (Figure 6). 159 of the participants give the correct answer to this question by checking the cloud computing option. 20 of the participants select big data and analytics, 3 cyber-physical systems, and 2 augmented reality options.

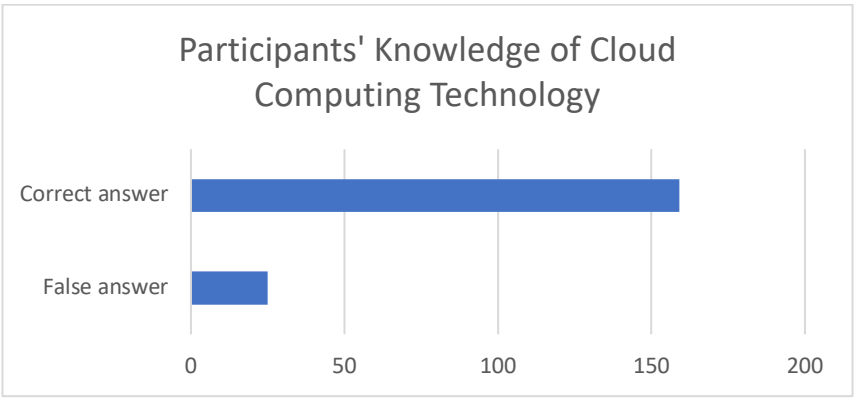

Figure 6: Participants' Knowledge of Cloud Computing Technology

The seventh question concerns participants' knowledge of cyber-physical system technology (Figure 7). 101 participants give the correct answer to this question by selecting the cyber-physical system option. 31 of the participants select additive manufacturing, 30 of the internet of things and 22 of them selected autonomous robots.

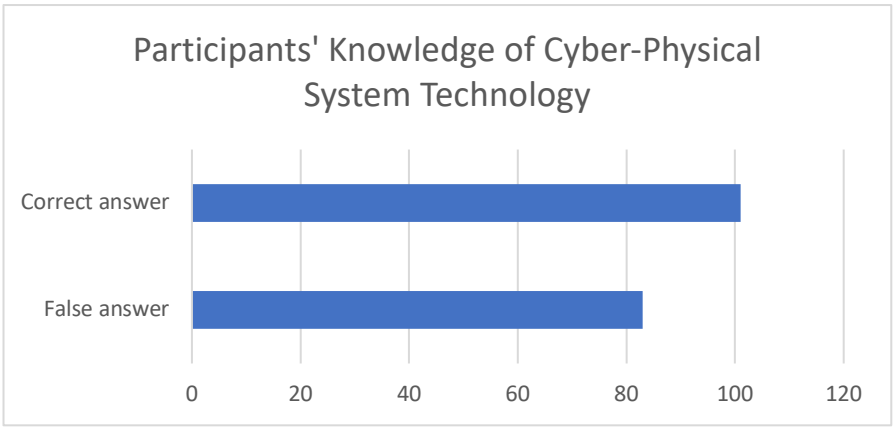

Figure 7: Participants' Knowledge of Cyber-Physical System Technology

The eighth question concerns participants' knowledge of big data and analytics technology (Figure 8). 172 of the participants give the correct answer to this question by selecting the big data and analytics option. In this question, 6 participants select cloud computing, and 6 selected additive manufacturing.

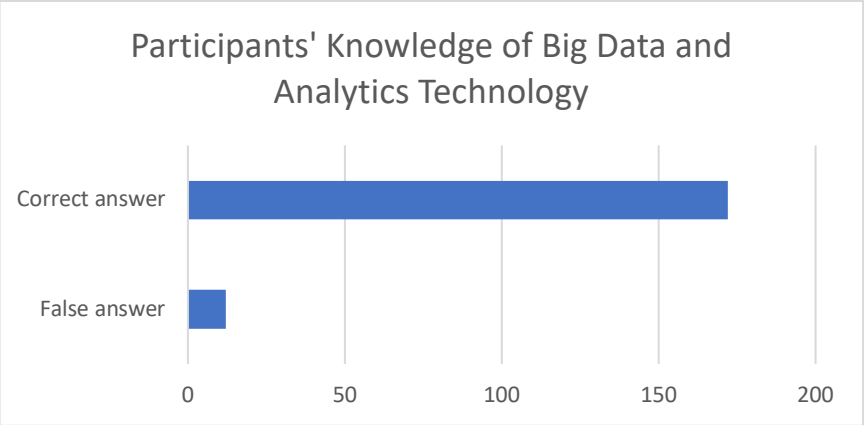

Figure 8: Participants' Knowledge of Big Data and Analytics Technology

The ninth question concerns participants' knowledge of augmented reality technology (Figure 9). 154 of the participants answer this question by selecting the augmented reality option. In this question, 22 of them select cyber-physical systems, 6 of them are horizontal/vertical integration and 2 of them select the internet of things option.

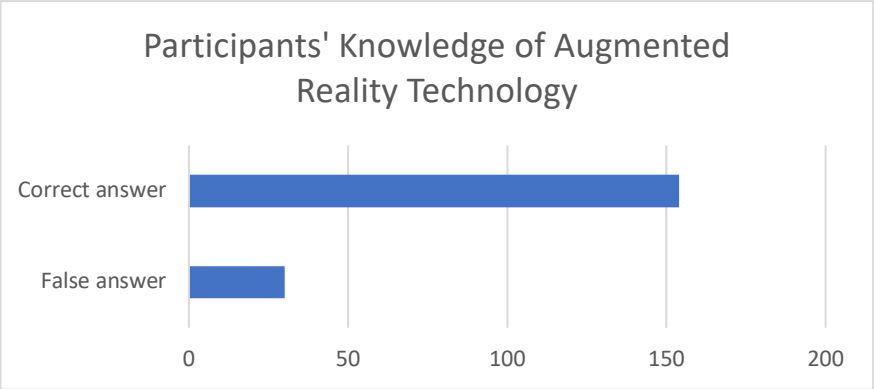

Figure 9: Participants' Knowledge of Augmented Reality Technology

The tenth question concerns participants' knowledge of internet of things technology (Figure 10). 159 of the participants give the correct answer by checking the internet of objects option in this question. In this question, 23 of the participants select cyber-physical systems and 2 of them select the augmented reality option.

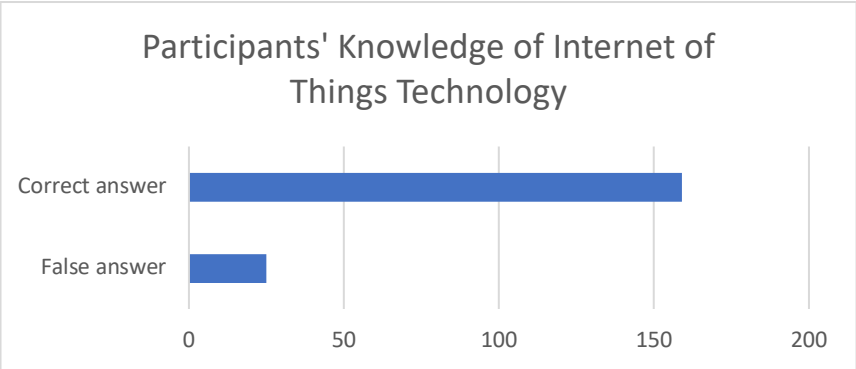

Figure 10: Participants' Knowledge of Internet of Things Technology

The eleventh question concerns participants' knowledge of horizontal/vertical integration technology (Figure 11). 83 of the participants give the correct answer by selecting the horizontal/vertical integration option. 62 of the participants select cloud computing, 34 of the internet of things, 5 of them select autonomous robots.

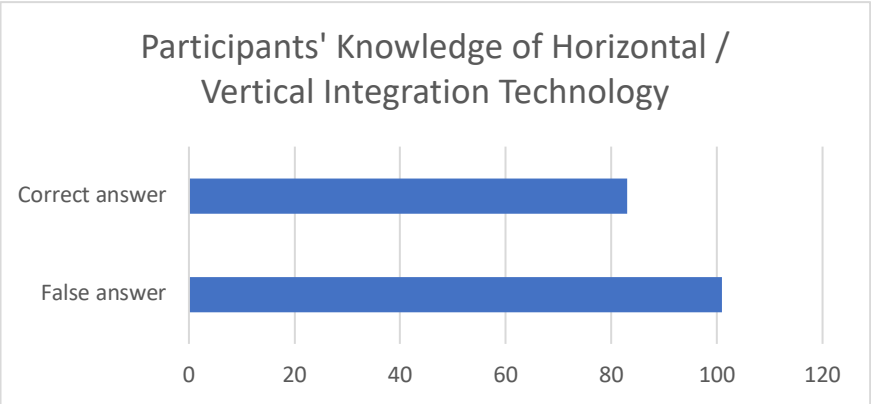

Figure 11: Participants' Knowledge of Horizontal/Vertical Integration Technology

The twelfth question concerns participants' knowledge of additive manufacturing technology (Figure 12). 166 of the participants give the correct answer to this question by checking the additive manufacturing option. In this question, 10 of the participants select augmented reality and 8 of them select autonomous robots.

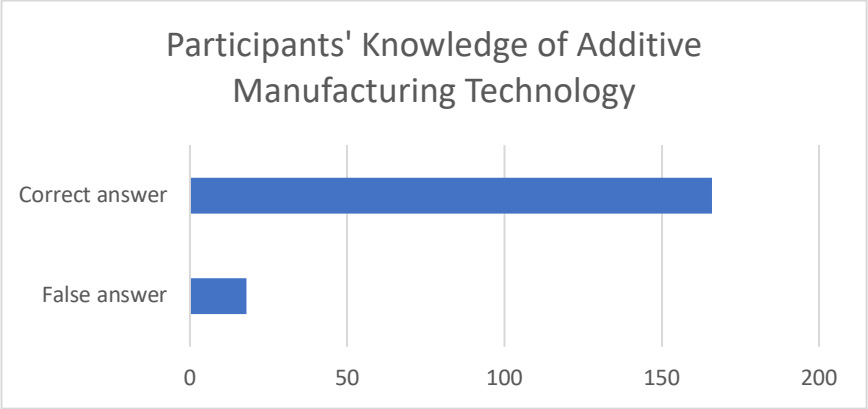

Figure 12: Participants' Knowledge of Additive Manufacturing Technology

The thirteenth question asks whether the participants have an existing work on Industry 4.0 and whether they are planning in the future (Figure 13). 70 of the participants state that they do not have any current work in this question and that they don't have any such plans in the following periods, 68 of them do not have any current works but they have such plans in the future, 42 of them have current work now and have such plans in the future. 4 of them state that they have much work but they don't have such a plan in the future.

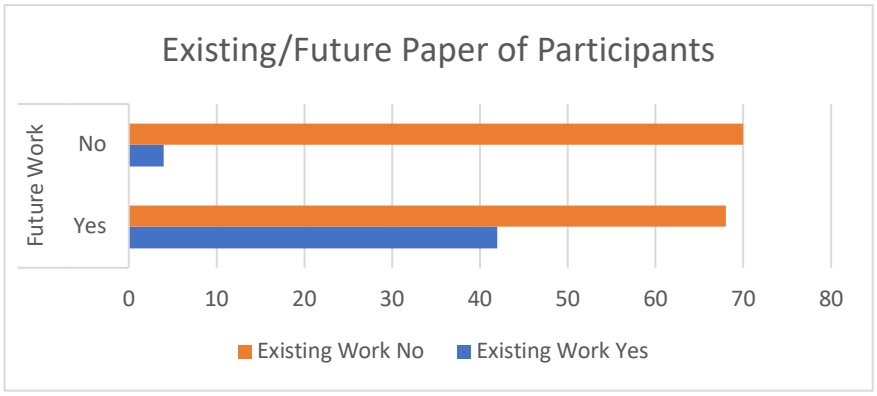

Figure 13: Existing/Future Paper of Participants

The fourteenth question is whether participants find Industry 4.0 and technologies useful for businesses (Figure 14). 179 participants answer yes and 5 answer no in this question.

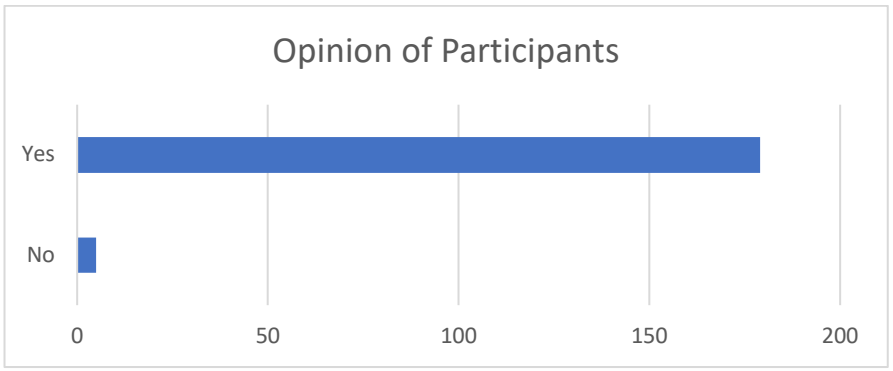

Figure 14: Opinion of Participants for Industry 4.0 Technologies' Useful to Businesses

In this study, the average number of correct answers by title and department are also evaluated. On average, the title of the participants who give the most correct answers to the questions is associate professor, while the title of the participants who give the least correct answer is the instructor. On average, the most correct answers to the questions asked are business administration while the least correct answers to the questions asked are mechanical engineering. A summary of the answers given by the participants about whether they know the technologies or not is given in Figure 15.

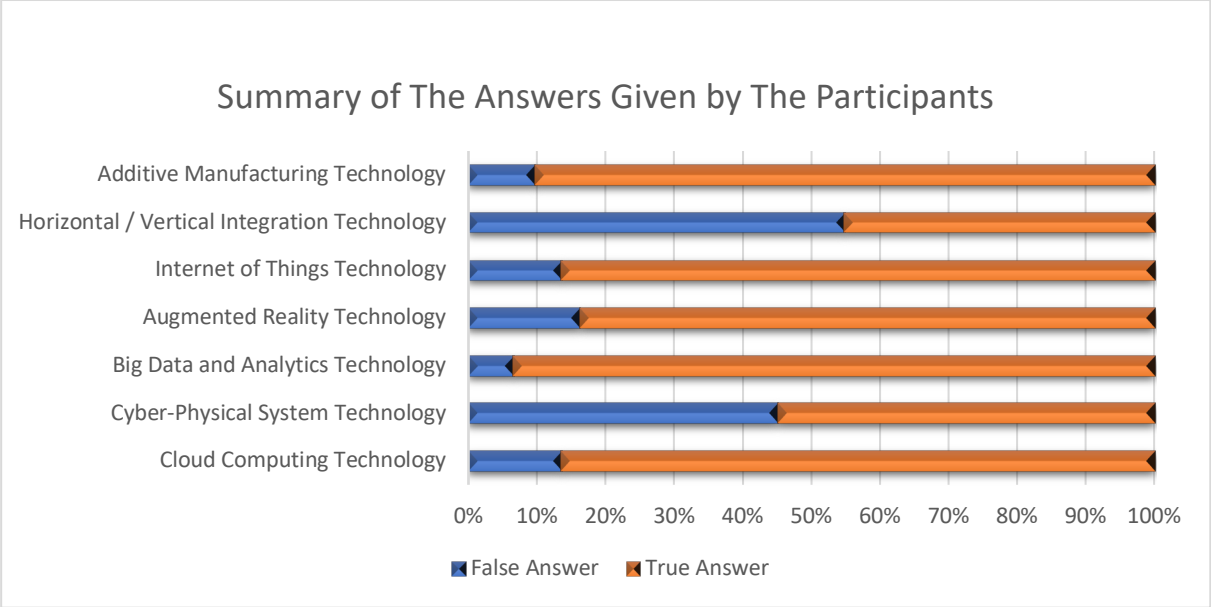

Figure 15: Summary of The Answers Given by The Participants

4. Conclusion

Industry 4.0 has been attracted interest from firms and academics since 2011. Firms increase their quality and profits by benefiting from the technologies of Industry 4.0. When it comes to academics, it provides both practical and theoretical information. In this study, we research academics' awareness. Therefore, a survey was prepared. The questionnaire prepared was sent to academicians working in the departments mentioned in the text of the universities.

When the results are evaluated, the participants generally know 6 out of 10 industry 4.0 technologies. The most well-known ones are big data and analytics, cloud computing technology while the least-known ones are horizontal/vertical integration and cyber-physical system technology. Although academic awareness is very high, 25% of the participants have a study on Industry 4.0. However, 37% of the participants plan to do a study on Industry 4.0 in the future. This is an indication that academicians will be more oriented towards this concept in the future. Academicians must increase their studies on this subject.

In this way, future business and engineering departments will have information about industry 4.0. apply the technologies of this concept in their units and increase productivity. With the efficiency of industry 4.0, businesses will be able to use their resources more effectively, manage their time better, and most importantly, do so at less cost. All of these will contribute not only to the business economy but also to the national economy. For all this to happen, academicians providing education in universities should provide training to the candidates related to this subject. This situation will be provided by academicians to develop themselves in this field and conduct research.

In this context, in this study, a study on the awareness of academicians about Industry 4.0 was prepared and the results were added to the literature. In the future, a study on industry 4.0 awareness in the industry is planned.

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Annex 1 Survey Questions

Question 1: What is your gender?

- Female
- Male

Question 2: What's your title?

- Professor
- Associate Professor
- Assistant Professor
- Instructor
- Research Assistant

Question 3: Which department do you work in?

- Computer Engineering
- Electrical and Electronic Engineering
- Industrial Engineering
- Business Administration
- Machine Engineering
- Mechatronic Engineering

Question 4: Do you know anything about Industry 4.0?

- Yes
- No

Question 5: Please select which Industry 4.0 technologies you have heard. You can make multiple selections.

- Internet of things
- Cloud computing
- Augmented reality
- Horizontal integration
- Vertical integration
- Big data and analytics
- Autonomous robots
- Additive production
- Cyber security
- Cyber-physical systems

Question 6: Which of the following describes the storage of data via the Internet?

- Big data and analytics
- Cloud computing
- Cyber-physical systems
- Augmented reality

Question 7: What is the concept related to the modeling of real-world objects using computer simulation techniques?

- Internet of things
- Additive production
- Cyber-physical systems
- Autonomous robots

Question 8: Existence of high volumes of data and analysis of these data is defined as:

- Additive production
- Cyber security
- Big data and analytics
- Cloud computing

Question 9: Real-world objects such as computer-generated audio images and so on. which is defined as the living and indirect physical appearance that is formed by enriching with?

- Cyber-Physical Systems
- Internet of Things
- Augmented Reality
- Horizontal/Vertical Integration

Question 10: Which of the following is the communication of the machines used in the enterprise with other machines through the internet?

- Internet of things
- Cyber security
- Cyber-physical systems
- Augmented reality

Question 11: Which of the following concepts fall within the scope of the communication between the units within the enterprise and the companies/units outside the enterprise through common systems?

- Cloud computing
- Horizontal / vertical integration
- Internet of things
- Autonomous robots

Question 12: Which of the following is defined as the fact that the final products are collected in layers and produced in a very short time with the help of some techniques?

- Autonomous robots
- Augmented reality
- Cyber-physical systems
- Additive manufacturing

Question 13: Do you have/do you plan to work on Industry 4.0?

- Yes / I am planning.
- Yes / No planning.
- None / I am planning.
- None / I'm not planning.

Question 14: Do you think Industry 4.0 is useful for businesses?

- Yes
- No