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Examining the Readiness of Science Teachers for Online Education with a Decision Tree

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Abstract

In this study, the preparedness of science teachers for online education was examined. The research, which used the survey method, involved 306 science teachers working in institutions affiliated with the Ministry of National Education during the 2023-2024 academic year. The "Preparedness for Online Teaching Survey" was used as the data collection tool, and descriptive statistical techniques along with the CHAID algorithm, a decision tree algorithm used for classification analysis, were employed for data analysis. According to the research results, it was found that the participants' competence and attitudes towards technology use in online teaching, as well as their perceptions of online teaching, social connections, and student participation, were positive (at the agree level). It was observed that as the frequency of using video conferencing and EBA (Educational Information Network) increased, the participants' perceptions of online teaching became more positive. Furthermore, the use of teaching methods and techniques such as direct instruction, educational games, question-answer, drama, discussion, and case studies positively affected their perceptions of online teaching.

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Introduction

Science studies natural phenomena encountered in everyday life. Science is not only concerned with numerical data, but also with scientific processes, methods, and skills, and because it covers most events that occur in everyday life, it is a comprehensive field of study that everyone, not just students, needs to understand (Maryanti, et al., 2023). In this age of information, rather than simply imparting scientific knowledge to students, they should be taught the skills to access information. This is achieved by developing students' higher-level scientific skills. Instead of equipping students with rote knowledge, they can be taught mental process skills such as learning through understanding and being able to generate solutions to problems. The importance of a good science education is crucial for students to acquire these skills.

Understanding and being aware of the impact of science and technology on society is part of the definition of scientific literacy (Laugksch, 2000), and scientific literacy is a new requirement for producing knowledgeable and autonomous citizens in post-industrial societies (Correia et al., 2010). According to Norris and Philips (2003), scientific literacy encompasses having knowledge of science, being able to use scientific thinking and problem-solving skills, developing curiosity and appreciation for science, thinking critically, and being able to make informed judgements on science-related issues.

In order to overcome the challenges of the 21st century in the fields of science and technology, students must be equipped with a variety of skills. These skills include digital literacy, creative thinking, effective communication and high productivity. Scientific literacy is an important part of digital literacy and is necessary for individual decision-making, social participation, and economic efficiency. These skills are taught to students through science courses, along with basic and integrated scientific process skills, thereby supporting the development of 21st-century skills (Turiman et al., 2012).

Science education is extremely important for ensuring that students succeed in today's complex and rapidly changing world. Today, countries place great importance on science education in order to remain competitive and stay ahead in the fields of science and technology (DeBoer, 2011). In science education, methods such as laboratory experiments, observation and interaction-based learning play an important role. The pandemic process brought about sudden and necessary changes in education systems, bringing online education to the forefront. This process necessitated pedagogical change, a different type of relationship with students, and a redefinition of teacher-student roles (Paliwal & Singh, 2021). This situation has been an important turning point, especially for science education, which has a strong practical component. During this process, while teachers tried to support students' scientific process skills through digital tools and virtual laboratories, various difficulties were observed in students' participation in class, motivation, and level of understanding of scientific concepts.

With the emergence of emergency and distance learning, the need for digital applications has increased, and it has become necessary to digitally reorganize educational processes to meet the learning needs of the digital age. In particular, in science education, it has become important to develop alternative solutions so that students are not deprived of experiments (Durkaya, 2022). At the same time, the online education process has created an

opportunity for science teachers to develop their digital competencies and has highlighted the importance of more effective use of technology in education. The experience gained during the pandemic has led to permanent changes in educational practices, and it is expected that this change will continue in order to prepare for similar situations (Howard et al., 2020).

Online teaching requires technological skills as well as pedagogical approaches that differ from face-to-face teaching in order to support online learning (Gurley, 2018). In online teaching, science teachers are expected to adapt their pedagogical approaches to digital platforms, ensure student participation, support scientific inquiry, and communicate effectively in virtual environments (Olofsson et al., 2019). In this process, teachers should be able to effectively use learning management systems and digital tools to plan, teach, assess, and provide feedback (Haleem et al., 2022; Tondeur et al., 2018). Nguyen and Habók (2024) stated that teachers' digital competence is important in teaching-learning processes, professional development, and supporting students through digital skills, and that teachers should be encouraged to use technology to assess student achievement and improve learning processes.

According to Hasyim and colleagues (2024), the better teachers are prepared for online education, the higher the online learning outcomes of students will be. Teachers' digital skills, technological pedagogical content knowledge (TPACK), online teaching self-efficacy, institutional support, and the ability to use online learning and teaching strategies are the most important factors in the process of preparing for online education (Hasyim et al., 2024; Hung, 2016; Koehler et al., 2014). TPACK, which is particularly important for online learning and advocates for the integration of teachers' pedagogical and technological knowledge, focuses on how online courses are designed and online teaching materials (Archambault and Crippen, 2009). Integrating technology and pedagogy is challenging for instructors with insufficient experience (Brinkley-Etzkorn, 2018).

Factors influencing readiness for online education include positive or negative attitudes, motivation levels, and perceptions of technology's contribution to learning (Mekheimer, 2025; Teo, 2011). Positive attitudes and high motivation increase active participation in the online education process. In addition, institutions must provide the hardware requirements for teaching and learning, internet connectivity, and necessary training. A robust technical infrastructure and continuous support mechanisms enable teachers to feel more secure in the online education process (Ally, 2004; Trust and Whalen, 2020).

Teachers with high readiness plan online lessons that are more effective from a pedagogical and technological perspective, use different teaching materials, increase interaction, and can adapt to students' individual needs (Baran, Correia, & Thompson, 2011; Mishra & Koehler, 2006). Additionally, by using online platforms and digital tools more effectively and creatively, they ensure a seamless flow of lessons and increase the speed of problem-solving in the face of technical issues (Hung, 2016; Tondeur et al., 2018). By improving the quality of student-teacher interaction, they can apply methods such as online discussion, instant feedback, and group work more effectively (Ally, 2004; Martin, Budhrani, & Wang, 2019). This increases students' motivation to participate in class and their learning success (Trust & Whalen, 2020). In unexpected situations such as a pandemic, teachers with high readiness transition to online teaching more quickly and effectively (Rapanta et al., 2020). Research

shows that teachers' high level of readiness for online education provides a critical advantage not only in terms of technical skills but also in terms of pedagogical flexibility, student interaction, and the ability to adapt to crisis situations.

In the literature, undergraduate students (Deveci Topal, 2016); classroom teachers (Geniş, 2022), teachers from different disciplines (Hasyim et al., 2024; Howard et al., 2020; Hung, 2016; Trust & Whalen, 2020) and faculty members (Barua & Urme, 2025; Gurley, 2018; Martin et al., 2019; Paliwal & Singh, 2021; Rapanta et al., 2020; Tezcan et al., 2025) regarding their readiness for online teaching. Although the literature has examined the readiness of teachers and teaching staff at different levels for online teaching, studies specific to science teachers are limited.

The lack of studies on the readiness of science teachers for online education is critical, particularly due to the unique requirements arising from the practical and experiment-based nature of science courses. Science education provides opportunities for students to develop their experimental, observational, measurement, and scientific process skills; however, it is challenging to conduct these activities as effectively in online teaching environments as in face-to-face settings (DeCoito & Estaiteyeh, 2022; Fernández-Batanero et al., 2021; Klein, 2021; Pavlou & Zacharia, 2024). The limited availability of virtual laboratories and digital experiment tools can make it difficult to concretise science topics, which can also affect students' motivation and comprehension levels. Therefore, determining the level of readiness of science teachers for online teaching is vital in terms of identifying technical and pedagogical needs and developing effective and practical strategies.

Science teachers working in institutions affiliated with the Ministry of National Education play an important role in emergency and distance education processes. This research was conducted to determine teachers' readiness for online teaching and the factors that influence it, to reveal the current situation, and to identify the shortcomings that need to be addressed before the transition to mandatory distance education in the future, in order to enable teachers to deliver effective and efficient instruction. With the rapid introduction of distance education into educational life, the opinions of science teachers on this subject are of great importance for the effective continuation of education and the improvement of its efficiency (Halder, 2012). These findings will form the basis for the development of more effective online teaching strategies for the future.

The purpose of this study is to determine science teachers' readiness for online teaching and their experiences with distance learning. In this study, the concept of readiness was examined in terms of teachers' technological competence, perceptions of online teaching, student interaction, institutional support, lesson design, and their views and competence regarding the use of technology in assessment and evaluation processes. The study sought answers to the following questions.

What are science teachers'

1. perceptions of the online learning and teaching process?
2. perceptions of the learning and teaching process in online teaching?
3. perceptions of social bonds and student participation in online courses?
4. What variables influence their use of technology and their attitude towards technology?

5. What methods and techniques do they use to monitor assessment and evaluation in online courses?

Studies Conducted in Literature

Various studies have been conducted in the literature on teachers' readiness for online teaching. These studies emphasize the importance of teachers' technical, pedagogical and communicative competencies in the transition to online education. For example, Paliwal and Singh (2021) found that teaching staff's course design, communication, and time management competencies were insufficient to manage online education during the pandemic, but that they were able to adopt online teaching more quickly due to their higher technical competencies. This finding shows that technical skills play a decisive role in adapting to online teaching.

Similarly, Hung (2016) examined the readiness of primary and secondary school teachers for online learning and identified differences based on gender and educational level. The study found that male teachers demonstrated higher readiness in learning-transfer self-efficacy than female teachers, and that master's degree graduates had higher communication and learning-transfer self-efficacy than bachelor's degree graduates. Additionally, it was found that teachers with less experience had higher communication self-efficacy, while teachers with more experience had higher self-directed learning levels. These results indicate that both individual characteristics and experience levels influence readiness for online teaching.

Hasyim and colleagues (2024) focused their study on teachers in urban and suburban areas in Indonesia and examined their readiness levels for online teaching and learning using mind mapping techniques. The research showed that teachers in urban areas had a higher level of online readiness than those in suburban areas, and that this had a positive impact on student achievement. This finding highlights that geographical location and access to resources are important factors in adapting to online teaching.

On the other hand, Howard et al. (2020) examined the readiness of secondary school teachers to transition to online teaching at both the individual (TPACK self-efficacy beliefs and online presence) and institutional (support provided by the institution) levels and identified four different ‘readiness profiles’ using latent profile analysis. These profiles show that teachers have different levels of individual and institutional readiness and emphasize the importance of personalized support strategies that take into account the needs of each group.

Research conducted by Trust and Whalen (2020) during the COVID-19 pandemic revealed significant differences in teachers' readiness to use technology to support remote learning. Teachers who frequently used technology adapted to the process more quickly, while most teachers had to learn online teaching methods and tools during the process. This situation shows that adaptation to online teaching is not limited to technical skills, but also requires pedagogical preparation and experience.

Similarly, Martin, Budhrani, and Wang (2019) examined faculty members' readiness to teach online in terms of their perceptions of the importance of course design, communication, and technical competence, as well as their self-confidence. The study found that faculty members perceived the importance of competencies in course design

and communication to be higher than their own abilities, while confidence in their abilities was higher than their perception of importance in time management. Additionally, factors such as gender, duration of online teaching experience, and teaching method were found to have significant effects on both competency perception and self-confidence.

In the context of Turkey, Tekcan et al. (2025) examined the readiness of teaching staff at a state university for online teaching using decision tree analysis. The findings show that teaching staff have high technology usage skills, moderate perceptions of online teaching, and positive perceptions of social connection and student participation. Additionally, increased access to web resources and the ability of those who have used learning management systems in face-to-face education to more easily transfer their skills to online exams have positively influenced their perceptions of online teaching. However, it was found that faculty members with no prior online experience tend to have negative perceptions.

Overall, these studies reveal that the readiness levels of teachers and instructors for online teaching vary depending on factors such as gender, educational level, years of experience, technical competence, institutional support, and geographical location. The findings indicate that technical skills are an important facilitator in the transition to online teaching, but that personalized and continuous support programs are needed to develop pedagogical and communicative competencies.

Method

In this study conducted to determine the readiness of science teachers for distance education, survey model was used and quantitative data were collected. This model examines individuals, groups, institutions, methods and materials to identify, compare, contrast, classify, analyze and interpret the entities and events that constitute different dimensions of the research (Cohen, Manion and Morrison, 2017).

Study Group

The population of the study consists of 306 science teachers working in institutions affiliated to the Ministry of National Education in Istanbul in the 2023-2024 academic year. In the quantitative part of the study, convenience sampling method was used. Convenience sampling is a sampling method preferred especially to speed up the research process and to reach the sampling units more easily. Table 1 shows the demographic information of the teachers who participated in the study.

When the ICT tools used by the teachers for educational purposes were analyzed, it was determined that the teachers who participated in the study used computers (98.4%) and smart phones (94.1%) the most, and smart boards (2.0%) the least. When the purposes of teachers' use of the internet were analyzed, it was seen that the participants used the internet mostly to follow social media (87.9%) and to read news-blocks (85.6%), and the least to play games and have fun (50.3%).

Table 1. Demographic Information of the Science Teachers Participating in the Study

Gender	**N**	**%**	**Educational Background**	**N**	**%**
Female	181	40.8	Undergraduate	270	88.2
Male	125	59.2	Master's Degree	34	11.1
Total	306	100	PhD	2	7
Age	**N**	**%**	**Professional Experience**	**N**	**%**
19-24	6	2	1-5 year	32	10.5
25-30	38	12.4	6-10 year	57	18.6
31-36	76	24.8	11-15 year	85	27.8
37-42	110	35.9	16-20 year	63	20.6
43-54	57	18.6	21-25 year	47	15.4
55-65	19	6.2	26 year and above	22	7.2
ICT tools used by science teachers for educational purposes			**Purposes of Science Teachers' Use of the Internet**		
Computer	301	98.4	Receiving/ Giving Training	236	77.1
Smartphone	288	94.1	Playing games - having fun	154	50.3
Video Camera	131	42.8	Reading News-Block	262	85.6
Tablet	179	58.5	To follow social media	269	87.9
Smart Board	6	2.0	Doing research/reading	224	73.2

Data Collection Tools

In this study, 'Online Teaching Readiness Questionnaire' adapted into Turkish by Hoşgörür and Adnan (2018) was used as a data collection tool. The questionnaire was developed by Chi (2015) as a measurement tool to meet the strategic planning needs of the University of Denver Morgridge School of Education. Hoşgörür and Adnan (2018) adapted the questionnaire into Turkish. The questionnaire consists of five separate sections: learning-teaching process, social connection and student engagement, technology support to instructors, course design and instructional design, and measurement and evaluation. In addition to structured questions rated on a 5-point Likert scale (1: strongly disagree to 5: strongly agree), the questionnaire includes open-ended questions; thus, qualitative and quantitative data can be collected together. Hoşgörür and Adnan (2018) found that the Cronbach's Alpha internal consistency coefficient of the questionnaire was 0.91. Developed by Chi (2015), this scale is based on internationally recognized quality standards, incorporates both infrastructure and teacher-learner perspectives, and also assesses institutional expectations.

Data Collection Process

The necessary permissions and ethics committee approval were obtained for the study. Data were collected from teachers who volunteered to participate in the study through Google Forms. Before the application, the participants were informed about how the collected data would be processed, by whom it could be accessed and how it would be protected in terms of the reliability of the research and the protection of the rights of the participants.

Analyzing the Data

Qualitative and quantitative analyses were performed on the data in order to understand the readiness and experiences of science teachers towards distance education in depth and to achieve the aims of the study. The methods used for the analysis of quantitative data include descriptive statistical techniques and CHAID algorithm. Among the descriptive statistical techniques, basic statistical measures such as percentage (%) and frequency (f) were used. CHAID algorithm, a decision tree algorithm used for classification analysis, was used to determine the interactions between categorical independent variables and a dependent variable and to discover and classify the interactions and relationships in the data set. Decision trees can be created using the CHAID algorithm to determine which factors affect the result in the data set, to reveal the complex relationships of factors and to determine the importance ranking of these factors (Breiman, et al. 1984). In decision trees, the root of the tree (Root Node) is located at the beginning of the structure and this root expresses the dependent variable (Milanović & Stamenković, 2016). While the branches in the tree express the values of the relevant attributes, the leaf nodes express the final result of the decisions. SPSS 22 package program was used for the analysis of quantitative data. In the interpretation of arithmetic averages; 1.00-1,79 point range was evaluated as ‘strongly disagree’, 1.80-2,59 point range as ‘disagree’, 2.60-3,39 point range as ‘slightly agree’, 3.40-4,19 point range as ‘agree’ and 4.20-5 point range as ‘strongly agree’.

Findings

In this study, the variables affecting science teachers' use of and attitudes towards technology, their perceptions about online learning, and their perceptions about social connection and student engagement were analyzed. For this purpose, the decision tree algorithm that classifies according to the most important variables affecting the situation was used. With decision trees, the effect of the variables of digital tools used in distance education, teaching techniques used in online teaching, taking courses on online education and the ability to use online applications on the scores obtained from these scales were examined. Mean scores were taken into consideration while evaluating the scales.

The averages obtained from the scales were first analyzed according to the frequency of using digital tools in distance education. These tools are EBA (Education Information Network), accessing web resources, software and applications, taking screenshots, virtual classroom, video conferencing, video camera and/or video processing system, smart board, student response system, projection, computer laboratory, needing help while using EBA and support provided by EBA. In the second stage, scale averages were analyzed according to the frequency of using teaching techniques used in distance education such as lecture, question-answer, discussion, demonstration, cooperative learning, drama, problem solving, case study, educational game. In the third stage, the effect of the variables of taking at least one online course as a student, receiving training on online teaching, creating applications in online teaching and having knowledge about best practices, using electronic quizzes, discussions and chats in lessons, and using EBA in face-to-face lessons on the scale scores were examined.

In line with the first aim of the study, science teachers' competencies and attitudes towards using technology in

online teaching process, their perceptions towards online teaching, and their perceptions about social bonding and student engagement were analyzed and the arithmetic mean and standard deviation values of the scales are given in Table 2.

Table 2. Teachers' Perceptions about their Competences in Using Technology in Online Teaching, their Perceptions towards Online Teaching, and their Perceptions about Social Bonding and Student Engagement

Scales	N	$\bar{X}$	SD
Competences and attitudes towards using technology in online teaching	306	4.07	.61
Perception towards online teaching	306	3.69	.68
Perceptions of social bonding and student engagement	306	3.57	.69

In general, it can be stated that teachers' competences and attitudes towards using technology in online teaching, their perceptions about online teaching, and their perceptions about social connection and student engagement are at a good (agree) level.

Learning and Teaching Process in Online Teaching

In the first model, the digital tool variables affecting science teachers' perceptions towards online teaching are shown in Figure 1. According to this model, it is seen that the participants' perceptions towards online teaching are at a good (agree) level.

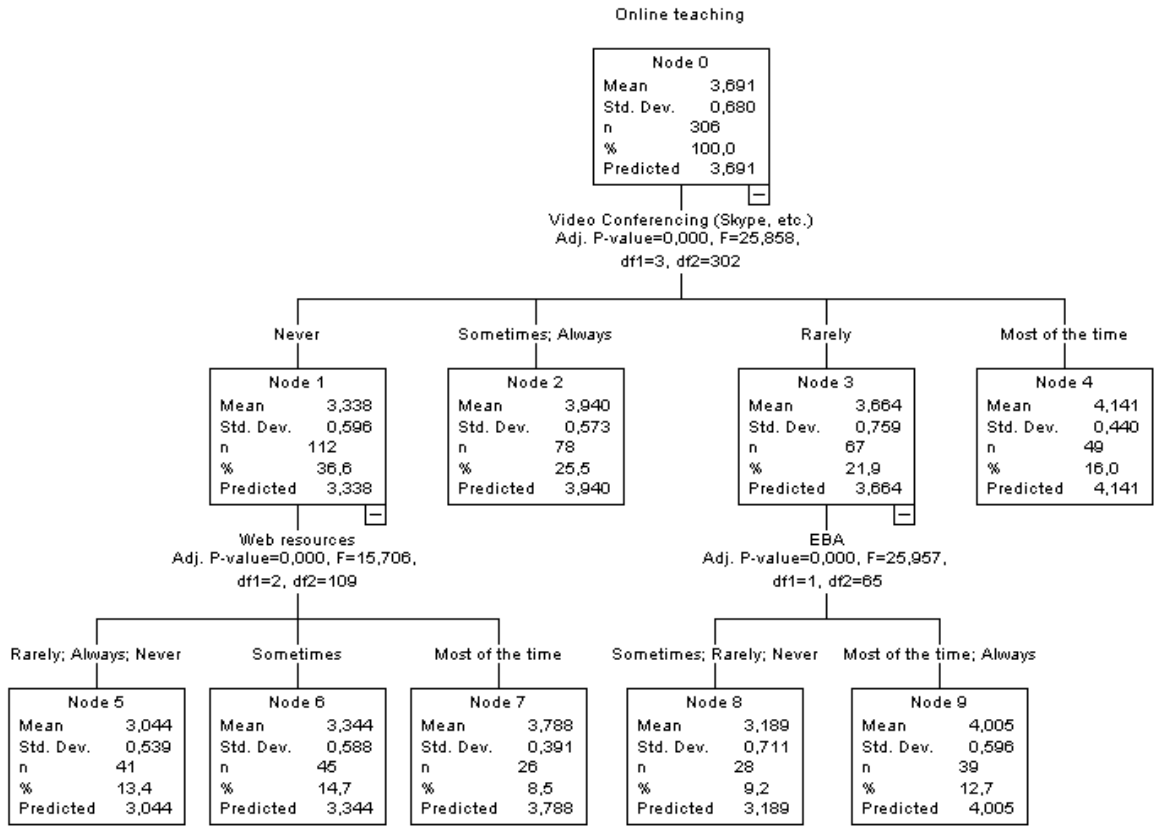

Figure 1. Digital Tool Variables Affecting Science Teachers' Perceptions of Online Teaching (Model 1)

According to Model 1, the most important factor affecting the participants' perceptions towards online learning is the frequency of using video conferencing, and the second factor is the frequency of using web resources and EBA. The most crowded first profile is the group that never uses video conferencing in online teaching processes (Node 1, 36.6%). The perceptions of the teachers in this profile towards online teaching are at a moderate level (slightly agree) and their perceptions towards online teaching become more positive as the frequency of using web resources increases. The second profile under the first main branch (Node 2, 25.5%) is the group that sometimes and always uses video conferences and their perceptions towards online teaching are good. The third profile (Node 3, 21.9%), which rarely uses video conferences, has good perceptions towards online teaching and their perception levels increase as the frequency of using EBA increases. According to this model, as the frequency of using video conferences and EBA increases, the perception towards online teaching becomes more positive. In cases where video conferences are not used, the frequency of using web resources has a positive effect.

In the second model, the effect of the teaching techniques used by the teachers in the distance education process on the perception of online teaching was analyzed (see Figure 2).

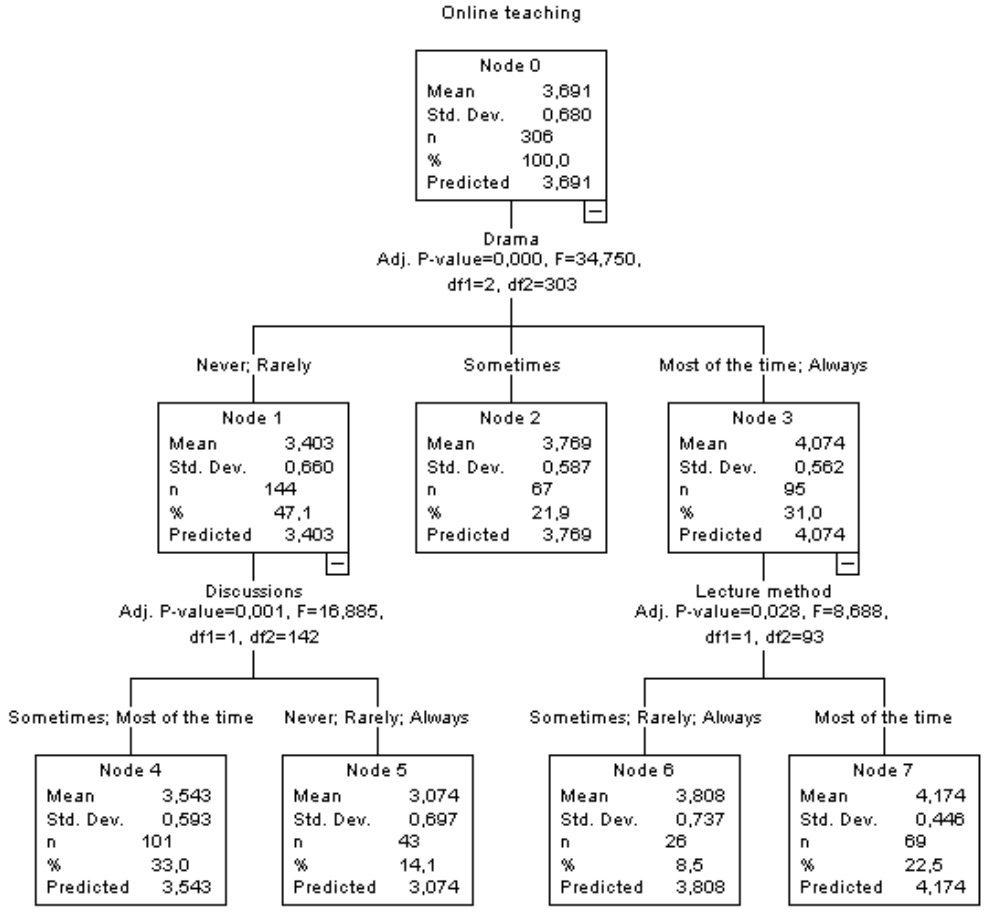

Figure 2. Teaching Techniques Variables Affecting Science Teachers' Perceptions of Online Teaching (Model 2)

According to Model 2, the most important teaching technique affecting teachers' perceptions towards online

teaching is drama. It is seen that those who never or rarely use the drama technique are in the majority (Node 1, 47.1%) and their perceptions towards online teaching are at a moderate level. In this profile, those who use the discussion method most of the time and sometimes are in the majority and their perceptions towards online teaching are at a good level, while those who never, rarely or always use it are at a medium level. In the profile where drama technique is usually used (Node 3, 31%), the perception towards online teaching is better and lecture technique is preferred. Those who use the lecture technique most of the time have higher perceptions towards the online teaching process. As the frequency of using drama technique and discussion method increases, the perception towards online teaching becomes more positive.

In Model 3, the variables of taking courses on online education and ability to use online applications that affect teachers' perceptions towards online teaching were analyzed (see Figure 3).

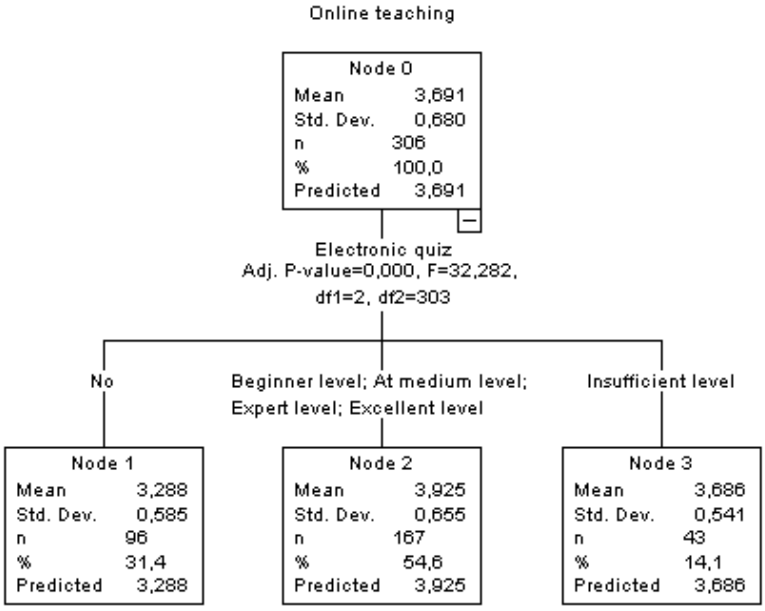

Figure 3. The Variables of Taking Courses on Online Education and Ability to Use Online Applications that Affect Science Teachers' Perceptions towards Online Teaching (Model 3)

According to Model 3, the variable affecting the perception of online teaching is the ability to use electronic quizzes. In this model, as the teachers' ability to use electronic quizzes increases (Node 2, 54.6%), their perceptions of online teaching become more positive.

The frequency and percentage values of science teachers‘ having given online courses before the pandemic, how much of the content can be carried out using online technologies in order for a course to be online in online teaching, and science teachers’ willingness to give online courses even if it is not a necessity are given in Table 3. When The table is analyzed, 73.2% of the teachers who participated in the study stated that they did not teach online courses before the pandemic and 70.3% of them stated that for a course to qualify as an online course, it should be conducted using 50% or more online technologies. In addition, 49% of the teachers stated that they would usually consider teaching online, while 5.6% stated that they would never consider teaching online.

Table 3. Frequency Analysis of Teachers' Having Given Online Courses, How Much of the Content of a Course should be Given Online in order for it to Qualify as Online, and their Willingness to Give Online Courses even if it is not a Necessity

Amount of the content			**Willingness to teach online even if it is not an obligation**		
	f	%		*f*	%
Less than 30%	24	7.8	Never	17	5.6
30%-50%	67	21.9	Rarely	52	17
50%-79%	157	51.3	Sometimes	87	28.4
More than 80%	58	19.0	Most of the time	116	37.9
Having taught online courses before the pandemic			Always	34	11.1
Yes	82	26.8			
No	224	73.2	**Total**	306	100

The motivations of science teachers towards online teaching and their views on the EBA platform are given in Table 4. According to this table, it is seen that science teachers' motivation for online teaching in their current work environment is low (slightly agree, $\bar{X}$=3.10). The participants stated that EBA platform is easy to use (agree, $\bar{X}$=3.75) and EBA platform is sufficient in the process of presenting and managing the lessons (agree, $\bar{X}$=3.51).

Table 4. Science Teachers' Motivation towards Online Teaching and their Views on EBA Platform

Online Education and EBA Platform	***N***	**$\bar{X}$**	**SD**
My current work environment motivates me to do online teaching.	306	3.10	1.037
The Educational Information Network (EBA) used in the process of presenting and managing online courses is easy to use.	306	3.75	.871
The Educational Information Network used in the process of presenting and managing online courses is sufficient.	306	3.51	.873

The frequency values of the responses of science teachers regarding the teaching strategies, methods and techniques they used in online courses are given in Figure 4.

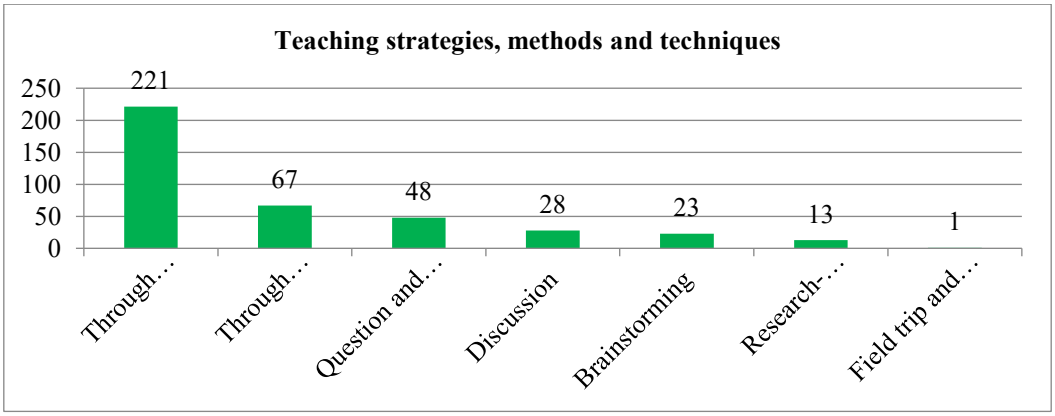

Figure 4. Teaching Strategies, Methods and Techniques used by Science Teachers in Online Courses

Social Bonding and Student Engagement in Online Teaching

The fourth model shows the effect of the digital tools used by teachers on their perceptions of social bonding and student engagement (see Figure 5).

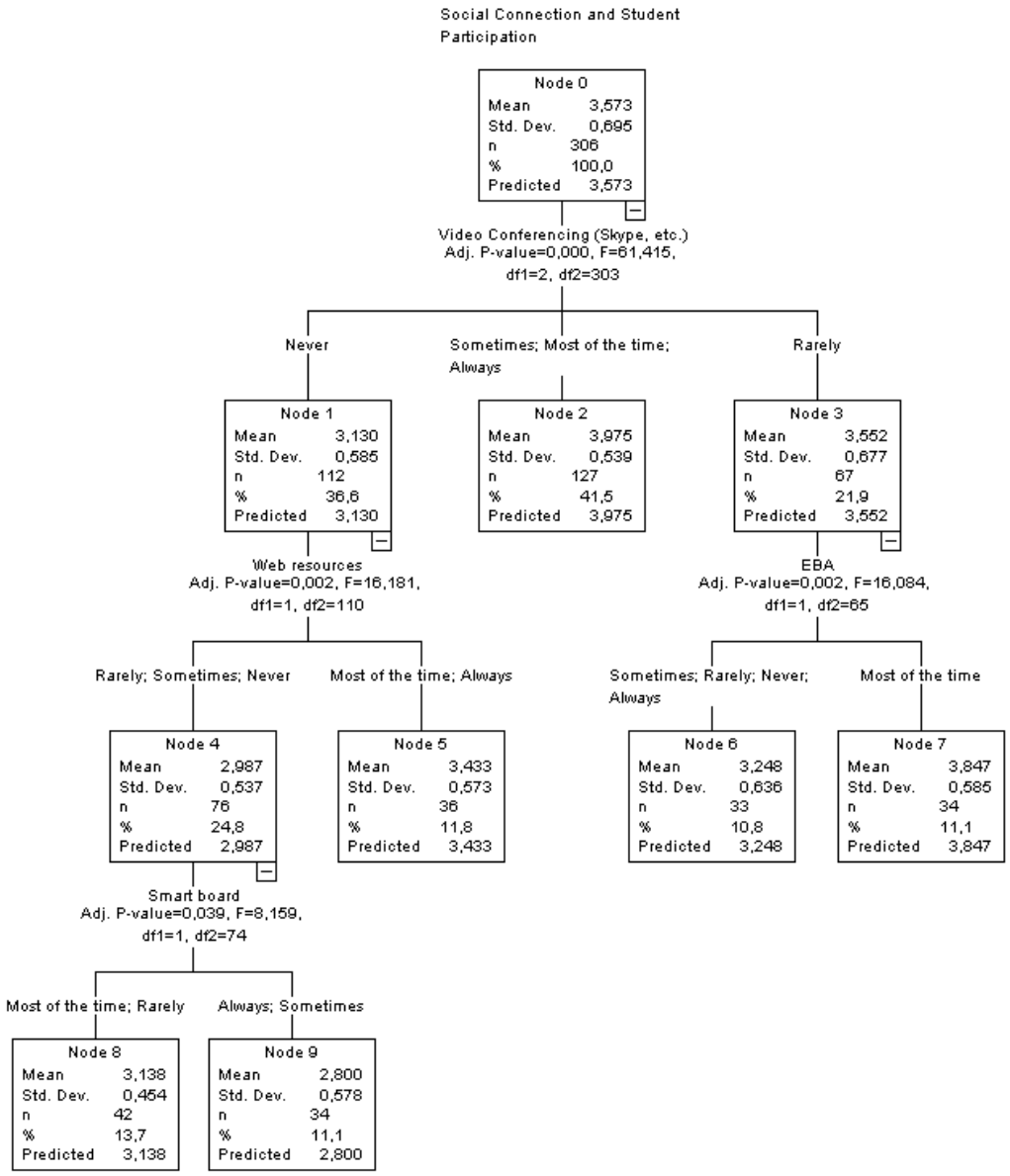

Figure 5. Digital Tool Variables Affecting Science Teachers' Perceptions of Social Connection and Student Engagement (Model 4)

According to this model, the participants' perception of social bonding and student engagement is good (agree, $\bar{X}$=3.57). According to Model 4, the frequency of using video conferences is the most important factor affecting participants' perceptions of social bonding and student engagement. It is seen that the majority of the participants who use video conferences sometimes, most of the time and always (Node 2, 41.5%) and the perception of this profile about social bonding and student engagement is more positive than the perception of the participants in other profiles ($\bar{X}$=3.98). In the profile that never uses video conferences (Node 1, 36.6%), it is seen that they

mostly use web resources sometimes, rarely and never (Node 4, 24.8%) and their social bonding-student engagement levels are moderate (slightly agree) and the most important variable affecting this profile is the rate of using smart boards. The frequency of using EBA plays an important role for those who rarely use video conferences (Node 3, 21.9%). The average of those who use EBA most of the time is higher than the other frequency of use. This result shows that as the frequency of using video conferencing, web resources and EBA increases, teachers' perceptions of social bonding and student engagement become more positive.

The fifth model analyzed the effect of the teaching techniques used by teachers in distance education on the perception of social bonding and student engagement (see Figure 6).

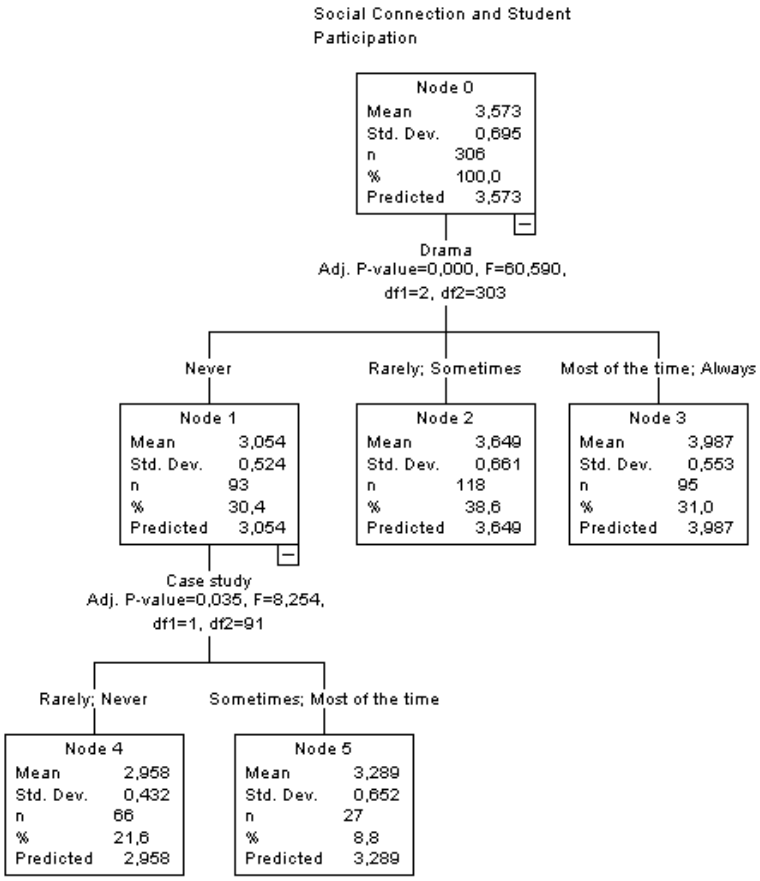

Figure 6. Teaching Techniques Variables Affecting Science Teachers' Perceptions of Social Bonding and Student Engagement (Model 5)

In Model 5, the most important method affecting teachers' perceptions of social bonding and student engagement is drama. In this model, the perception of social bonding and student engagement in the profile of those who never use the drama method (Node 1, 30.4%) is at a moderate level. The perceptions of those in this profile who frequently use the case study method are more positive. The profile of those who use the drama method most of the time and always (Node 3, 31%) has the highest perception of social bonding and student engagement and is interpreted as a good level. Drama method positively affects teachers' perceptions of social bonding and student engagement.

In Model 6, the variables of taking courses on online education and ability to use online applications that affect teachers' perceptions of social bonding and student engagement were analyzed (see Figure 7).

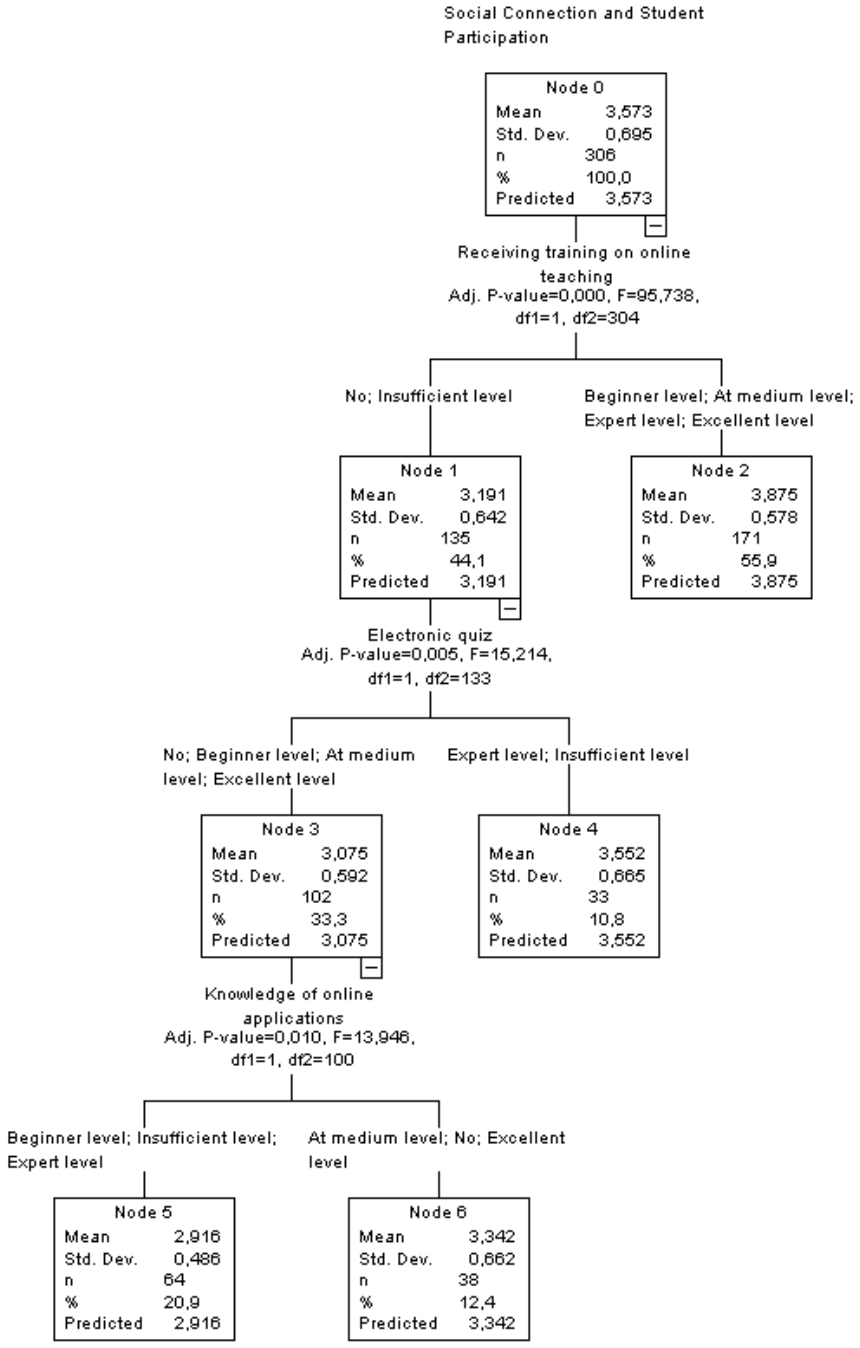

Figure 7. Variables Affecting Science Teachers' Perceptions of Social Bonding and Student Engagement, Taking Courses on Online Education and their Ability to use Online Applications (Model 6)

In Model 6, the most important variable affecting the participants' perceptions of social bonding and student engagement is the level of education about online teaching. In this model, it is seen that teachers who received various levels of training (Node 2, 55.9%) are in the majority and their perceptions of social bonding and student engagement are good. It is seen that the perceptions of those who have received insufficient or no training are at

a medium level (Node 1, 44.1%), and the perceptions of those in this profile who have high skills in using electronic quizzes (Node 4, 10.8%) are better and at a higher level than those who do not (Node 3, 33.3%). The profile with low ability to use electronic quizzes is best affected by having knowledge about online applications. Receiving training on online teaching and the ability to use electronic quizzes positively affect the perception of social bonding and student engagement.

Technology Support for Science Teachers in Online Teaching

In the seventh model obtained, the impact of the digital tools used by science teachers, their level of technology usage, and their attitudes towards technology is shown in Figure 8. Accordingly, it can be seen that a large portion of the participants have high levels of technology usage and attitude scores (agree).

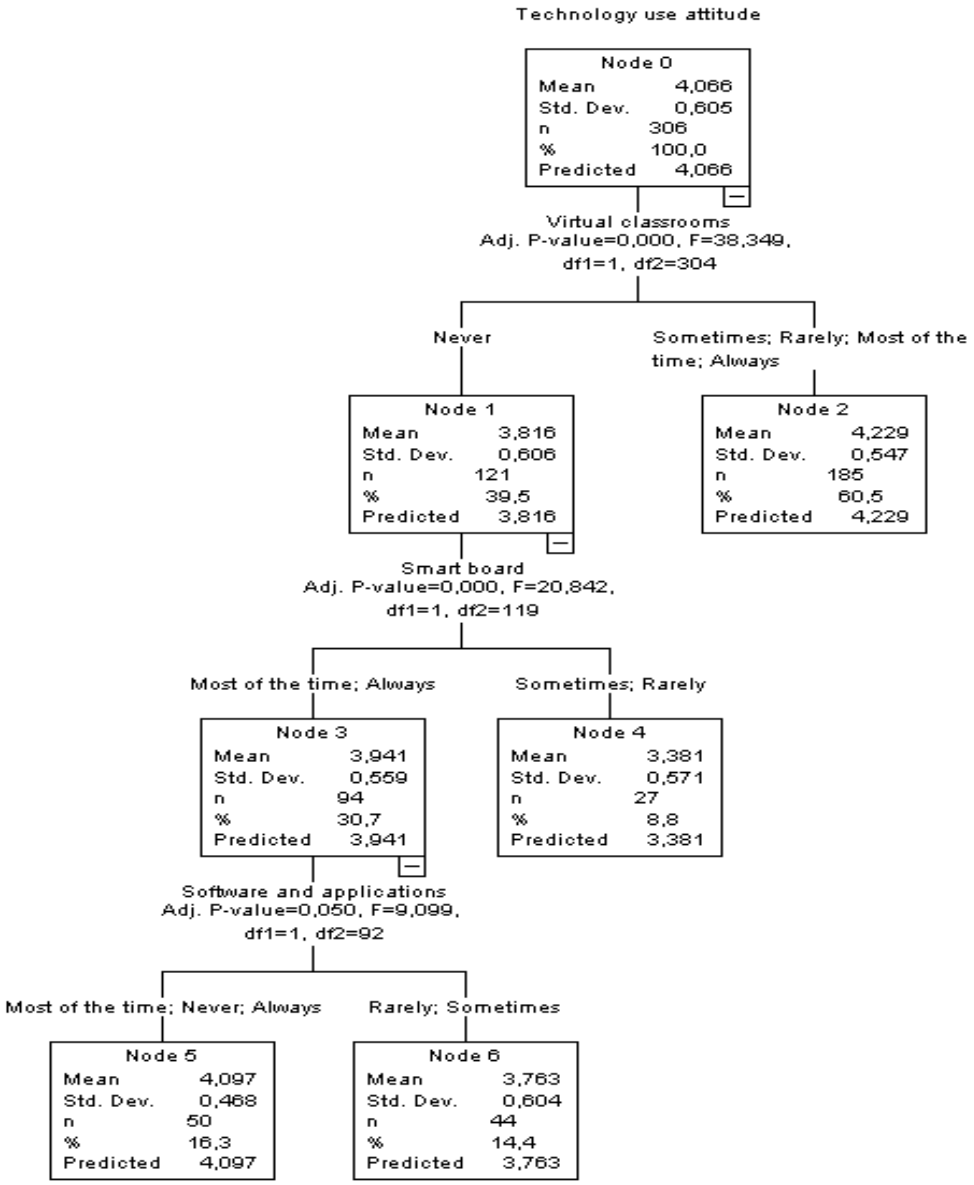

Figure 8. Digital Tool Variables Affecting Science Teachers' Technology Usage and Attitudes Towards Technology (Model 7)

According to Model 7, the frequency of using virtual classrooms is the most significant factor affecting the participants' technology usage and attitudes. The group that never uses virtual classrooms (Node 1, 39.5%) has good technology usage and attitude scores ($\bar{X}$=3.82), while the second and larger group (Node 2, 60.5%) has a very good level of technology usage ($\bar{X}$=4.23). In the group that never uses virtual classrooms, the frequency of using the smartboard is an important variable, whereas in the group that uses virtual classrooms, the frequency of using the EBA platform is significant. Participants in the group that never uses virtual classrooms but frequently uses the smartboard (Node 3, 30.7%) show a close proportion of those who use software and applications rarely or sometimes (Node 8, 14.4%) to those who use them frequently or always (the number of those who never use software and applications is 12, so its impact on this tree is limited and has not been interpreted here). However, as the frequency of using applications increases, the level of positive perception towards technology usage increases. This indicates that as the frequency of using virtual classrooms increases, teachers' technology usage skills and attitudes improve positively. It also shows that those who do not use virtual classrooms prefer using the smartboard more, and as the frequency of using the smartboard with software and applications increases, their technology usage skills improve.

In the eighth model, the impact of the teaching techniques used by teachers in distance education on their perceptions of technology usage skills and attitudes is examined (see Figure 9).

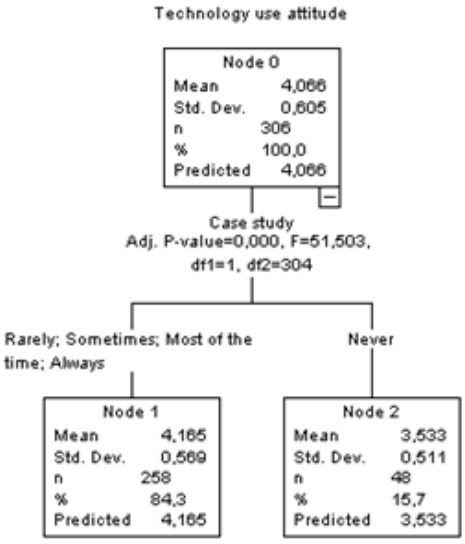

Figure 9. Teaching Technique Variables Affecting Science Teachers' Perceptions of Technology Usage Skills and Attitudes (Model 8)

According to this model, the only teaching method affecting teachers' perceptions of their technology usage skills and attitudes is the case study method. Teachers who use the case study method with varying frequencies have good technology usage skills and attitudes (Node 1, 84.3%), while those who do not use it have an average level of skills and attitudes. Using the case study method positively influences teachers' technological skills and attitudes.

In Model 9, the variables related to taking online courses and the ability to use online applications that affect

teachers' technology usage and attitudes are examined (see Figure 10).

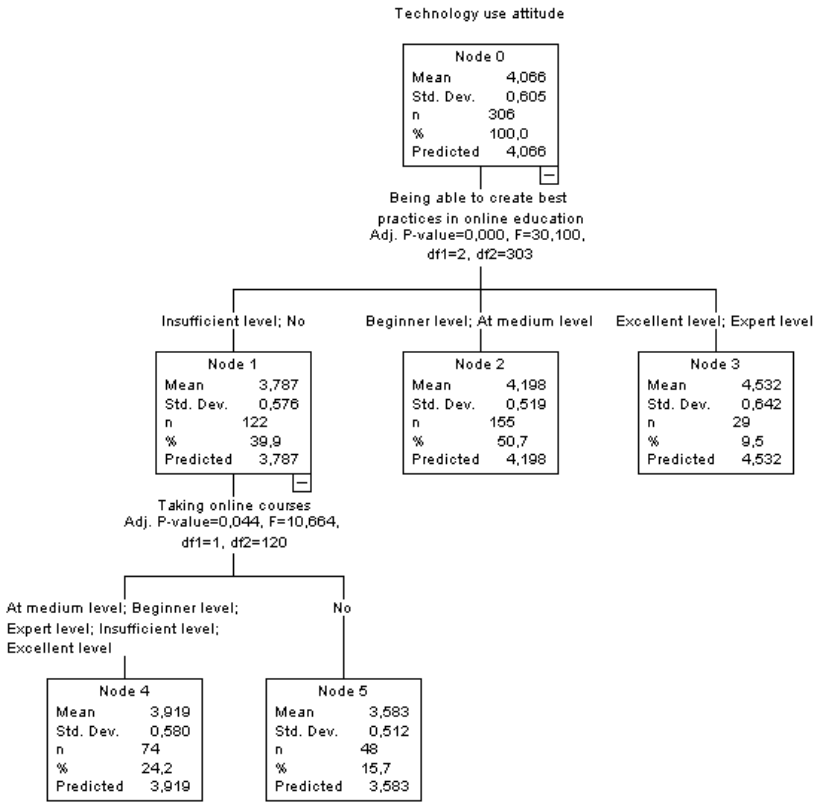

Figure 10. Variables of Taking Online Courses and the Ability to use Online Applications Affecting Science Teachers' Technology Usage and Attitudes towards Technology (Model 9)

According to Model 9, the most significant variable affecting teachers' technology usage and attitudes towards technology is their knowledge of how to create best practices in online education. In this model, those who do not know how to create these practices or have insufficient knowledge (Node 1, 39.9%) have good perceptions of technology usage and attitudes, but these are lower than the other profiles. This profile is also influenced by the status of taking online courses. The proportion of those who have taken online courses at different levels (Node 4, 24.2%) and their perceptions towards technology are higher compared to those who have not taken online courses. The group that is able to create best practices for online teaching at an expert and excellent level (Node 3, 9.5%), despite being the smallest group, has the highest technology usage skills, which are at a very good level. The ability to develop good practices for online teaching and having previously taken an online course enhances the participants' technology usage skills.

Measurement and Evaluation in Online Teaching

The frequency and percentage values of the responses given by science teachers regarding the use of technology in the process of assessing students' learning in online teaching are provided in Table 5. According to this table, 33.3% of science teachers stated that they used technology at a rate of 0-20% in the assessment and evaluation process of their students in online education. A small portion, 2.3%, expressed that they used technology at a rate

of 81-100% in this process. Overall, it can be said that technology is used at a low level for measurement and evaluation.

Table 5. Use of Technology in the Process of Measurement and Evaluation in Online Teaching

Ratio	% 0-20	% 21-40	% 41-60	% 61-80	% 81-100	Total
f	102	91	68	38	7	306
%	33.3	29.7	22.2	12.4	2.3	100

The frequency values of the responses given by science teachers regarding the different technologies they use to monitor students' learning status in online teaching are given in Figure 11.

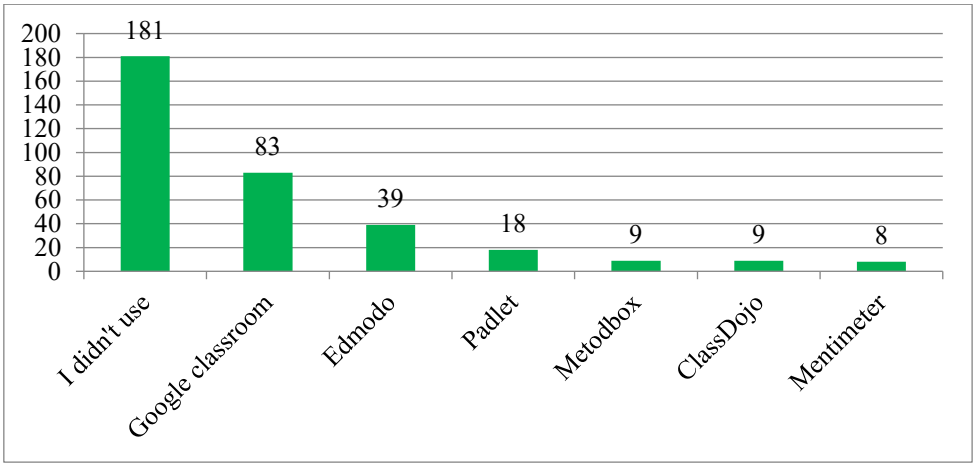

Figure 11. Different Technologies used to Monitor Students' Learning Status in the Online Teaching Process

When the graph in Figure 11 is examined, the majority of science teachers (59.15%) stated that they use technologies determined by the Ministry of National Education (MNE) to monitor students' learning status. 13.39% of teachers stated that they use more than one technological application to monitor students' learning status. The frequency values of the responses given by science teachers regarding the different technologies they use to monitor students' success in online teaching are given in Figure 12.

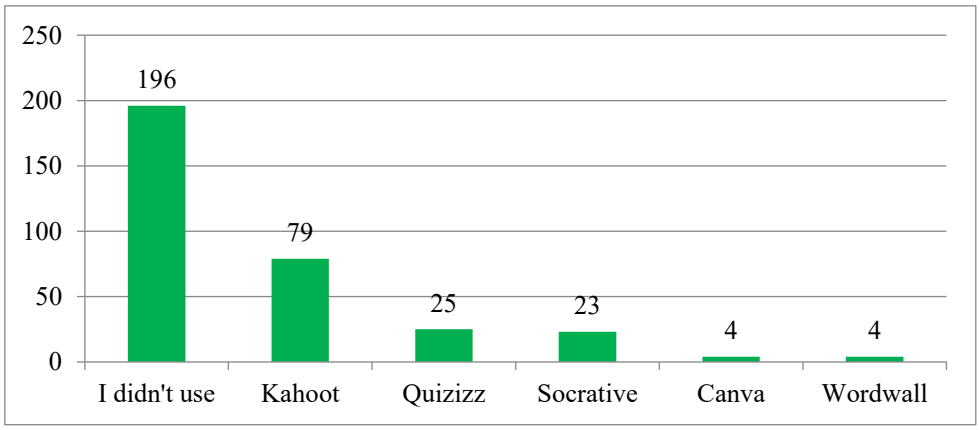

Figure 12. Different Technologies Used to Track Students' Success in Online Teaching Process

When examining the graph in Figure 12, it is observed that the majority of science teachers do not use different programs, and those who do use programs most frequently use tools such as Kahoot, followed by Quizizz and Socrative.

Discussion and Conclusion

The aim of this research was to assess the readiness of science teachers working in institutions affiliated with the Ministry of National Education for online teaching, examine their distance education experiences, and thereby understand the current situation in education. Science teachers' readiness for online teaching was examined under the headings of the teaching-learning process, social bonds and student participation, technology support for teachers, and measurement and evaluation.

Decision tree algorithms were used to understand the readiness of science teachers for distance education, and the variables affecting teachers' technology use, perceptions of online learning, social bonds, and student participation perceptions were investigated. The effects of variables such as technological tools used in distance education, teaching techniques used in online education, skills in taking online classes, and abilities to use online education tools on the scores obtained from the scales were examined.

According to the research results, it is seen that the participants' competencies and attitudes regarding the use of technology in online teaching, along with their perceptions of online teaching, social bonds, and student participation, are favorable (at an agree level). Aldhahi, et al. (2022) also observed a positive relationship between the level of technology use and attitudes toward distance education in their study. Having good competencies and attitudes in using technology in online teaching can enhance the quality of the online teaching process and support student success.

Models 1, 2, and 3 examine the variables affecting teachers' perceptions of online learning, while models 4, 5, and 6 focus on social bonds and student participation, and models 7, 8, and 9 explore digital tools, teaching techniques, and the ability to use online applications that affect technology use and attitudes toward technology. According to Model 1, the frequency of using video conferencing is the most important factor affecting teachers' perceptions of online learning, with the second factor being the frequency of using web resources and EBA (Educational Informatics Network). Teachers who do not use video conferencing at all have moderate perceptions of online teaching, while those who use web resources more frequently have more positive perceptions. As the frequency of using video conferencing and EBA increases, the perception of online teaching improves. Video conferencing systems allow individuals in different geographical locations to communicate simultaneously via audio and video. These systems enable participants to hold interactive meetings with each other (Gillies, 2008). In distance education, they allow students to follow lessons more effectively and make it easier for teachers to interact with students. Therefore, video conferencing systems are considered one of the most effective presentation methods in distance education (Chapman, 1996). In a study by Arkan and Kaya (2018), platforms such as EBA, which provide access to various resources for students and teachers using technology in education, were found to be an essential resource and need. Kuyubaşıoğlu and Kılıç (2019) stated that teachers can easily access information through EBA,

facilitating learning, serving as the teacher's new tool, and making lessons more enjoyable.

According to Model 2, the most significant teaching technique affecting teachers' perceptions of online teaching is drama, followed by discussion and direct instruction techniques. As the frequency of using drama and discussion methods increases, the perception of online teaching becomes more positive. Drama and discussion techniques are methods that encourage active student participation and create interactive learning environments (Liyanawatta, et al. 2022). Başaran and colleagues (2020) stated that the use of techniques such as educational games, question-answer, discussion, and case studies, along with direct instruction, positively impacts teachers' perceptions of online teaching.

According to Model 3, as teachers' ability to use electronic quizzes increases, their perceptions of online teaching become more positive. It is crucial for teachers to effectively use technology and adopt online learning processes to succeed in online education environments. Therefore, technology must be viewed as a natural tool in online teaching and learning processes and integrated harmoniously with pedagogical methods (Carrillo and Flores, 2020).

According to Model 4, as the frequency of using video conferencing, web resources, and EBA increases, teachers' perceptions of social bonding and student participation become more positive. Interaction is frequently emphasized in the literature as an extremely important issue in distance education. Researchers like Swan (2002) and Wilson and Stacey (2004) have stated that interaction plays a critical role in the learning process and that ensuring interaction in distance education environments has a positive impact on student success and satisfaction. In their study Fabriz et al. (2021) found that synchronous learning environments increase students' motivation toward lessons, provide opportunities for more effective participation, and allow students to actively engage in the learning process. In our research, when teachers' responses were examined, it was seen that there were also many negative views on this matter. Another study (Ali et al., 2011) found that the lack of face-to-face communication between the instructor and student in distance education leads to some problems, which decreases students' interest in the lessons.

According to Model 5, the most significant teaching technique affecting teachers' perceptions of social bonds and student participation is the drama technique, followed by case study techniques. As the frequency of using drama and case study techniques increases, teachers' perceptions of social bonds and student participation improve. During the distance education process, teachers reported that they could not effectively use student-centered methods and techniques. Approaches such as drama, collaborative learning, and project-based learning were found to be rarely used in distance education (Ayaydın & Küçük, 2022). If teachers can use these methods in online classes, it could allow them to engage more deeply with students, make the learning process more dynamic and engaging, and enable them to observe students' development more closely.

In Model 6, the most significant variable affecting participants' perceptions of social bonds and student participation is whether they have received training related to online teaching. Teachers who have received online teaching training have positive perceptions of social bonds and student participation. Training on online teaching

and the ability to use electronic quizzes have positively affected teachers' perceptions of social bonds and student participation. Factors such as teachers' willingness to use technology, their technology skills, and how effectively they can use technology for educational purposes significantly affect students' attitudes toward distance education (Dada, 2006). The use of various materials in online classes and the application of different methods and techniques in the teaching process are essential factors that highlighted the pedagogical value of multimodal instructional strategies in fostering learner engagement in online settings (Trifonova & Kiryakova, 2025).

According to Model 7, it has been observed that as the frequency of using virtual classrooms and the frequency of using software and applications increases, technology use skills develop and positive attitudes emerge. It has been determined that those who do not use virtual classrooms prefer to use smart boards more. Virtual classroom applications offer teachers the ability to manage course content, assign homework, track student progress, and provide feedback more efficiently, allowing for better planning and management of lessons (Daviset al., 2019; Manegre & Sabiri, 2020). Teachers' ability to use digital technology effectively depends on their knowledge, skills, and attitudes toward digital technology. The frequency and manner in which teachers use digital technologies for teaching and learning are also important. For teachers to use digital technology effectively and create learning opportunities for students, they need to view technology not only as a tool for transmitting information but also as interactive learning environments (Sailer et al., 2021).

According to Model 8, using the case study method positively affects teachers' technological skills and attitudes. In distance education, direct instruction can be an effective method for conveying complex topics, but it is essential to use various supportive strategies to capture students' attention and ensure participation. Monroe-Baillargeon's (2002) study revealed that the case study method is an effective tool for teachers' integration with technology. It was concluded that teacher candidates developed their technology knowledge and application skills, making teaching processes more efficient and effective. In another study with teacher candidates, it was determined that the case study method, supported by multimedia, had a positive impact on participants' knowledge of teaching technologies (Kinzer, 2008).

According to Model 9, the most important variable affecting teachers' use of technology and attitudes toward technology is knowing how to create best practices for online education. The ability to develop applications for online teaching and having previously taken an online class has enhanced participants' technological skills. Teachers' use of educational technologies depends on the training, experience, and personal preferences they have in this field. Some teachers can effectively use educational technologies, while others may have limited knowledge or experience. To encourage and support teachers in using educational technologies effectively, it is essential to provide them with the necessary training and resources (Sugar, 2002). Teachers' educational programs should be designed to suit today's technology-focused education environments and include courses to enhance technological literacy. By providing training, teachers can gain the skills to use digital tools effectively.

Before the pandemic, science teachers had limited experience with online education, and the pandemic created a necessity in this field. When teachers were asked if they would teach online if it weren't mandatory, a significant portion of them (most of the time) stated that they would be able to teach online. Despite their hesitation toward

online education, only a very small group said they would never want to teach online. In their study, Bojović et al. (2020) stated that distance education will be a part of the lives of teachers and students from now on, and Antoninis et al. (2023) stated that distance education should not replace face-to-face education.

It was observed that teachers' motivation for online teaching in their current work environments is low. Teachers' motivation for online education can be increased by support from the institutions they work for, educational support, and applications and software related to their field. An example of such software and applications in the literature is the Target program developed by Weeldenburg et al. (2024). This program involved teachers as active and reflective participants in their professional development, with the digital application they prepared to support teachers' professional development and increase their motivation, and how this led to changes in all areas of professional development. Bayındır (2021) stated that student-teacher interaction in online environments, the appropriateness of lesson durations, class size, and students' sufficient knowledge and skills in using technology have a significant impact on teachers' motivation.

A large majority of teachers indicated that they did not participate in professional development and certification programs provided by MNE for distance education (online education). In October 2020, MNE launched a project called "Turkey Safe Schooling and Distance Education Project," which emphasized the importance of distance education after the negative experiences during the pandemic. This project highlighted the significance of strong e-learning support, digital content, and pedagogical support.

When examining teachers' responses regarding the measurement and evaluation process in distance education, it was found that the majority did not use a different technological tool for tracking the measurement and evaluation process. Most teachers stated that they made assessments related to the process, such as homework and projects. To make measurement and evaluation methods in distance education more effective and diverse, it is important to increase teachers' technological knowledge and skills. Introducing teachers to Web 2.0 technologies and using them effectively can improve the quality of distance education processes. To enhance the quality of online education, the number of in-service training programs provided by MNE should be increased, where teachers can be informed about which web resources they can use and how to access these resources (Arslan, 2021).

According to the research findings, science teachers' perceptions of distance education are positive, but their knowledge about educational technologies is limited. They reported difficulty applying the teaching methods and techniques they use in face-to-face education in online teaching. This situation creates a negative perception of student participation and motivation toward the lessons. This study can provide guidance on what factors are effective in preparing teachers for distance education and what steps should be taken based on influencing variables.

Recommendations

Based on the results obtained from the research, the following suggestions have been made:

- Teachers can be given distance teaching experience to increase their attitudes toward distance education.

Practical training on technologies, web resources, software, applications, and environments that enhance student-teacher interaction can be organized.

- Training programs can be offered on how to use digital tools and how to create and implement online education activities and evaluations, particularly for science teachers.
- Courses can be provided to teach teachers how to use learning management systems (LMS), online assessment tools, and educational software.
- Teachers can be encouraged to utilize educational applications and tools such as Kahoot, Quizizz, and Socrative for more interactive and engaging online learning environments.
- Teacher motivation for online teaching can be increased by offering online training and professional development programs.
- Research can be conducted to identify existing shortcomings, flaws, and negative opinions in order to increase the diversity and reliability of measurement and evaluation systems in distance education, and the necessary adjustments and improvements can be made to solve the identified problems.
- In order to ensure that the results are generalizable and to obtain more comprehensive results, the research can be repeated in different universes and sample groups, in different provinces or regions.

Statements and Declarations

Data Availability: The data of the research can be shared if requested.

AI Use: We only used tools that include artificial intelligence in the process of translating the article into English.

Ethical Approval: "Ethics Committee Permission" was obtained on 16.3.2023 with the number E-10017888-100-384294 from Kocaeli University.

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