



AN INVESTIGATION OF PRE-SERVICE SCIENCE TEACHERS' PERCEPTIONS AND ATTITUDES TOWARD EDUCATION 4.0

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Abstract:

The purpose of this study is to determine the perceptions and attitudes of pre-service science teachers toward Education 4.0 and to examine whether these attitudes differ significantly based on gender, grade level, and academic achievement. Designed using the descriptive survey model, a quantitative research method, the study was conducted in the spring semester of the 2023–2024 academic year with 98 pre-service teachers enrolled in the science education program at a public university in Türkiye. Data were collected using the “Education 4.0 Attitude Scale” developed by Karaman, Çalışır, and Taş (2020) and analyzed using SPSS 28.0. Since the data did not show normal distribution, non-parametric tests—Mann-Whitney U and Kruskal-Wallis H—were employed. The results indicated that the participants’ overall attitude toward Education 4.0 was above average. A statistically significant difference was observed in favor of male students in some sub-dimensions based on gender. Regarding grade level, a significant difference was found only in the “Perception” sub-dimension, in favor of second-year students. No significant difference was observed in attitudes according to academic achievement. The findings suggest that while pre-service science teachers generally hold positive attitudes toward Education 4.0, these attitudes may vary depending on individual and demographic factors in certain sub-dimensions.

Keywords: Education 4.0, teacher education, pre-service science teachers, digital competence, attitude

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1. Background of the Problem

Education plays a fundamental role in the social, economic, and cultural development of societies. Therefore, global trends and technological advancements have necessitated the restructuring of educational systems. In recent years, industrial transformations—especially those related to the Fourth Industrial Revolution, or Industry 4.0—have introduced innovations such as digitalization, automation, artificial intelligence, and the Internet of Things. These changes have also compelled education systems to evolve in parallel. One key reason is the shift in the qualifications demanded by the labor market; another is the change in how today's learners' access and interact with information. Born into the digital era, learners now expect more interactive, fast, flexible, and personalized learning experiences. They do not see technology merely as a tool but as an integral part of the learning process.

The impact of Industry 4.0 on education has given rise to the concept of Education 4.0—a next-generation educational approach shaped by digital transformation. According to Fisk (2017), Education 4.0 is not merely a reflection of technological change but a model that supports personalized, creative, flexible, and lifelong learning integrated with technology. Similarly, Hussin (2018) defines Education 4.0 as a student-centered, innovative model that reshapes learning based on technological advances and promotes active participation in the digital world. In general, Education 4.0 aims to equip individuals with the skills required for the digital age while redefining the roles of teachers and students through technology integration (Öztemel, 2018; Karaman, Çalışır & Taş, 2020). It envisions individuals as creative, digitally literate, adaptable, and capable of multidimensional thinking.

The World Economic Forum's report titled "Schools of the Future: Defining New Models of Education for the Fourth Industrial Revolution" identifies eight key transformation points that education systems must undergo to adapt to Industry 4.0. These include four areas related to content and four related to learning experiences (WEF, 2020). As shown in Table 1, these dimensions emphasize global citizenship, creativity, technological competence, and interpersonal skills in terms of content, and personalized, inclusive, collaborative, and lifelong learning in terms of experience.

As seen in Table 1, the transformation required by Education 4.0 necessitates a comprehensive restructuring of both learning content and experiences. While content focuses on equipping individuals with 21st-century competencies, the experience dimension promotes an education that is inclusive, collaborative, and continuously evolving.

Table 1: Transformation points of Education 4.0 (WEF, 2020)

Content (built-in mechanisms for skills adaptation)	Global citizenship skills: To include content that focuses on building awareness about the wider world, sustainability and playing an active role in the global community.
	Innovation and creativity skills: To include content that fosters skills required for innovation, including complex problem-solving, analytical thinking, creativity and systems-analysis
	Technology skills: To include content that is based on developing digital skills, including programming, digital responsibility and the use of technology.
	Interpersonal skills: To include content that focuses on interpersonal emotional intelligence (i.e. empathy, cooperation, negotiation, leadership and social awareness).
Experiences (leveraging innovative pedagogies)	Personalized and self-paced learning: From a system where learning is standardized, to one based on the diverse individual needs of each learner, and flexible enough to enable each learner to progress at their own pace.
	Accessible and inclusive learning: From a system where learning is confined to those with access to school buildings to one in which everyone has access to learning and is therefore inclusive.
	Problem-based and collaborative learning: From process-based to project and problem-based content delivery, requiring peer collaboration and more closely mirroring the future of work.
	Lifelong and student-driven learning: From a system where learning and skilling decrease over one's lifespan to one where everyone continuously improves on existing skills and acquires new ones based on their individual needs.

Note: Adapted from "Schools of the Future: Defining New Models of Education for the Fourth Industrial Revolution" (World Economic Forum, 2020).

This transformation also reshapes the roles of teachers who design and guide learning experiences. Teachers are no longer seen as transmitters of knowledge but as facilitators who support personalized development and integrate technology effectively into pedagogy. Teachers are expected to possess a wide range of competencies, including digital literacy, creativity, problem-solving, communication, collaboration, and critical thinking (Asıl & Asıl, 2024; Öztemel, 2018). They should also be able to design personalized, technology-supported environments where students actively manage their own learning (Aberšek & Flogie, 2018). Education 4.0 redefines teachers as learning leaders who create student-centered, technology-enhanced experiences (Hussin, 2018; Miranda et al., 2021; Oliveira & de Souza, 2022). Teachers' attitudes and self-efficacy in using technology are critical for their alignment with this paradigm (Sabuncu, Çalışır & Kışla, 2022).

Understanding how the transformation points of Education 4.0 align with science education is crucial, as science is inherently grounded in knowledge, technology, and innovation. Science education plays a vital role in developing students' analytical thinking, problem-solving, scientific reasoning, and technological literacy. To cultivate individuals who meet the demands of Education 4.0, science education must move away from traditional knowledge transmission toward a student-centered, interdisciplinary, inquiry-based, and technology-integrated approach. Learning environments should

foster both scientific thinking and real-life problem solving through the effective use of digital tools. Aydın Ceran (2021) emphasized that science education is central to equipping students with 21st-century skills and that relevant policies hold transformative potential.

Pre-service science teachers play a pivotal role in this transformation. They must not only possess strong content knowledge but also be capable of integrating technology meaningfully, addressing learner diversity, and applying flexible, modern teaching practices. Therefore, assessing their awareness, attitudes, and readiness regarding Education 4.0 prior to entering the profession is essential. Such assessment is important for evaluating the quality of teacher training programs and predicting future instructional practices. Teachers' understanding of Education 4.0 directly influences classroom applications and, ultimately, student outcomes.

Despite the significance of this topic, empirical studies examining pre-service science teachers' perspectives on Education 4.0 remain limited in the literature. Most existing research is theoretical, highlighting the need for data-driven investigations that explore differences based on demographic variables.

This study aims to determine the perceptions and attitudes of pre-service science teachers toward Education 4.0 and to examine whether these differ based on gender, grade level, and academic achievement. The findings are expected to inform teacher training policies and programs by identifying how well future educators are prepared for the demands of the digital age.

The research seeks to answer the following questions:

- 1) What are the general perception and attitude levels of pre-service science teachers toward Education 4.0?
- 2) Do these perceptions and attitudes differ significantly by gender?
- 3) Do they differ significantly by grade level?
- 4) Do they differ significantly by academic achievement level?

2. Material and Methods

2.1 Research Design

This study was designed within the framework of the descriptive survey model, which is one of the quantitative research methods. The descriptive survey model is appropriate for studies aiming to present the current situation as it is and to examine whether there are statistically significant differences based on specific variables. In this research, it was aimed to describe pre-service science teachers' attitudes toward Education 4.0 and to determine whether these attitudes differ significantly in relation to certain demographic variables (gender, grade level, and academic achievement).

2.2 Participants

The study group consisted of a total of 98 pre-service science teachers enrolled in the Science Education undergraduate program at the Faculty of Education of a public

university during the spring semester of the 2023–2024 academic year. The participants were selected from an accessible student group and participated voluntarily in the study. Demographic characteristics of the participants are presented below.

Table 2: Demographic Characteristics of the Participants

Variable	Groups	f	%
Gender	Female	70	71.4
	Male	28	28.6
Grade Level	2nd Year	35	35.7
	3rd Year	37	37.8
	4th Year	26	26.5
Academic Achievement	Unsuccessful	2	2.0
	Successful	57	58.2
	Very successful	39	39.8
	Total	98	100

Note: Percentages are rounded to one decimal place

2.3 Data Collection Tool

In this study, the "Education 4.0 Attitude Scale" developed by Karaman, Çalışır, and Taş (2020) was used as the data collection instrument. The scale consists of a total of 38 items and is structured into six sub-dimensions. It is designed as a five-point Likert-type scale (1 = Strongly Disagree, 5 = Strongly Agree). The sub-dimensions of the scale are defined as: impact on the instructor, impact on learning, perceived benefit, perception, applicability, and impact on socialization.

Some items in the scale were reverse-coded, and the necessary coding adjustments were made prior to data analysis. In the original study, the Cronbach's alpha internal consistency coefficient was reported as .91. In the current study, the Cronbach's alpha was calculated as .94, indicating a high level of internal reliability.

2.4 Data Analysis

The collected data were analyzed using the SPSS 28.0 statistical package program. First, reverse-coded items were recoded, and sub-dimension scores were calculated for each participant. To determine whether the data followed a normal distribution, the Kolmogorov-Smirnov test was applied. The results indicated that some sub-dimensions did not exhibit a normal distribution.

Accordingly, the Mann-Whitney U test was used for comparisons between two groups, while the Kruskal-Wallis H test was employed for comparisons involving three or more groups. For the first research question, descriptive statistics (arithmetic mean, standard deviation, minimum, and maximum values) were calculated. For the remaining research questions, appropriate non-parametric tests were used to compare groups.

3. Results and Discussion

In this section, the findings regarding pre-service science teachers' attitudes toward Education 4.0, as well as the differences based on gender, grade level, and academic achievement, are presented and discussed according to each research question.

3.1 Attitudes Toward Education 4.0 – General Level

The first research question aimed to determine the general level of pre-service science teachers' attitudes toward Education 4.0. Descriptive statistics related to the sub-dimensions and the total score of the Education 4.0 Attitude Scale were calculated. It was found that the participants' overall attitude scores were above the moderate level ($\bar{X} = 3.74$, $SD = 0.49$). The highest mean scores were obtained in the sub-dimensions of Perceived Benefit ($\bar{X} = 3.83$) and Impact on the Instructor ($\bar{X} = 3.82$), while the lowest scores were observed in Impact on Socialization ($\bar{X} = 3.11$) and Perception ($\bar{X} = 3.30$). These findings suggest that participants may be more cautious or undecided regarding the individual and social effects of Education 4.0. The descriptive statistics are presented in Table 3.

Table 3: Descriptive Statistics for the Sub-Dimensions of the Education 4.0 Attitude Scale (n=98)

Dimension	Mean (\bar{X})	Standard Deviation (SD)	Min	Max
Impact on the Instructor	3.82	0.48	2.00	5.00
Impact on Learning	3.76	0.54	2.00	4.92
Perceived Benefit	3.83	0.61	2.00	5.00
Perception	3.30	1.08	1.00	5.00
Applicability	3.58	0.63	2.00	5.00
Impact on Socialization	3.11	0.91	1.00	5.00
Overall Attitude	3.74	0.49	2.03	4.87

These results indicate that pre-service teachers are generally familiar with the educational paradigm of the digital age and approach the concept of Education 4.0 positively. The high scores in the "Perceived Benefit" and "Impact on the Instructor" dimensions reveal that participants believe Education 4.0 practices can contribute to teaching processes and enhance their professional competencies. Similarly, in the original study conducted by Karaman, Çalışır, and Taş (2020), participants' overall attitudes were also reported as positive.

The findings are also consistent with Hussin's (2018) definition of Education 4.0 as a student-centered, flexible, and technology-integrated learning model. The willingness of pre-service teachers to align with this new paradigm suggests that the core principles of Education 4.0 are beginning to take hold within teacher education. However, the relatively lower means in the "Perception" and "Impact on Socialization" dimensions indicate that participants may still harbor hesitations about the individual and social aspects of this transformation. These outcomes align with Ramírez-Montoya et al. (2022),

who emphasize the importance of fostering higher-order cognitive competencies such as complex, innovative, and systems thinking within Education 4.0 frameworks.

Similarly, Akimov et al. (2023) emphasize in their systematic review of 21st-century skills that adapting to the digital age requires not only technical competencies but also character development, self-regulation, and meta-learning capacities. In this context, pre-service teachers' generally positive attitudes toward Education 4.0 should be reinforced with instructional practices that foster these multifaceted qualities. On the other hand, although Alkayış (2021) did not directly study teacher attitudes, their philosophical and structural evaluations of Education 4.0 also highlighted potential concerns about digitalization and technological transformation, which may help explain the lower scores in the socialization and perception dimensions.

In conclusion, although pre-service teachers seem generally prepared for Education 4.0, this readiness must be deepened through enhanced personal awareness, hands-on experience, and digital socialization. Therefore, it is essential to restructure teacher education programs in alignment with Education 4.0 components and to expand learning experiences that support the holistic technological and pedagogical development of teacher candidates.

3.2 Gender-Based Differences in Attitudes Toward Education 4.0

The second research question examined whether pre-service science teachers' attitudes toward Education 4.0 significantly differed by gender. Since the data were not normally distributed, the Mann-Whitney U test was applied for analysis.

According to the results, statistically significant differences were found in the sub-dimensions of Impact on Learning ($U = 637.00$, $p = .007$), Perceived Benefit ($U = 676.00$, $p = .015$), and Applicability ($U = 727.50$, $p = .040$), in favor of male participants. No significant differences were found in the other sub-dimensions or in the overall attitude score ($p > .05$). The results are presented in Table 4.

Table 4: Attitudes Toward Education 4.0
by Gender: Mean Scores and Mann-Whitney U Test Results

Dimension	Female (X)	Male (X)	U	p
Impact on the Instructor	3.77	3.93	787.00	.129
Impact on Learning	3.67	3.99	637.00	.007 **
Perceived Benefit	3.74	4.05	676.00	.015 *
Perception	3.36	3.14	1070.00	.479
Applicability	3.49	3.80	727.50	.040 *
Impact on Socialization	3.04	3.33	945.00	.267
Overall Attitude	3.70	3.84	843.00	.198

Note: * $p < .05$, ** $p < .01$.

The findings revealed that male participants had significantly higher scores in the sub-dimensions of Impact on Learning, Perceived Benefit, and Applicability. This suggests that male teacher candidates perceive Education 4.0 practices as more functional and applicable in learning processes. This result aligns with the findings of Miranda et al.

(2021), who emphasized that personalized and flexible learning environments within the Education 4.0 framework may be perceived differently based on individual characteristics. Their study highlighted the need to adapt customized learning experiences to students' needs, suggesting that individual variables such as gender may play a determining role in attitudes toward Education 4.0.

Moreover, Campos and Scherer (2023), in their large-scale study across 32 countries, found that male students tend to develop more positive attitudes toward technology. While female students demonstrated higher performance in digital skills, the researchers reported that gender-based differences in attitudes could partially explain the observed variation. This implies that differences in attitudes toward Education 4.0 may also stem from individual approaches to digital technologies.

However, the lack of significant differences in several sub-dimensions and in the overall attitude score suggests that these gender-based variations are limited to specific areas. This indicates that female teacher candidates also possess general awareness about Education 4.0 but may be more cautious, particularly in terms of perceived benefits and applicability. Therefore, considering individual differences in the transition to Education 4.0 is essential. To minimize gender-based disparities, it is recommended that teacher education programs incorporate inclusive, hands-on learning environments and ensure equal access to digital tools.

3.3 Differences in Attitudes Toward Education 4.0 by Grade Level

The third research question aimed to determine whether pre-service science teachers' attitudes toward Education 4.0 differed significantly based on grade level. Due to the non-normal distribution of the data, the Kruskal-Wallis H test was conducted.

The analysis revealed a statistically significant difference only in the Perception sub-dimension ($H(2) = 11.97, p = .003$). The mean scores indicate that third-year students had lower perception levels compared to second- and fourth-year students. No significant differences were observed in the other sub-dimensions or in the overall attitude scores. The results are presented in Table 5.

Table 5: Attitudes Toward Education 4.0
by Grade Level: Mean Scores and Kruskal-Wallis Test Results

Dimension	2nd Year (X)	3rd Year (X)	4th Year (X)	H	p
Impact on the Instructor	3.75	3.86	3.86	3.72	.156
Impact on Learning	3.69	3.77	3.84	2.68	.262
Perceived Benefit	3.79	3.86	3.84	1.66	.437
Perception	3.54	2.84	3.62	11.97	.003 **
Applicability	3.54	3.64	3.54	0.75	.686
Impact on Socialization	3.14	3.07	3.15	0.48	.788
Overall Attitude	3.68	3.73	3.82	2.42	.298

Note: * $p < .05$, ** $p < .01$.

The results indicate that, in general, pre-service teachers' attitudes toward Education 4.0 did not significantly differ by grade level. However, a significant difference in the

Perception sub-dimension suggests that students' mental representations of Education 4.0 may vary across different stages of their educational experience.

This finding aligns with the study conducted by Sabuncu, Çalışır, and Kışla (2022), which found that teachers' technological competencies significantly varied depending on variables such as age and professional seniority. This supports the idea that individual development and experience during the learning process may influence attitudes, and that grade level can also be a determining factor.

Gürsev (2022) emphasizes that the development of digital competencies is shaped by individuals' time spent with technology, practice-based experiences, and active involvement in problem-solving. Accordingly, the relatively lower perception scores of third-year students may be explained by their limited pedagogical interaction with Education 4.0 components.

Furthermore, Kocaman-Karoğlu, Bal-Çetinkaya, and Çimşir (2020) suggest that in the context of Education 4.0 and Society 5.0, students should become individuals who not only use technology but also design and transform it while managing their own learning processes. The asynchronous internalization of such a transformation across grade levels may cause variation in attitudes toward abstract and future-oriented concepts like Education 4.0.

3.4 Differences in Attitudes Toward Education 4.0 by Academic Achievement Level

The final research question investigated whether pre-service science teachers' attitudes toward Education 4.0 differed significantly based on their academic achievement levels. The Kruskal-Wallis H test revealed no statistically significant differences across any of the sub-dimensions or in the overall attitude scores ($p > .05$). The relevant findings are presented in Table 6.

Table 6: Attitudes Toward Education 4.0
by Academic Achievement Level: Mean Scores and Kruskal-Wallis Test Results

Dimension	Unsuccessful (X)	Successful (X)	Very Successful (X)	H	p
Impact on the Instructor	3.80	3.80	3.85	0.80	.670
Impact on Learning	3.38	3.73	3.82	2.63	.268
Perceived Benefit	3.75	3.80	3.87	0.33	.849
Perception	4.00	3.27	3.30	1.22	.542
Applicability	3.50	3.57	3.59	0.18	.913
Impact on Socialization	3.25	3.12	3.06	1.75	.417
Overall Attitude	3.79	3.71	3.78	0.98	.612

Note: * $p < .05$, ** $p < .01$.

This result suggests that attitudes toward Education 4.0 may develop independently of academic achievement. Similarly, in a study conducted by Göker (2021), it was reported that students' attitudes toward digital learning environments were more closely related to personal experiences, digital literacy levels, and technological interaction skills rather than academic success. It was emphasized that students' readiness for technology may not be directly explained by traditional indicators of academic performance. This finding

supports the idea that attitudes toward a technology-centered concept like Education 4.0 may not vary significantly with academic achievement.

Moreover, Gürsev (2022) noted that within the scope of Education 4.0, the effectiveness of personalized, flexible, and technology-supported learning models depends more on factors such as digital awareness, access, and learning motivation than on academic success. Accordingly, it can be suggested that even individuals with high academic achievement may exhibit lower attitudes toward Education 4.0 if they lack sufficient pedagogical interaction with technology.

Similarly, in their systematic review, González-Pérez and Ramírez-Montoya (2022) emphasized that positive attitudes toward Education 4.0 are more strongly supported by frequent digital interaction, complex thinking, and experience-based learning than by cognitive performance alone. Their study indicated that such attitudes develop through character, meta-learning, and integrated learning experiences with technology.

Finally, Sabuncu, Çalışır, and Kışla (2022) reported that pre-service teachers' self-efficacy and attitudes toward digital technologies are shaped more by their experiences and interactions with technology than by academic success. This reinforces the present study's findings, highlighting that academic achievement is not the sole determinant of attitudes toward Education 4.0. Instead, the diversity of digital experiences and the acquisition of hands-on learning with technological tools play a more substantial role.

4. Recommendations

Based on the findings of this study, the following recommendations are proposed:

- Teacher education programs should directly incorporate Education 4.0 components and integrate them into pedagogical practices. Pre-service teachers should not only be equipped with technical knowledge but also develop the competencies necessary to translate this knowledge into classroom applications.
- To enhance sub-dimensions such as "Perception" and "Impact on Socialization," collaborative digital activities such as group projects, problem-solving tasks, and scenario-based learning environments should be integrated into the curriculum.
- In order to reduce gender-based differences, practical workshops, seminars, and mentorship programs should be designed to support the digital competencies of especially female pre-service teachers.
- To eliminate grade-level differences, Education 4.0 content should be structured and progressively integrated into all years of teacher training. The lower "Perception" scores observed among third-year students should be addressed by adjusting practice opportunities and balancing content distribution over time.
- Recognizing that attitudes are shaped more by digital experience than academic achievement, teacher candidates should be provided with increased opportunities for interaction with technology through digital materials, hands-on learning environments, and project-based tasks.

- This study was conducted with a limited sample. Future studies should be conducted with larger and more diverse samples, including pre-service teachers from different disciplines. Additionally, mixed-method research designs supported by qualitative approaches are recommended to gain deeper insight into the factors influencing attitudes toward Education 4.0.

5. Conclusion

This study examined the attitudes of pre-service science teachers toward Education 4.0 and analyzed whether these attitudes differed significantly based on variables such as gender, grade level, and academic achievement. The findings can be summarized as follows:

The participants' overall attitude level was found to be above moderate. While high mean scores were observed in the sub-dimensions of Perceived Benefit and Impact on the Instructor, relatively lower scores were recorded in Perception and Impact on Socialization. This indicates that participants found Education 4.0 practices functional for teaching processes but were more cautious about their individual and social implications. With respect to gender, male participants showed significantly more positive attitudes in the sub-dimensions of Impact on Learning, Perceived Benefit, and Applicability compared to female participants, although no significant difference was found in the overall attitude scores. This suggests that gender-based perceptual differences may exist in specific areas, while general attitudes remain relatively balanced.

In terms of grade level, no significant difference was found in overall attitude; however, a significant difference was observed in the Perception sub-dimension, disadvantaging third-year students. This may reflect variations in cognitive representations of Education 4.0 across different stages of the teacher training process, suggesting that such representations may develop as students progress through their education.

Regarding academic achievement, no significant differences were found in any sub-dimension or the overall attitude scores. This finding implies that attitudes toward Education 4.0 may be shaped more by digital experiences, interaction with technology, and pedagogical awareness than by academic success alone.

In conclusion, pre-service science teachers generally demonstrated a positive attitude toward Education 4.0. However, these attitudes showed variation across certain sub-dimensions depending on demographic factors, highlighting the importance of designing teacher education programs that support both technological competence and inclusive pedagogical development.

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Conflict of Interest Statement

The authors declare no conflicts of interest.

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