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INDUSTRY 4.0 TEACHER AWARENESS: AVCILAR DISTRICT EXAMPLE

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Abstract: This research aims to determine the level of awareness of teachers working in public schools affiliated to the Ministry of National Education regarding Industry 4.0. In this context, it aims to determine whether teachers' Industry 4.0 awareness levels differ significantly according to their gender, age, school level, professional seniority, branch, educational status and class size of the school they work in. The research was designed according to the single survey type, one of the general survey models. The population of the study consisted of 2468 teachers working in public schools in Avcılar district of Istanbul province. The sample of the study consisted of 1697 teachers selected from purposeful sampling in the maximum diversity model. Industry 4.0 Awareness Scale (Yelkikalan et al. 2019) was used as a data collection tool. In the analysis of the data, descriptive statistical analysis was used by using a ready-made statistical package programme. Some of the research results are as follows: Teachers' awareness of Industry 4.0 is at a high level. In addition, there are statistically significant differences in teachers' Industry 4.0 awareness levels according to their gender, age, educational status, class size of the school where they work, while there is no significant difference in terms of their branches and school levels. According to the results obtained, the following suggestions are given: Training programmes should be organised to increase teachers' awareness of Industry 4.0. In order for teachers to access up-to-date information about Industry 4.0, cooperation should be established with universities, industrial organisations and technology companies, and training seminars and field visits should be organised.

Key-words: Industry 4.0, awareness, 4th industrial revolution, teacher training.

1. Introduction

The industrialization process started at the end of the 18th century with the introduction of mechanical production equipment. This transformation was followed by a second industrial revolution that started in the 20th century and involved mass production of goods based on the division of labor and powered by electricity (Kagermann et al. 2013). These developments were replaced by the use of information and communication technologies to increase the automation of production processes with the third industrial revolution that started in the early 1970s and continued until today (Bauernhansl 2014). With the transformation of the third industrial

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revolution into the fourth industrial revolution, technology integration in production and logistics, the Internet of Things and the use of services in industrial processes come to the fore (Hermann et al. 2015).

Industry 4.0 was first introduced at the Hannover Fair held in Germany in 2011 and stated that a new industrial revolution is taking place by adding an innovative, digital and technological dimension to production processes (Kafa 2021).

Industry 4.0, as the basic concept of transformation, includes strategic activities and technological applications for digitalization worldwide. It is seen that this transformation is effective not only in the field of industry and economy, but also in many areas of social life, including education. The adaptation of education systems to this digital transformation necessitates the restructuring of teachers, students and educational processes. In this context, it is important to examine the awareness levels of teachers towards the concept of Industry 4.0. This study aims to reveal teachers' Industry 4.0 awareness levels and to examine whether these awareness levels differ according to demographic variables such as gender, age, school level, professional seniority, branch, educational status and class size. In this context, the study reveals that increasing teachers' awareness of Industry 4.0 technologies directly contributes to the development of digital competencies within the scope of SDG 4 - Quality Education. In addition, this awareness paves the way for the innovation-oriented transformation of education systems in line with SDG 9 - Industry, Innovation and Infrastructure, and makes teachers key actors in the process of raising individuals suitable for the requirements of the digital industrial age. In this respect, the study overlaps with the science, technology and innovation (STI) based development approach emphasized in the Stakeholder Engagement & The 2030 Agenda (UN DESA 2020) for Sustainable Development and provides a concrete roadmap for transformation in education.

2. The Theoretical Framework

Industry 4.0 encompasses strategic activities focusing on digital technologies across the world in this transformation process, which is also known as the “Industrial Internet” and referred to as the “Fourth Industrial Revolution”. For example, China's “Made in China 2025” strategic plan is one of the main policies guiding digital transformation activities developed within the scope of Industry 4.0. However, there are various problems on a global scale today, such as depletion of natural resources, global warming, economic inequalities and security threats. In order to overcome these problems, it is necessary to produce knowledge by establishing connections between the physical and virtual worlds, to develop solutions to social problems through information technologies and to ensure sustainable economic growth. In this context, a common vision of the future can be created by addressing digitalization processes within the framework of Industry 4.0 (Fukuyama 2018). With the acceleration of technological developments, traditional production and training methods are being replaced by new paradigms offered by Industry 4.0. There have been three major industrial revolutions, Industry 1.0, 2.0 and 3.0, and each of them aimed to increase production efficiency. In the 2000s, rapid advances in technology have changed the needs and expectations of individuals, and interdisciplinary studies have gained importance in order to adapt to these changes. Especially with the proliferation of internet and network technologies, the concept of Industry 4.0 has emerged, where objects can communicate and interact with each other. Industry 4.0 focuses on production processes that identify needs and minimize waste by analyzing data through sensor-based communication systems. In this context,

innovative solutions such as smart factories, cyber-physical systems, internet of things and cloud technologies are widely used (Avcı and Candan 2023; Jędrzejczyk 2021; Zalozhnev and Ginz 2023).

The impacts of Industry 4.0 on education can be listed as (1) transforming the educational mission, (2) updating educational goals, (3) expanding education and research activities for new professional fields, (4) strengthening interdisciplinary integration, (5) increasing competencies in research and human resource development, (6) expanding digital and smart school applications, and (7) developing creative innovation capabilities (Bich 2025). The increasing need for professionals with the skills to adapt to Industry 4.0 requires education systems to keep pace with this transformation. Accordingly, educational institutions are expected to restructure their basic educational principles in line with Industry 4.0 methodologies. In this process, it is critical to equip teachers and students with the knowledge and skills to adapt to technological changes.

Today's students are able to adapt more flexibly to technological changes thanks to their upbringing in the digital ecosystem and acquire the skills required by the digital age at an early age. This makes it possible for students to quickly integrate into new systems without experiencing major difficulties when stepping out of their comfort zones. In this context, as future professionals, students need to develop cognitive skills such as critical thinking, analytical thinking, computational thinking, complex problem solving, innovation, creativity, originality and initiative in their academic processes. In addition, soft skills such as teamwork, leadership, reasoning, and idea generation have an important place in educational processes (Pinto and Reis 2025; Svitek et al. 2022). Restructuring education systems in order to provide these skills is of great importance in terms of raising individuals with the competencies required by Industry 4.0.

Industry 4.0 applications are now widely used in many sectors such as health, economy, security and banking (Novak et al. 2021; Vetiška et al. 2020). However, research in the field of education mostly focuses on Industry 4.0 awareness levels of K12 and university level students (Neaga 2019; Özkoç and Karalar 2019; Torun and Cengiz 2019). However, in order to adapt to the requirements of the digital age and meet the educational needs of students, teachers need to be equipped with digital skills (Furtak et al. 2012). In this context, the need for innovative teaching strategies such as transforming educational environments in formal education and lifelong learning processes and developing interdisciplinary education programs supported by virtual simulations is increasing day by day (Efe et al. 2010). In order to effectively implement Education 4.0, Industry 4.0 technologies and innovations should be integrated into every stage of the education process, students should be trained as individuals ready for this transformation, and teachers should continue their professional development with lifelong learning strategies (van der Vorst and Jelicic 2019).

3. Method

This study was designed in accordance with the single survey type, one of the general survey models based on quantitative research approach. Survey models are research approaches that aim to describe a past or present situation as it exists (Karasar 2016).

3.1. Sample and Population

The population of the study consists of 2468 teachers working in public schools affiliated to the Ministry of National Education in Avcılar district of Istanbul province. The sample consists of 1697 teachers in Avcılar district who participated in the research in the maximum diversity sampling model within purposive sampling. The maximum variation sampling method, which is used within the scope of purposive sampling, aims to find and identify basic themes that include some differences (Patton 2014). In this direction, it was aimed to ensure diversity among the school levels (kindergarten, primary school, secondary school, academic high school and vocational high school) where teachers work and the sample was formed to reflect this diversity. Demographic information of the teachers participating in the study is given in Table 1.

Table 1. Demographic information of the teachers participating in the study

		f	%
Gender	Male	488	28.8
	Female	1209	71.2
	Total	1697	100
Age	25 years and under	114	6.7
	26- 30 years	377	22.2
	31- 35 years	375	22.1
	36- 40 years	298	17.6
	41- 45 years	269	15.9
	46 years and over	264	15.6
	Total	1697	100
School Level	Preschool	112	6.6
	Primary school	441	26.0
	Secondary school	645	38.0
	Academic high school	130	7.7
	Vocational high school	369	21.7
	Total	1697	100
Professional Seniority	1- 6 years	594	35.0
	7- 12 years	445	26.2
	13- 18 years	255	15.0
	19- 24 years	261	15.4
	25 years and above	142	8.4
	Total	1697	100
Branches	Preschool teacher	133	7.8
	Class teacher	366	21.6
	Branch teacher	1019	60.0
	Vocational teacher	179	10.5
	Total	1697	100
Educational Status	Associate's degree	37	2.2
	Bachelor's degree	1416	83.4
	Master's degree	235	13.8
	Doctorate	9	.5
	Total	1697	100

According to the data presented in Table 1, a total of 1,697 teachers participated in the study. 71.2% of the participants were female teachers and 28.8% were male teachers. This gender distribution reflects that female teachers are generally in the majority in the education sector. The fact that male teachers scored higher on Industry 4.0 awareness than female teachers indicates that the majority of women in the sample may have an impact on the generalization of the results and gender-based interpretations.

In terms of age distribution, the participants show a homogeneous distribution: Teachers aged 25 and under constitute the lowest proportion with 6.7%, while other age groups were represented at similar rates. The findings revealed significant differences in Industry 4.0 awareness between age groups ($p < .05$). This shows that age is a determining factor in technology awareness and adaptation and that the attitudes of different age groups towards technology can diversify the results.

In terms of school level, middle school teachers have the highest representation (38%), while academic high school teachers are relatively underrepresented (7.7%). Increasing the number of relatively underrepresented levels may yield more comprehensive results in future research.

In terms of professional seniority, there are different levels of experience, with a particularly high proportion of teachers with 1-6 years of experience (35%). In the findings, significant differences were observed in the sub-dimensions of perceived usefulness and usage behavior depending on professional seniority ($p < .05$). This shows that teachers' level of experience is effective on technology perception and intention to use.

In terms of branch distribution and education level, the fact that the majority were branch teachers (60%) and undergraduate graduates (83.4%) supports that the findings represent a wide range of teachers. The fact that there was no significant difference in awareness levels between branches ($p > .05$) suggests that different teacher branches exhibit similar attitudes towards Industry 4.0 awareness. On the other hand, the significant differences between the level of education and awareness levels ($p < .05$) indicate that technology awareness may change as academic qualification increases. As a result, these differences and variations in demographic structure have a critical importance in the interpretation of the findings of the study on Industry 4.0 awareness.

3.2. Data Collection Tool

The data were collected with the help of "Industry 4.0 Scale" (Yelkikalan et al. 2019). This scale is a 5-point Likert-type scale consisting of 15 items developed to measure teachers' perceptions of their tolerance tendency levels towards Industry 4.0. In addition, the scale consists of four sub-dimensions: perceived usefulness, perceived ease of use, intention to use, and usage behavior. The development process of the scale and important information about the scale are given in Yelkikalan et al. (2019). In order to analyze the data, the items in the scale were evaluated by giving 1 point for "strongly disagree", 2 points for "disagree", 3 points for "undecided", 4 points for 'agree', and 5 points for "strongly agree". In this context, the findings obtained as a result of the analysis were interpreted as 4.21-5.00 completely agree, 3.41-4.20 strongly agree, 2.61-3.40 moderately agree, 1.81-2.60 slightly agree and 1.00-1.80 strongly disagree. In this study, the internal consistency (α) reliability coefficient of the Industry 4.0 Scale was 0.88. Karasar (2016) states that the reliability is high as the value of the scale used approaches one (1.00), and Özdamar (1997) states that the Cronbach Alpha internal consistency coefficient of the scale is reliable if it is between 0.80 and 1.00. Therefore, it is possible to say that the scale is reliable.

3.3. Data Collection Process

During the data collection process, the Industry 4.0 scale and the link to the online questionnaire form of the research were shared through the common school communication groups of the public schools at the level of kindergarten, primary school, secondary school, academic high school and vocational high school in Avcılar district. The communication groups consisted of institutional

communication groups actively used by school administrators and teachers. Along with the questionnaire form, a text informing that participation was voluntary was also provided and teachers were asked to participate in the survey and fill out the form completely. A total of 1,697 teachers completed the questionnaire within the specified time period and were included in the data set. As a matter of fact, the survey feature of an international search engine was utilized in this study. Internet-based online data collection tools are not only time- and cost-efficient for researchers, but also offer the opportunity to store data, visualize and analyze data, and access to participants distributed over a wide geographical area (Lefever et al. 2007). In this respect, the online survey application provided considerable savings in terms of labor, time and cost, and convenience in terms of reaching the sample. With the online data collection tool, maximum diversity was achieved by reaching all teachers in the district and reaching schools at different socioeconomic levels with different professional seniority working at different levels.

3.4. Data Analysis

As the first stage of the data analysis, data cleaning was performed to identify and correct errors and inconsistencies in the demographic data included in the scale. After data cleaning, a reliability analysis was conducted with the data collected for this study.

As a result of the analysis, the internal consistency reliability coefficient for the whole scale was calculated as 0.88. After the reliability analysis, the frequency and percentage values of the data entered by the participants according to the 5-point Likert-type scale for the frequency of encountering problems were calculated. The data collected in the study were analyzed using IBM SPSS Statistics 20 for Windows program. In the interpretation of the obtained scores, descriptive statistical information such as frequency and percentage distributions, arithmetic mean and standard deviation, as well as Mann-Whitney U Test, Kruskal-Wallis Test significance test were used. In addition, the Kolmogorov Smirnov test was used to test whether the data were normally distributed and it was determined that the data were not normally distributed. The test results are given in Table 2.

Table 2. Kolmogorov Smirnov Test Results

	Statistics	p
Perceived benefit	. 18	.00
Perceived ease of use	.15	.00
Intention to use	.13	.00
Usage behaviour	.53	.00
Industry 4.0 scale	.05	.00

When Table 2 is examined, according to the results of the Kolmogorov-Smirnov test, the p values of all variables in the study were found to be less than .05 and it was determined that they did not fit the normal distribution. In particular, the fact that the usage behavior sub-dimension (D = 0.53) has a higher test statistic compared to other variables indicates that there is a significant deviation in the distribution of this variable. Accordingly, it is necessary to use nonparametric tests in the analyses.

4. Findings

In this section, the awareness levels of students towards Industry 4.0 were determined. At the same time, it was also examined whether the teachers' Industry 4.0 awareness levels differ

significantly according to their gender, age, school level, professional seniority, branch, educational status and class size of the school they work in. When $p > 0.05$, it is accepted that there is no statistically significant difference between the groups and the observed differences may be coincidental. $p < 0.05$ means that there is a significant difference between the groups and this difference is not coincidental.

4.1. Teachers' Awareness Level of Industry 4.0

In Table 3, teachers' awareness levels of Industry 4.0 in terms of four sub-dimensions and in general are presented.

Table 3. Teachers' Industry 4.0 Awareness Levels

Survey items	$\bar{X}$	Ss
1. Using Industry 4.0 technologies improves my performance in lessons.	4.12	.91
2. Using Industry 4.0 technologies increases my productivity.	4.14	.89
3. Using Industry 4.0 technologies increases my effectiveness.	4.14	.87
4. I find it useful to use Industry 4.0 technologies.	4.21	.85
5. Using Industry 4.0 technologies is clear and understandable.	4.10	.92
6. Using Industry 4.0 technologies does not require too much mental effort.	4.16	.88
7. It is easy to use Industry 4.0 technologies.	4.13	.92
8. It is easy to do what I want using Industry 4.0 technologies.	3.90	.97
9. I intend to use Industry 4.0 technologies in the future.	3.49	.94
10. I plan to use Industry 4.0 technologies in the future.	3.18	1.05
11. I expect to use Industry 4.0 technologies in the future.	3.72	.91
12. I can use Industry 4.0 technologies frequently.	3.59	.89
13. I cannot work efficiently without Industry 4.0 technologies.	1.88	1.14
14. I do not use Industry 4.0 technologies.	2.41	1.14
15. I rarely use Industry 4.0 technologies.	2.75	1.14
Perceived benefit sub-dimension	4.15	.83
Perceived ease of use sub-dimension	4.07	.85
Intention to use sub-dimension	3.46	.80
Usage behaviour sub-dimension	2.66	.66
Industry 4.0 scale	3.60	.59

In Table 3, the item of the scale showing 'very high' Industry 4.0 awareness is the statement 'I find it useful to use Industry 4.0 technologies' ($\bar{X}$ = 4,21). On the other hand, the item indicating 'low' awareness is the statement 'I cannot work efficiently without Industry 4.0 technologies' ($\bar{X}$ = 1,88). In addition, it was determined that the level of awareness was 'high' in the sub-dimensions of 'perceived benefit', 'perceived ease of use' and 'intention to use'. It is seen that the level of awareness in the 'usage behaviour' sub-dimension is at 'medium' level. In general, it was concluded that the level of teachers' awareness of Industry 4.0 is 'high'.

4.2. Industry 4.0 Awareness Level of Teachers According to Gender

In Table 4, Industry 4.0 awareness levels of teachers according to their gender are presented.

Table 4. Mann-Whitney U Test Results of Industry 4.0 Awareness Levels of Teachers According to Their Gender

	Gender	n	Rank Mean	Rank Sum	U	p
Perceived benefit	Male	488	882.27	430547.00	278761.00	.06
	Female	1209	835.57	1010206.00		
Perceived ease of use	Male	488	887.09	428021.50	281286,50	.12
	Female	1209	837.66	1012731.50		
Intention to use	Male	488	879.72	429303,50	280004,50	.09
	Female	1209	836.60	1011449,50		
Usage behaviour	Male	488	868,19	423678,00	285630,00	.30
	Female	1209	841,25	1017075,00		
Industry 4.0 scale	Male	488	890,70	434662,00	274646,00	.02
	Female	1209	832,17	1006091,00		

p >.05: When p > 0.05, it is accepted that there is no statistically significant difference between the groups and the observed differences may be random. p < 0.05 means that there is a significant difference between the groups and this difference is not random.

According to Table 4, the awareness levels of teachers about Industry 4.0 were measured according to their gender in terms of 'perceived benefit' (U=278761.00, p=.06>.05), 'perceived ease of use' (U=281286.50, p=.12>.05), 'intention to use' (U=280004.50, p=.09>.05) and 'usage behaviour' (U=285630.00, p=.30>.05). However, when awareness levels were compared according to gender, it was determined that male teachers (Median=890.70) had higher Industry 4.0 awareness than female teachers (Median=832.17).

4.3. Industry 4.0 Awareness Level of Teachers According to Their Age

In Table 5 presents the Industry 4.0 awareness levels of teachers according to their ages.

Table 5. Kruskal-Wallis Test Results for Industry 4.0 Awareness Levels of Teachers According to Their Ages

	Age	n	Rank Mean	sd	χ^2	p	Significant Difference
Perceived benefit	1. 25 years and under	114	1000.85	5	19.12	.00	1>2 1>3 1>4 1>5 1>6 2>3 2>4 2>5
	2. 26- 30 years	377	893.35				
	3. 31- 35 years	375	819.98				
	4. 36- 40 years	298	821.43				
	5. 41- 45 years	269	816.23				
	6. 46 years and over	264	825.82				
Perceived ease of use	1. 25 years and under	114	1019.00	5	20.47	.00	1>2 1>3 1>4 1>5 1>6 2>6
	2. 26- 30 years	377	879.32				
	3. 31- 35 years	375	838.61				
	4. 36- 40 years	298	828.22				
	5. 41- 45 years	269	824.89				
	6. 46 years and over	264	795.08				
Intention to use	1. 25 years and under	114	945.39	5	7.04	.21	-
	2. 26- 30 years	377	867.19				
	3. 31- 35 years	375	829.49				
	4. 36- 40 years	298	821.20				
	5. 41- 45 years	269	832.58				
	6. 46 years and over	264	857.23				
Usage behaviour	1. 25 years and under	114	798.69	5	14.17	.01	1>6 2>6 3>6
	2. 26- 30 years	377	827.82				
	3. 31- 35 years	375	839.19				

	4. 36- 40 years	298	853.42				4>6
	5. 41- 45 years	269	813.36				5>6
	6. 46 years and over	264	946.21				
Industry 4.0 scale	1. 25 years and under	114	986.96	5	13.73	.01	1>2
	2. 26- 30 years	377	881.20				1>3
	3. 31- 35 years	375	823.73				1>4
	4. 36- 40 years	298	821.18				1>5
	5. 41- 45 years	269	818.56				1>6
	6. 46 years and over	264	841.76				

p >.05

In Table 5, the Kruskal-Wallis test was applied to determine whether the awareness levels of teachers regarding Industry 4.0 differed between age groups. As a result of the analysis, a statistically significant difference was found between age groups (X^2=13.73, p=.01<.05). As a result of multiple comparisons made with the Mann-Whitney U test, it was determined that this difference was between the 25 and under age group and the 26-30, 31-35, 36-40, 41-45 and 46 and over age groups.

4.4. Industry 4.0 Awareness Level of Teachers According to School Levels

In Table 6 presents teachers' awareness levels of Industry 4.0 based on school levels.

Table 6. Kruskal-Wallis Test Results on Teachers' Industry 4.0 Awareness Levels According to School Levels

	School Level	n	Rank Mean	sd	χ^2	p	Significant Difference
Perceived benefit	1. Preschool	112	877.96	4	1.29	.86	-
	2. Primary school	441	859.91				
	3. Secondary school	645	847.85				
	4. Academic high school	130	849.39				
	5. Vocational high school	369	829.04				
Perceived ease of use	1. Preschool	112	867.51	4	2.45	.65	-
	2. Primary school	441	859.09				
	3. Secondary school	645	854.06				
	4. Academic high school	130	868.99				
	5. Vocational high school	369	815.43				
Intention to use	1. Preschool	112	825.09	4	5.77	.21	-
	2. Primary school	441	883.27				
	3. Secondary school	645	827.28				
	4. Academic high school	130	801.05				
	5. Vocational high school	369	870.16				
Usage behaviour	1. Preschool	112	865.47	4	1.22	.87	-
	2. Primary school	441	863.41				
	3. Secondary school	645	846.13				
	4. Academic high school	130	814.96				
	5. Vocational high school	369	843.80				
Industry 4.0 scale	1. Preschool	112	864.71	4	2.11	.71	-
	2. Primary school	441	874.44				
	3. Secondary school	645	842.58				
	4. Academic high school	130	838.98				
	5. Vocational high school	369	828.58				

p >.05

As shown in Table 6, the Kruskal-Wallis test was conducted to determine whether teachers' awareness levels of Industry 4.0 differed across school levels. The analysis results indicated that

there was no statistically significant difference in Industry 4.0 awareness levels among school levels (X^2=2.11, p=.71>.05).

4.5. Industry 4.0 Awareness Level of Teachers According to Their Professional Seniority

Table 7 presents the Industry 4.0 awareness levels of teachers according to their professional seniority.

Table 7. Kruskal-Wallis Test Results on Industry 4.0 Awareness Levels of Teachers According to Their Professional Seniority

	Professional Seniority	n	Rank Mean	sd	χ^2	p	Significant Difference
Perceived benefit	1. 1- 6 years	594	893.88	4	13.33	.01	1>2 1>3 1>4 5>3 5>4
	2. 7- 12 years	445	833.24				
	3. 13- 18 years	255	798.89				
	4. 19- 24 years	261	795.90				
	5. 25 years and above	142	898.22				
Perceived ease of use	1. 1- 6 years	594	876.91	4	7.17	.12	-
	2. 7- 12 years	445	868.58				
	3. 13- 18 years	255	815.49				
	4. 19- 24 years	261	799.80				
	5. 25 years and above	142	821.49				
Intention to use	1. 1- 6 years	594	857.28	4	5.72	.22	-
	2. 7- 12 years	445	847.74				
	3. 13- 18 years	255	821.33				
	4. 19- 24 years	261	817.45				
	5. 25 years and above	142	926.01				
Usage behaviour	1. 1- 6 years	594	853.13	4	11.57	.02	1>5 5>2 5>3
	2. 7- 12 years	445	805.74				
	3. 13- 18 years	255	837.12				
	4. 19- 24 years	261	863.92				
	5. 25 years and above	142	961.20				
Industry 4.0 scale	1. 1- 6 years	594	883.53	4	9.33	.06	-
	2. 7- 12 years	445	837.65				
	3. 13- 18 years	255	804.26				
	4. 19- 24 years	261	803.68				
	5. 25 years and above	142	903.76				

p >.05

As seen in Table 7, the Kruskal-Wallis test was applied to determine whether the awareness levels of teachers regarding Industry 4.0 differ according to their professional seniority. As a result of the analysis, a statistically significant difference was found between the Industry 4.0 awareness levels depending on professional seniority in the perceived benefit sub-dimension (X^2=13.03, p=.01<.05). As a result of multiple comparisons made with the Mann-Whitney U test, it was determined that this difference was in the groups of 0-6 years and 7-12 years, 0-6 years and 13-18 years, 0-6 years and 19-24 years, 25 years and above and 13-18 years, and 25 years and above and 19-24 years.

In addition, a statistically significant difference was found between the Industry 4.0 awareness levels depending on professional seniority in the usage behavior sub-dimension (X^2=11.57, p=.02<.05). It was determined that this difference was in the groups between 0-6 years and 25 years and above, 25 years and above and 7-12 years, and 25 years and above and 13-18 years.

4.6. Industry 4.0 Awareness Level of Teachers According to Their Branches

Table 8 presents the teachers' Industry 4.0 awareness levels according to their branches.

Table 8. Kruskal-Wallis Test Results on Industry 4.0 Awareness Levels of Teachers According to Their Branches

	Branches	n	Rank Mean	sd	χ^2	p	Significant Difference
Perceived benefit	1. Preschool teacher	133	864.61	3	2.18	.53	-
	2. Class teacher	366	863.03				
	3. Branch teacher	1019	835.84				
	4. Vocational teacher	179	883.64				
Perceived ease of use	1. Preschool teacher	133	859.56	3	1.68	. 64	-
	2. Class teacher	366	866.50				
	3. Branch teacher	1019	836.92				
	4. Vocational teacher	179	874.14				
Intention to use	1. Preschool teacher	133	859.24	3	5.03	. 16	-
	2. Class teacher	366	877.61				
	3. Branch teacher	1019	828.66				
	4. Vocational teacher	179	898.66				
Usage behaviour	1. Preschool teacher	133	882.19	3	.92	. 81	-
	2. Class teacher	366	855.15				
	3. Branch teacher	1019	841.69				
	4. Vocational teacher	179	853.35				
Industry 4.0 scale	1. Preschool teacher	133	869.32	3	3.85	. 27	-
	2. Class teacher	366	875.76				
	3. Branch teacher	1019	830.21				
	4. Vocational teacher	179	886.15				

p >.05

As seen in Table 8, the Kruskal-Wallis test was applied to determine whether the awareness levels of teachers regarding Industry 4.0 differed between branches. As a result of the analysis, no statistically significant difference was found between the branches of teachers and Industry 4.0 awareness levels (X^2=3.85, p=.27>.05).

4.7. Industry 4.0 Awareness Level of Teachers According to Their Educational Status

Table 9 presents the teachers' Industry 4.0 awareness levels according to their educational status.

Table 9. Kruskal-Wallis Test Results on Industry 4.0 Awareness Levels of Teachers According to Their Educational Status

	Educational Status	n	Rank Mean	sd	χ^2	p	Significant Difference
Perceived benefit	1. Associate's degree	37	930.72	3	4.20	. 24	-
	2. Bachelor's degree	1416	840.77				
	3. Master's degree	235	877.45				
	4. Doctorate	9	1065.61				
Perceived ease of use	1. Associate's degree	37	890.43	3	8.09	. 04	2>1
	2. Bachelor's degree	1416	835.75				
	3. Master's degree	235	912.23				
	4. Doctorate	9	1111.56				
Intention to use	1. Associate's degree	37	1043.96	3	12.38	. 00	1>2 2>1 2>4
	2. Bachelor's degree	1416	832.96				
	3. Master's degree	235	907.84				
	4. Doctorate	9	1035.17				

Usage behaviour	1. Associate's degree	37	1139.72	3	20.57	. 00	1>2 1>3 1>4
	2. Bachelor's degree	1416	851.87				
	3. Master's degree	235	799.50				
	4. Doctorate	9	495.06				
Industry 4.0 scale	1. Associate's degree	37	1022.50	3	9.75	. 02	1>2
	2. Bachelor's degree	1416	834.81				
	3. Master's degree	235	899.86				
	4. Doctorate	9	1040.94				

p >.05

As seen in Table 9, the Kruskal-Wallis test was applied to determine whether the awareness levels of teachers regarding Industry 4.0 differ according to their educational background. As a result of the analysis, a statistically significant difference was found between the education levels of teachers and their Industry 4.0 awareness levels (X^2=9.75, p=.02<.05). As a result of multiple comparisons made with the Mann-Whitney U test, it was determined that this difference was between teachers with an associate degree and a bachelor's degree.

4.8. Industry 4.0 Awareness Level of Teachers According to Class Size of School Where They Work

Table 10 presents the teachers' Industry 4.0 awareness levels according to class size of school where they work.

Table 10. Kruskal-Wallis Test Results on Industry 4.0 Awareness Levels of Teachers According to Class Size of School Where They Work

	Class Size	n	Rank Mean	sd	χ^2	p	Significant Difference
Perceived benefit	1. 1-10 students	48	864.83	5	12.95	.02	6>1 6>2 5>3 5>4 6>5
	2. 11-20 students	172	885.00				
	3. 21-30 students	431	806.80				
	4. 31-40 students	822	843.64				
	5. 41-50 students	200	897.86				
	6. 51 and above students	24	1093.73				
Perceived ease of use	1. 1-10 students	48	830.11	5	12.55	.02	6>1 2>3 6>5
	2. 11-20 students	172	907.86				
	3. 21-30 students	431	803.33				
	4. 31-40 students	822	855.09				
	5. 41-50 students	200	847.73				
	6. 51 and above students	24	1087.13				
Intention to use	1. 1-10 students	48	907.21	5	4.97	.41	-
	2. 11-20 students	172	899.13				
	3. 21-30 students	431	815.50				
	4. 31-40 students	822	855.85				
	5. 41-50 students	200	834.45				
	6. 51 and above students	24	861.50				
Usage behaviour	1. 1-10 students	48	962.67	5	4.10	.53	-
	2. 11-20 students	172	851.72				
	3. 21-30 students	431	846.38				
	4. 31-40 students	822	835.39				
	5. 41-50 students	200	875.54				
	6. 51 and above students	24	894.08				
Industry 4.0 scale	1. 1-10 students	48	900.46	5	11.98	.03	2>3 5>4
	2. 11-20 students	172	905.26				
	3. 21-30 students	431	804.43				
	4. 31-40 students	822	845.57				

	5. 41-50 students	200	871.16				
	6. 51 and above students	24	1076.00				

p >.05

As seen in Table 10, the Kruskal-Wallis test was applied to determine whether the awareness levels of teachers regarding Industry 4.0 differ according to the class sizes in the schools they work. As a result of the analysis, a statistically significant difference was found between the class sizes and the Industry 4.0 awareness levels (X^2=11.98, p=.03<.05). As a result of multiple comparisons made with the Mann-Whitney U test, it was determined that this difference was between the groups of 11-20 students and 21-30 students and between the groups of 41-50 students and 31-40 students.

5. Conclusion

In this study, it was concluded that teachers' level of awareness about Industry 4.0 is 'high'. In addition, teachers rated the item 'I find it useful to use Industry 4.0 technologies' at a very high level. Male teachers' awareness of Industry 4.0 is higher than female teachers. Teachers aged 25 and under have higher awareness of Industry 4.0 than other age groups. There is no significant difference between the Industry 4.0 awareness of teachers with different school levels. There is no significant difference between the Industry 4.0 awareness of teachers with different branches. It was concluded that teachers with associate degree have higher Industry 4.0 awareness than teachers with bachelor's degree. Teachers with a class size of 11-20 students have a higher level of Industry 4.0 awareness than teachers with a class size of 21-30 students. These findings emphasize the need to increase teachers' digital skills in line with SDG 4 - Quality Education, and contribute to the innovative transformation of education systems in line with SDG 9 - Industry, Innovation and Infrastructure. Therefore, strengthening teachers' awareness of Industry 4.0 is critical for a sustainable transformation in education in line with the 2030 Agenda for Sustainable Development's vision of science, technology and innovation-driven development (UN DESA 2020).

6. Discussion

Education plays a central role in preparing individuals for society and working life by providing them with competencies appropriate to the workforce demands of revolutions such as Industry 4.0 (Ananiadou and Claro 2009). Productive and innovative approaches in education are seen as an important opportunity in the light of Industry 4.0 (Fisk 2019). In this respect, especially teachers are in a critical position in the education system and their perceptions, competencies and behaviors in teaching-learning processes are a determining factor in students' academic success (Soenarto et al. 2020). The findings show that Industry 4.0 awareness differs depending on certain demographic variables. This suggests that teachers' individual characteristics affect their adaptation to technological transformation processes. In particular, it was determined that teachers' awareness levels on Industry 4.0 were generally high. While the highest awareness was observed in the item "I find it useful to use Industry 4.0 technologies", the lowest awareness was observed in the item "I cannot work efficiently without Industry 4.0 technologies". These results overlap with the findings of Avcı and Candan (2023).

According to the gender variable, male teachers' awareness levels were found to be higher than female teachers. While this finding supports the studies of Avcı and Candan (2023), Doğan and Baloğlu (2020) and Yelkenalan et al. (2019), it contradicts Özsakarya (2022) and Torun and Cengiz

(2019). When the age variable is analyzed, the awareness levels of young teachers are higher than other age groups. Especially the fact that young teachers have higher awareness can be explained by the fact that they have been raised in the digital age. Although this result is compatible with the study of Ekizce et al. (2022), no significant difference was found in Özsakarya's (2022) study.

While school level and branch variables did not make a difference, professional seniority and educational status created significant differences in awareness levels. Especially significant differences were observed between teachers with 0-6 years of seniority and other groups. There was also a difference between associate degree and bachelor's degree graduates. There was also a difference between certain groups in the class size variable. In addition, Industry 4.0 presents new opportunities and challenges in education as one of the main dynamics of the information society. Industry 4.0 and digitalization create great opportunities for educational institutions by offering new teaching possibilities. This is leading to the emergence of complex, multifaceted and interdisciplinary challenges that affect all fields of knowledge, as well as promoting progress at a global level. While Industry 4.0 brings significant innovations to schools, universities and industry, it also requires students to be trained with the skills, competencies and equipment appropriate to this transformation. In this context, it is crucial that educational institutions adapt to Industry 4.0 and undergo a systematic development process (Neage 2019).

Toth et al. (2020) state that teachers are not adequately equipped to develop students' digital skills. In order for teachers to acquire these skills, they need to perceive the benefits of Industry 4.0, be willing to use related technologies, embrace ease of use, and integrate these technologies into their teaching processes. Therefore, it is a critical requirement for teachers to have a high level of Industry 4.0 awareness.

Equipping students with 21st century skills is only possible if teachers are competent enough to provide these skills. At this point, teachers' perceptions of digital technologies, their motivation for professional development and their participation in learning communities will be decisive. In this context, the integration of Industry 4.0 into education systems should not be limited to technological infrastructure; teachers' perceptions, attitudes and competencies in using these technologies should also be taken into consideration. In order for teachers to contribute to digital transformation, it is important that their awareness in this field is high and then they are supported in pedagogical integration.

7. Recommendation

Based on the findings of the study, the following recommendations were developed:

- Education Policies: The Ministry of National Education and the Council of Higher Education should make strategic plans to integrate Industry 4.0 components into all levels of education. In particular, content that raises digital awareness at an early age should be added to pre-school education programs.
- In-Service Trainings: Teachers should be included in continuous professional development programs to enable them to use Industry 4.0 technologies pedagogically. In particular, practical trainings to improve teachers' competencies on perceived benefits and ease of use are recommended.

- Applied Projects: Collaborative projects should be developed between vocational high schools and industry; university students should be provided with Industry 4.0 experience through interdisciplinary projects.
- Research: It is recommended to conduct validity and reliability analyses of the Industry 4.0 Awareness Scale in different age groups, branches and country samples; and to conduct comparative studies with mixed methods.
- Social Awareness: In order to train teachers who can grasp the opportunities offered by digitalization and lead this transformation, not only individual efforts but also institutional and systemic transformations are necessary.

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