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Investigation into Science Teachers' Attitudes and Acceptance of Social Robot Technology

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Abstract

This study examined teachers' perceptions, attitudes, and acceptance of social robots in education, focusing on their roles as assistants and interaction enhancers. Globally and locally, robots like Pepper and ADA are utilized to deliver lessons, keep students engaged, and facilitate transitions, particularly in science and math classes. Evidence suggests these robots boost student participation through social cues such as nodding, verbal prompts, and guided discussions. However, successful integration depends greatly on teachers' readiness and perceptions, which influence classroom dynamics. Using a descriptive approach, the research evaluates teachers' views on the educational potential and challenges of social robots. Results show a cautious yet optimistic outlook, acknowledging their motivational advantages and potential to lessen teachers' workload by managing repetitive tasks, while also raising concerns about supervision needs, high costs, and the possibility of replacing traditional roles. The study highlights the importance of ethics and AI reliability to foster a positive learning environment. Overall, social robots are seen as supportive, engaging tools rather than substitutes for human educators. Effective curriculum integration requires targeted teacher training to improve both technological and pedagogical skills. These insights are useful for policymakers and developers seeking to modernize classrooms through human-robot collaboration.

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Introduction

Social robots with advanced AI capabilities -such as deep learning -based emotion recognition, multimodal perception, real-time facial expression analysis, vocal tone interpretation, and context-aware autonomous interaction -have become more prominent in educational settings recently. Notably, breakthroughs in Human–Robot Interaction (HRI) have shifted social robots from simple response-delivering tools to systems that adapt to learners' emotional states, personalize interactions, and exhibit pedagogically structured behaviors (Rosanda & Starčič, 2023). Humanoid robots like Pepper and NAO are increasingly used as teacher assistants and interactive learning partners in classrooms across Europe and Asia. Research shows that these robots provide instructional support in science and math by using gestures like head nodding and arm movements to complement verbal explanations, effectively guiding student attention and managing activity transitions (Siever, 2025). When combined with models like ChatGPT, Pepper detects student responses and offers encouraging feedback and guiding dialogue, boosting interaction and engagement (Trinquet Mishra & Pande, 2025). Similarly, NAO enhances cognitive engagement through coordinated gestures, facial expressions, and verbal feedback within structured lessons (Rosanda et al., 2025).

While research on social robots in Turkish education is limited, the ADA 7 robot, introduced in 2022, stands out as a significant example. Featuring capabilities such as speech interaction, AI-supported responses, and classroom guidance, ADA 7 serves as an active participant in teaching and student counseling. It answers questions, boosts engagement in lessons, and supports teachers with lesson planning and classroom management. Consequently, ADA is seen as an innovative educational tool that increases students' interaction with technology and boosts motivation to learn (Akın Robotix, 2023). In lessons where ADA 7 has been used, it has helped improve students' understanding of subjects and allowed teachers to organize classroom activities more effectively. Furthermore, ADA 7 has proven beneficial in special education, especially in enhancing communication skills, establishing eye contact, and encouraging social interaction. It has been employed as a social robot to increase student participation in learning processes and to improve interaction during awareness activities (Selcuklu Autism Individuals Education Foundation [SOBE], 2025).

The OECD's 2021 Digital Education Outlook highlights social robots as valuable pedagogical tools that can enhance classroom learning by boosting student engagement, interaction, and personalized instruction. Similarly, UNESCO's 2025 report stresses that emerging educational technologies, including social robots, should support, not replace, teachers, aligning with human-centered and ethical principles. Belpaeme et al. (2018) suggest that social robots could become as commonplace as paper, whiteboards, and tablets in educational infrastructure. The successful and sustainable integration of social robots depends not only on technological features but also on teachers' attitudes, acceptance, and perception of pedagogical suitability (Ceha et al., 2022; Kennedy et al., 2016; Sharkey, 2016; Smakman et al., 2021). Ewijk et al. (2020) found that teachers' positive attitudes are linked to a clear understanding of the robot's pedagogical role, perceived classroom control, and predictable behavior. LeTendre and Gray (2024) noted that teachers' concerns primarily focus on technical reliability, classroom management, and pedagogical responsibility, which can hinder the integration of robots. Overall, these studies emphasize that teacher acceptance, perceived pedagogical fit, and readiness are crucial factors in the adoption of robotic technologies in education.

Social Robots as Instructional Assistants

Social robots are more than just programmable devices; they can form social relationships with humans through facial expressions, gestures, speech, and reciprocal interactions, creating the impression of being a "social entity" (Kory et al., 2016; LeTendre & Gray, 2024). This conceptual framework helps us understand how social robots are perceived in educational settings, especially in interactions with children. Thanks to their verbal and nonverbal communication skills, social robots can evoke social responses in individuals - particularly children-that mirror human–human interactions. Research shows that children's engagement with social robots goes beyond verbal exchange; it involves a complex social dynamic through facial cues, gestures, gaze, vocal tone, and immediate feedback (Kanda et al., 2004; Leite et al., 2013; Michaelis & Mutlu, 2021). This multimodal interaction encourages children to see robots not just as technological tools but as social partners, fostering more active emotional and cognitive involvement in learning (Kennedy et al., 2016; Woo et al., 2021). During these exchanges, children tend to treat robots as social beings and apply human social norms to them, expecting appropriate behaviors (Han et al., 2008; LeTendre & Gray, 2024). Such interactions enable social robots to serve as both technological tools and social partners, fostering reciprocal relationships with learners.

Michaelis and Mutlu (2021) showed that the social robot "Minnie," by engaging in behaviors such as head nodding, affirmation, and guiding conversations during science lessons, helped students better understand the material, express their thoughts more deeply, and participate more actively. Similarly, Kory et al. (2016) found that the social robot "Tega" boosted children's motivation and encouraged repetitive behaviors through affective feedback. Additionally, Kanda et al. (2004) reported that social behaviors such as addressing children by name and recalling past interactions facilitated social bonds between children and robots, leading to increased voluntary participation in learning. Overall, these studies suggest that social robot–child interactions promote a sense of "social presence," which enhances attention, motivation, and cognitive effort. As a result, social robots have significant potential as "interaction-based learning partners" in education. This strong interaction also raises questions about the pedagogical roles and positioning of these technologies in educational environments.

Analyzing the roles of social robots in education reveals that, although the use of robots resembling teachers is increasing, their primary function remains as supporting tools for teachers. For instance, the humanoid robot Pepper has served as a teaching assistant in a high school biology class, directly presenting content and performing instructional tasks (Sievers & Russwinkel, 2024). Likewise, the social robot NAO has delivered instructional material aligned with specific learning goals, provided guiding explanations, and supported the learning process by assuming an instructional role (Gardenghi & Gherardi, 2024; Rosanda et al., 2025). Pepper has also been reported to act as an instructional element in project-based learning settings by delivering lesson instructions, organizing activities, and helping maintain the flow of learning (LeTendre & Gray, 2024).

However, these studies highlight that core responsibilities -such as making pedagogical decisions, managing the classroom, and setting learning goals - still fall under the teacher's control. Social robots mainly serve supportive, structuring roles rather than acting as autonomous teachers. The results suggest that social robots are currently used as pedagogical tools that assist and organize the teaching process more effectively and sustainably (Rosanda et al., 2025; Serholt, 2018). In addition to these supportive roles, the "learning companion" model, which features a more balanced, horizontal relationship between social robots and learners, also plays a significant role in the research (Han et al., 2008; Short et al., 2017).

Social robots serve as "learning companions" in children's education, helping reinforce knowledge learned at home or school through practice with the robot. For instance, the home and educational robot IROBI was created to address parents' long working hours by performing daily activities such as teaching English, dancing, reciting nursery rhymes, and providing home security functions (Han et al., 2008). Similarly, the social robot Cozmo is used as a learning partner via game- and task-based interactions; long-term interaction with Cozmo has been shown to boost children's interest in learning and their willingness to engage in problem-solving and repetitive activities (Short et al., 2017). Likewise, Mini Ada is designed for one-on-one interaction with students in classroom and out-of-school settings, acting as a learning companion that supports the learning process. It provides verbal responses to questions, offers hints for topics requiring repetition, and maintains engagement through facial expressions and limited body movements (Akınrobotics, 2019). In a study by Sagdic (2024), Mini Ada was used as a conversational partner and learning aid for children with autism spectrum disorder; its predictable, nonjudgmental interactions fostered positive changes in social communication skills, including increased eye contact, conversation maintenance, motivation, and confidence.

Critique of Social Robots Used in Education

Research shows that humanoid robots serve as effective educational tools both in and out of the classroom, boosting student achievement, motivation, and engagement (Chang et al., 2010; Han et al., 2008; Komatsubara et al., 2014; Michaelis & Mutlu, 2021; Shiomi et al., 2015). Khalifa et al. (2016) found that robots, especially, enhance mathematics and science instruction by capturing students' attention, focusing their engagement, and increasing motivation; students who interacted with robots performed better academically than those in traditional settings. Chang et al. (2010) reported that using humanoid robots as instructional aids with elementary students increased participation, made learning more enjoyable, and significantly boosted the performance of lower-achieving students. Likewise, Komatsubara et al. (2014) observed in Japan that social robots in science classes increased student interaction and interest, although they did not significantly improve achievement. Shiomi et al. (2015) noted that while robots did not directly raise interest in science, they prompted more questions and active participation. Furthermore, Michaelis and Mutlu (2021) found that students engaging in interactive reading sessions with social robots showed greater interest and motivation.

An analysis of Turkish literature reveals that research on social and humanoid robots in education primarily focuses on special education, autism spectrum disorder, social skills enhancement, teachers' and pre-service teachers' attitudes, and robot-assisted, interaction-based teaching methods. In particular, studies involving children with autism demonstrate that humanoid robots effectively foster joint attention, imitation, verbal communication, and social interaction skills. Additionally, consistent and structured interactions with robots have been shown to boost children's engagement in learning activities (Cakmak Ekici, 2024; Sen, 2021; Turkalp, 2023).

Besides these studies, it is important to note that social robots can serve as tools to increase motivation and support learning in special education. However, most current applications are short-term, experimental, and involve small sample sizes (Akalin, 2014; Turkalp, 2023). Research in Türkiye with teachers and pre-service teachers shows that attitudes toward social and humanoid robots tend to be cautious and conditional. Concerns about pedagogical roles, classroom management, and ethical responsibilities strongly influence teachers' perspectives (Cinar, 2018; Koksalan, Akpinar & Akyildiz, 2024; Yildirim & Sad, 2019).

Yildirim and Sad (2019) found that teachers' acceptance of humanoid robot technology is moderate, indicating neither full rejection nor full embrace. Similarly, Cinar (2018) noted that while pre-service science teachers generally have positive views on social robots, they are concerned about the robots' proximity to the teacher's role and how they might affect classroom management. Recent thesis research also highlights that, although teachers and pre-service teachers see social robots as useful educational tools, they feel they need more support in areas like readiness, technical skills, and pedagogical integration (Cakmak Ekici, 2024; Turkalp, 2023).

When considering these studies together, it is clear that social and humanoid robots can serve as valuable educational tools, especially by improving student–robot interactions that boost motivation, classroom engagement, and interest in learning. However, the literature shows that the impact of robot-assisted applications on academic achievement varies based on factors such as subject matter, duration, and the robot's pedagogical role. Some studies report limited academic improvements despite increased interaction and motivation. Furthermore, many international and Türkiye-based studies focus on short-term use, specific populations such as students with special needs, and controlled environments. Research on classroom-based, teacher-robot collaborations within natural learning settings is scarce. This highlights the need for a comprehensive approach to integrating social robots in education -one that considers student outcomes, teachers' attitudes, perceptions of pedagogical fit, and practical classroom experiences for sustainable and effective use.

Problem Statement

The successful and sustainable implementation of robotic technologies in classrooms depends not only on having the necessary technical infrastructure but also heavily relies on teachers' knowledge, skills, pedagogical understanding, and attitudes toward these tools (Ertmer & Ottenbreit-Leftwich, 2010; Mubin et al., 2013; Tondeur et al., 2017). Studies on technology integration have shown that teachers' beliefs and attitudes toward new technologies are crucial in determining their classroom use, pedagogical alignment, and the likelihood of long-term adoption (Kucuk, 2022; Namdar & Kucuk, 2018; Yildirim et al., 2014). Tondeur et al. (2017) found that teachers' attitudes are among the strongest predictors of their pedagogical practices, and that teacher beliefs significantly influence the effective utilization of technology.

In the context of social robots, teachers tend to perceive them as more complex and multidimensional compared to traditional educational technologies. Unlike simple digital tools, social robots are interactive systems that demonstrate some level of autonomy and human-like social behaviors. This complexity raises additional concerns beyond their pedagogical value, such as classroom management, ethical considerations, how humans and robots interact, the predictability of robot behavior, and the evolving role of teachers in relation to robots (Belpaeme et al., 2018; Lampropoulos, 2025; Sharkey, 2016; Woo et al., 2021).

Research shows that teachers see social robots as potentially useful, but they have significant concerns about managing classrooms, ethical issues, robot predictability, autonomy levels, and human–robot interactions (Belpaeme et al., 2018; Lampropoulos, 2025; Sharkey, 2016; Woo et al., 2021). In line with this, Kennedy et al. (2016) found that although teachers view social robots as beneficial, they still face considerable uncertainties about these aspects. Ceha et al. (2022) added that, despite having specific expectations for how social robots should behave in classrooms, teachers worry about their pedagogical fit. Additionally, the lack of a clear framework for the pedagogical roles of social robots leads teachers to adopt a cautious, 'conditional acceptance' approach to their classroom use (Serholt, 2018). Yildirim and Sad (2019) showed that teachers' acceptance of humanoid robots is moderate, neither fully embracing nor rejecting the technology.

Research with pre-service teachers indicates that such uncertainty appears early in their professional development. Concerns about placing humanoid robots in classrooms, along with feelings of alienation and a sense of losing control, are common. While overall attitudes towards social robots are positive, there are still reservations about their application in fields like education and care (Cinar, 2018; Istenič et al., 2025). Similarly, Istenič et al. (2021) found that pre-service teachers generally view social robots favorably but remain cautious about using them in educational and caregiving settings. These results suggest significant doubt about teachers' preparedness to incorporate social robots into classroom environments.

The literature underscores that for successful implementation of robotic technologies, teachers must believe in their pedagogical benefits, clearly understand their roles, and feel confident in working with them (Belpaeme et al., 2018; Edwards et al., 2016). Mubin et al. (2013) suggest that integration is achievable only when teachers develop positive perceptions of the technology, incorporate robots seamlessly into lesson plans, and are convinced of their educational value. Without teacher acceptance, social robots risk being used only superficially or as mere "attention-grabbing tools." Thus, teacher approval is essential for the pedagogically meaningful and sustainable use of social robots (Smakman et al., 2021).

Science teachers are crucial in this context because they are key in developing scientific skills, STEM practices, and integrating technology (Yildirim et al., 2013). The effectiveness of social robots in experiments, modeling, problem-solving, and interactive learning in science education relies heavily on teachers' acceptance and how they pedagogically interpret these tools. However, research specifically examining science teachers' acceptance of social robots, what influences this acceptance, and their views on pedagogical fit remains limited. Existing studies indicate that science teachers often approach social robots with "cautious acceptance," have concerns about autonomy, and feel uncertain about their pedagogical roles (Kennedy et al., 2016; Serholt, 2018; Smakman et al., 2021; Ewijk et al., 2020).

Most studies to date have focused on student outcomes such as achievement and motivation, the application of social robots in special education, and overall research patterns. Conversely, there is limited research on teachers' readiness, acceptance, and pedagogical integration, especially among in-service science teachers, with most studies focusing on pre-service teachers.

Based on these findings, I identified a notable research gap regarding science teachers' perceptions of social robots in classrooms, how they balance autonomy and control, how robots relate to the teacher's role, and the barriers they face during integration. I also argued that understanding science teachers' acceptance levels of social robot technology can deepen insights into why classroom integration is limited, help identify pedagogical and psychological barriers, and guide the development of teacher training, support, and policies. Therefore, this study aims to assess teachers' acceptance levels, fill a key gap in the literature, and lay a strong theoretical and practical foundation for incorporating social robots into educational settings.

Methods

This study aimed to evaluate science teachers' acceptance of social robot technology. The scarcity of existing research focusing directly on teachers' attitudes, readiness, and perceptions of pedagogical fit with social robots influenced the choice of methodology. Consequently, I adopted a "Survey Research Design" to describe the current situation and quantitatively measure teachers' attitudes. This survey method is suitable for systematically gathering opinions from a large number of teachers and aligns with the goal of addressing uncertainties about teachers' acceptance levels, as outlined in the problem statement.

Participants

The primary sample for the study included 100 science teachers (64 females, 36 males) from various provinces in Türkiye (see Table 1). This group was purposely chosen from a larger pool of 313 science teachers who had applied to the TÜBİTAK 4005 projects I led. The questionnaire was emailed to the teachers and completed online.

Table 1

Distribution of Participants by Demographic Characteristics

Variable	*Category*	*n*
Gender	Male	36
	Female	64
Extensive years of professional experience	0–5 years	18
	6–10 years	23
	10–15 years	44
	16–20 years	15
Educational Level	Bachelor's degree	72
	Master's degree	26
	Phd	2
Employment Region	Black Sea	16
	Central Anatolia	18
	Eastern Anatolia	15
	Southeastern Anatolia	16
	Mediterranean	12
	Aegean	15
	Marmara	8
Total		*100*

Table 1 indicates that the study includes 100 science teachers from various regions of Türkiye. Among them, 36% are male (n = 36) and 64% are female (n = 64), showing a relatively balanced gender distribution. This aligns with the overall gender makeup of teachers in Türkiye (Ministry of National Education [MoNE], 2025).

Analysis of professional experience shows that 18 teachers have 0–5 years, 23 have 6–10 years, 44 have 10–15 years, and 15 have 16–20 years of teaching experience. Regarding education levels, most participants hold a bachelor's degree (n = 72); 26 teachers have a master's degree, and 2 have a doctoral degree.

The distribution of teachers across various regions demonstrates diversity, with participants from the Black Sea (n = 16), Central Anatolia (n = 18), Eastern Anatolia (n = 15), Southeastern Anatolia (n = 16), Mediterranean (n = 12), Aegean (n = 15), and Marmara (n = 8). This spread suggests that my study's sample is broadly representative of different demographic and geographic groups, and the results capture perspectives from teachers with varying regional backgrounds and levels of professional experience.

Data Collection Tools

I used the "Social Robot Attitude Survey (SRAS)," developed by Kennedy, Lemaignan, and Tony (2016), to assess teachers' attitudes toward integrating social robots into the classroom. The SRAS is a detailed tool that examines various aspects, including teachers' perceptions, acceptance levels, and expectations regarding social robots in education. The survey begins with an information form to collect participants' personal and professional details, followed by 18 questions that measure attitudes toward social robots. For this study, I worked with a measurement and evaluation specialist and a science education expert to translate the instrument into Turkish and ensure its linguistic accuracy. I then conducted a pilot test with 30 science teachers in Rize. Based on their feedback, I adjusted the scale items and finalized the questionnaire for the main data collection.

Validity and Reliability

Language Validity: I conducted the Turkish adaptation process of the Social Robot Attitude Survey (SRTA) within the scope of this study. During the adaptation process, the scale items were independently translated into Turkish by two language experts, and I reconciled the translations to produce a unified version. The resulting text was then back-translated into the original language using the back-translation technique, and the translation quality was verified.

Subsequently, the scale was evaluated by a committee of experts in educational technologies, measurement and evaluation, and linguistics on conceptual equivalence, cultural appropriateness, clarity of expression, and suitability for the target population, and the necessary revisions were made. As a result of this multi-stage process, the language validity of the Turkish version of the survey was deemed established.

Content Validity: I examined the survey items' content validity through a panel of five academic experts in educational technologies and measurement and evaluation. The experts classified each item as *"necessary," "needs revision,"* or *"unnecessary,"* and I analyzed the resulting evaluations using Fleiss' Kappa coefficient.

The results showed an agreement level of $\kappa = .73$, largely due to the concentration of ratings in the "necessary" category. According to the classification proposed by Landis and Koch (1977), this value indicates substantial agreement and a high degree of consistency among expert judgments.

Following expert evaluation, only Item 15 received feedback, which recommended changing the format from open-ended to multiple-choice. I revised this item to include options like cost, technical limitations, workload, and pedagogical constraints. The updated item and the final survey version were resubmitted to the experts, who then approved them.

Feasibility and Structural Reliability: I tested the survey's feasibility and item comprehensibility for the target population through a pilot study with 30 science teachers. Based on the pilot implementation results, I made the necessary linguistic and structural revisions and confirmed that the items were clear, functional, and aligned with the intended measurement purpose.

The adapted survey consists of 18 items and includes a variety of question types. The survey items include:

- Statements measured using 5-point Likert-type rating scales (e.g., *strongly disagree – strongly agree*) to assess acceptance levels regarding the use of social robots in schools;
- Impact evaluation scales (e.g., *very negative – very positive*) to measure perceptions of the long-term learning effects of robots;
- Multiple-choice items to determine how teachers position the roles of robots in classroom settings (e.g., instructional material, teaching assistant, peer);
- Multiple-response formats allowing participants to indicate which learning domains social robots may contribute to across different subjects;
- Single-choice questions assessing predictions regarding the timeline for the widespread adoption of social robots in schools;
- Open-ended questions designed to elicit teachers' free-form opinions about the use of social robots in classroom environments.

The diversity of these question types enables the survey to evaluate attitudes toward social robots comprehensively across pedagogical, technical, ethical, and affective dimensions.

As illustrated, the SRTA utilized in this research features a mixed survey design, including Likert-type questions, multiple-choice items, multiple-response options, and open-ended questions. Consequently, conventional internal consistency metrics, such as Cronbach's alpha, which are typically used for unidimensional scales, are not suitable here because the survey items target different constructs and have varying response formats (DeVellis, 2017; Tavsancil, 2002). DeVellis (2017) notes that Cronbach's alpha is only meaningful for scales comprising homogeneous items that assess a single construct with continuous responses. For mixed surveys with diverse item types and constructs, internal consistency coefficients are not valid measures of reliability.

Since the survey lacks unidimensional continuous scales, internal consistency coefficients are not suitable reliability indicators for this data type. Instead, reliability was confirmed through expert evaluations, language validity procedures, pilot testing, and item performance checks. These approaches are among the recommended methods for establishing reliable evidence in mixed-structure attitude surveys.

In conclusion, after evaluating all these processes, I found the Turkish version of the SRTA to be appropriate for research use, considering both its validity and reliability. The survey provides a reliable tool for collecting data and enables a thorough evaluation of teachers' attitudes toward social robots across pedagogical, technical, ethical, and emotional dimensions.

Data Collection and Analysis

I analyzed quantitative data from the SRTA survey items (1–17) using descriptive statistics. Descriptive statistics, including frequencies (f) and percentages (%), were calculated, and the findings were reported in tables and figures. The open-ended textual responses from Item 18 of the survey were analyzed using content analysis. In this process, I coded the responses, grouped similar codes into overarching themes, and presented the code frequencies and representative participant quotations (e.g., T1, T2, …) in tables accompanying the findings.

Coding Reliability: Utilizing multiple coders and achieving consensus among them are key to improving reliability in qualitative analysis (Yildirim & Simsek, 2019). In this study, another researcher independently re-coded the qualitative data in a different setting. To assess coding reliability, I used the percentage agreement method suggested by Miles and Huberman (1994), resulting in an agreement rate of 82% between myself and the second researcher.

The remaining 18% of discrepant codes were reviewed jointly by both researchers. As a result, 13 of the 15 codes were kept in the analysis, while two that were conceptually inconsistent were removed from the study's scope. After this review, the codes were reorganized, the data were regrouped, and the final themes were developed. In certain cases, teachers' responses to a single question were assigned to multiple codes if they conveyed multiple ideas.

Results

Aligned with the research questions, I organize the findings into four main themes.

Science teachers' overall attitudes toward technology and social robots.

Within this theme, I explored science teachers' interest in science and technology, their views on social robots, and their hands-on experiences with social robots.

Interest in Science and Technology

All science teachers reported being interested in science and technology (see Table 2). This finding indicates that the teachers in the sample generally show a strong interest in science and technology.

Table 2

Interest in Science and Technology

	Interested		*Not interested*	
Total	f	%	f	%
	100	100	-	-
Gender				
Male	36	100	-	-
Female	64	100	-	-

Perspectives on Social Robots

Regarding perspectives on social robots, 50% of the science teachers reported a positive attitude, 30% reported a neutral attitude, and 20% reported a negative attitude. Among teachers with a positive attitude toward social robots, 48% were female, while 44% were male. Accordingly, a descriptive difference of 4% in favor of female teachers was observed (see Table 3).

Table 3

Perspectives on Social Robots

	Negative		*Neutral*		*Positive*	
Total	f	%	f	%	f	%
	20	17	30	30	50	50
Gender						
Male	12	19	5	14	19	44
Female	8	14	25	39	31	48

Experience with Social Robots

The findings show that the vast majority of science teachers lack direct experience with social robots in any setting. This pattern is similar for both female and male teachers, indicating no notable gender difference in prior experience with social robots (see Table 4).

Table 4
Experience with Social Robots

Total	*Yes, at home*		*Yes, at work*		*Yes, elsewhere*		*No*		*I do not know*	
	f	%	f	%	f	%	f	%	f	%
							100	100		
Gender										
Male							36	100		
Female							64	100		

Perceived Acceptability and Appropriateness

Within this theme, I examined teachers' levels of acceptance regarding the use of social robots in schools and their views on the conditions under which such use would be appropriate.

Integrate with other technologies in educational settings

Among the science teachers, 59% agreed that social robots could be used in schools alongside other technologies, whereas 19% disagreed and 23% were undecided. Among those who agreed with this statement, the proportion of female teachers was 56%, while the proportion of male teachers was 61%, indicating a descriptive difference of 5% in favor of male teachers (see Table 5).

Table 5
Using Social Robots Alongside Other Technologies in Schools

Total	*Disagree*		*Undecided*		*Agree*	
	f	%	f	%	f	%
	19	19	23	23	59	59
Gender						
Male	11	31	4	11	22	61
Female	8	14	19	30	37	56

Usage in Educational Settings Under Human Oversight

73% of the science teachers agreed that social robots should be used in schools under human supervision, while 13% disagreed. Among teachers who agreed with this statement, 75% were female, whereas 69% were male. This finding indicates a descriptive difference of 6% in favor of female teachers in terms of acceptance of supervised use (see Table 6).

Table 6
Implementing Social Robots in Schools with Human Oversight

	Disagree		*Undecided*		*Disagree*	
Total	f	%	f	%	f	%
	13	13	16	16	73	73
Gender						
Male	5	14	6	17	25	69
Female	8	13	10	16	48	75

Use in Schools Without Human Supervision

Most science teachers (79%) opposed using social robots in schools without human oversight, with only 10% in favor. Among those who disagreed, 80% were female teachers and 78% were male teachers, indicating minimal gender difference in this opinion (see Table 7).

Table 7
Use of Social Robots in Schools Without Human Supervision

	Disagree		*Undecided*		*Disagree*	
Total	f	%	f	%	f	%
	79	79	11	11	10	10
Gender						
Male	28	78	4	11	4	11
Female	51	80	7	11	6	9

Use as a Support Tool for Learning at Home

77% of teachers agreed that social robots could contribute to children's learning at home, whereas 11% disagreed. Among those who agreed with this statement, 72% were female teachers, while 86% were male teachers. Accordingly, a descriptive difference of 6% in favor of male teachers emerged regarding perceptions of robots' contribution to learning at home (see Table 8).

Table 8
Use of Social Robots as a Support Tool for Learning at Home

	Disagree		*Undecided*		*Disagree*	
Total	f	%	f	%	f	%
	11	11	12	12	77	77
Gender						
Male	3	9	2	6	31	86
Female	8	13	10	16	46	72

Long-Term Effects on Learning in School

74% of the science teachers believed that social robots would have a positive long-term effect on learning in school settings, whereas 14% believed they would have a negative effect (see Table 9). Among teachers who agreed with the positive effect statement, 72% were female, and 75% were male, indicating largely similar views across genders.

Table 9
Long-Term Effects of Social Robots on Learning in School Settings

	Negative effect		*No effect*		*Positive effect*	
Total	f	%	f	%	f	%
	14	14	11	11	74	74
Gender						
Male	8	22	2	6	26	72
Female	6	9	9	15	48	75

Long-Term Impact of Home Learning

As shown in Table 10, 77% of the teachers believed that social robots would make a positive long-term contribution to learning at home, while 14% believed that they would have a negative effect. Among those who expressed a positive view, the proportions of female and male teachers were 75% and 80%, respectively, indicating a 5% descriptive difference in favor of male teachers.

Table 10
Long-Term Effects of Social Robots on Learning at Home

	Negative effect		*No effect*		*Negative effect*	
Total	f	%	f	%	f	%
	14	14	9	9	77	77
Gender						
Male	5	14	2	6	29	80
Female	9	31	7	11	48	75

Using Social Robots as Educational Tools

Within this theme, I examined science teachers' views on the roles of social robots in schools and classrooms and on how they could be used.

Roles in Schools or Classrooms

Most science teachers see social robots as an instructional technology tool (100%), a multifunctional instrument frequently utilized in classrooms (78%), and a teaching assistant (77%). Additionally, 72% of teachers consider social robots as peers for students, while only 11% see them as replacements for teachers (see Figure 1). When broken down by gender, 78% of male teachers and 77% of female teachers view robots as teaching assistants. The percentage of male teachers who see robots as equivalent to the teacher is 14%, compared to 10% for female teachers, showing a 4% difference. Overall, both female and male teachers share similar perceptions regarding the role of social robots as instructional assistants.

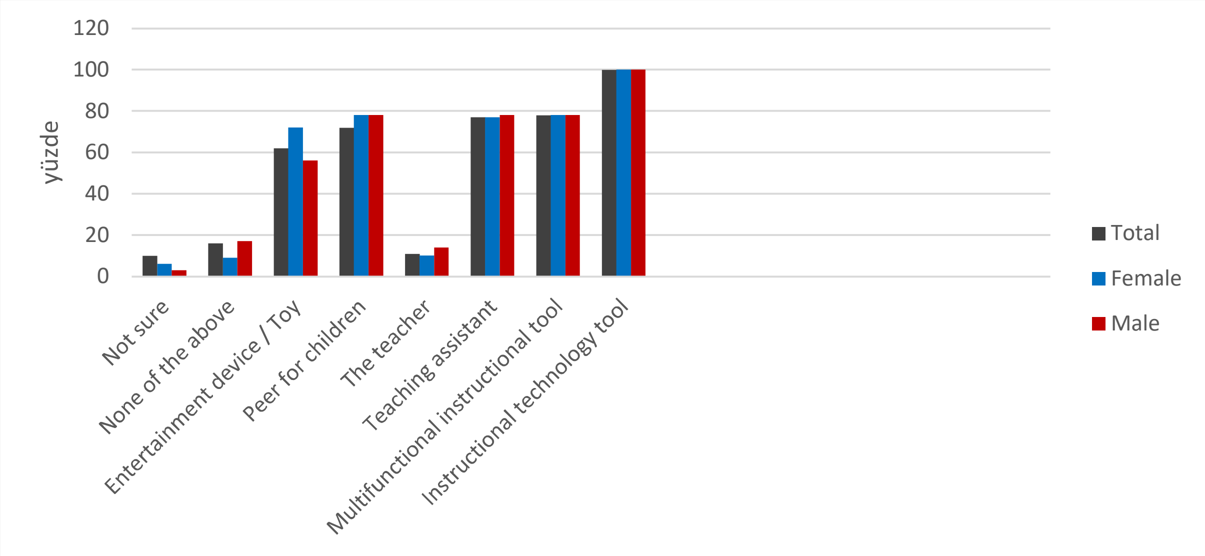

Figure 1. *Distribution of Usage Roles*

Subjects for Instructional Use

All science teachers indicated that social robots could be incorporated into foreign-language instruction. Furthermore, 87% thought they might be useful in music education, 82% in Turkish language classes, 70% in geography, and 68% in history and other social sciences. Around 70% of teachers, regardless of gender, shared similar views on these subjects. Conversely, lower percentages believed social robots could be applied in science, mathematics, and technology and design courses, at 33%, 29%, and 24%, respectively. Specifically, for science, the rates were 31% for males and 33% for females; in mathematics, 25% and 28%; and in technology and design, 33% and 31%. Overall, about 25% of both female and male teachers believed that social robots could be used in STEM subjects (see Figure 2).

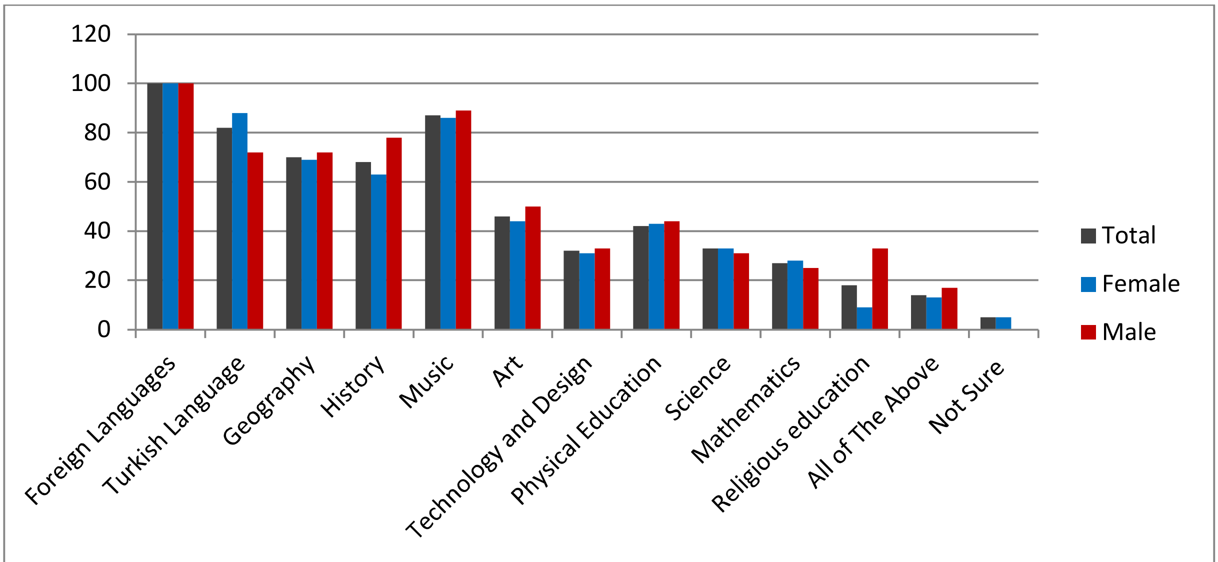

Figure 2. *Subjects in Which Social Robots May Support Instruction*

Use in Children's Education

Most participants supported the moderate use of social robots in children's education, aligning with other instructional technologies (41%), and viewed them as having an important role as a teaching tool (34%) (see Figure 3). Conversely, 17% believed social robots should be reserved for very specific cases, while only 5% thought they should join the teaching staff as educators. Regarding gender differences, half of the male teachers (50%) supported moderate use, with 33% advocating for them to play a significant instructional role. Among female teachers, responses mainly favored moderate use (36%) and an important instructional role (34%). Importantly, no teachers from either gender group suggested banning social robots from education.

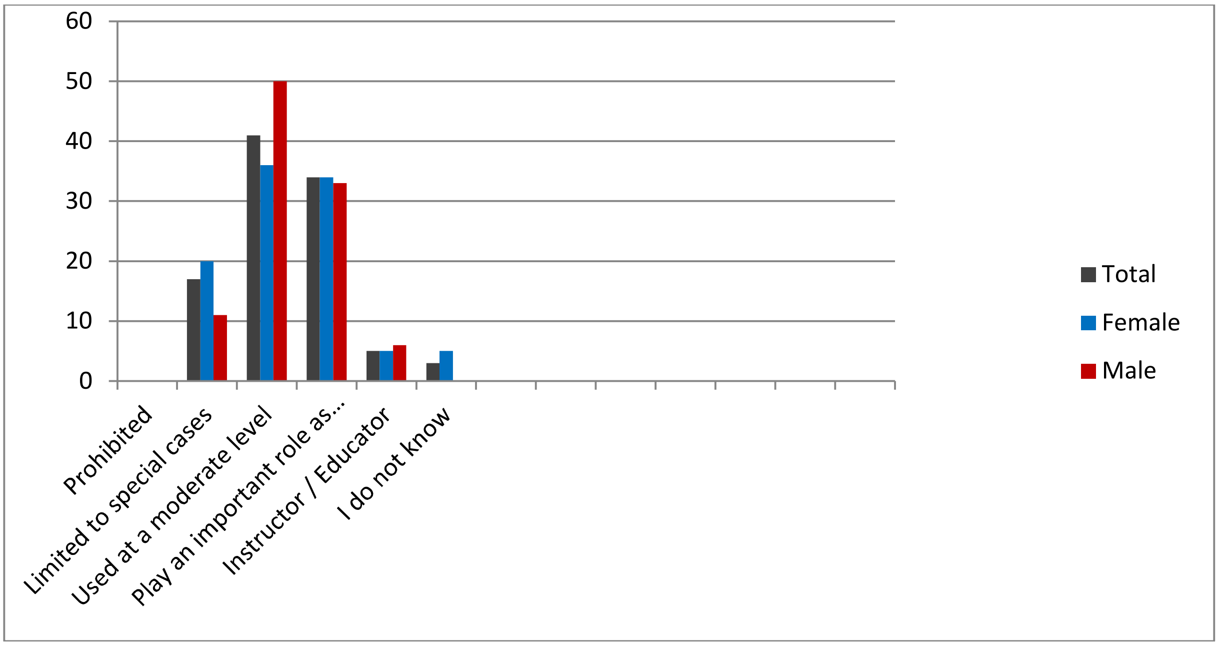

Figure 3. *Distribution of Views on Usage*

Role as an Assistant

As shown in Table 11, 75% of teachers viewed social robots as assistant tools, with 15% disagreeing. Among male teachers, 77% accepted robots as assistants, compared to 74% of female teachers.

Table 11

Social Robots as Assistant Tools

	Disagree		*Undecided*		*Disagree*	
Total	f	%	f	%	f	%
	15	15	10	10	75	75
Gender						
Male	6	17	2	6	28	77
Female	9	14	8	12	47	74

Perceived Concerns and Challenges Regarding Social Robots in Educational Settings

Within this theme, I explored science teachers' opinions on potential barriers to using social robots in schools or classrooms, as well as their expectations for when robots might be integrated into classroom practice.

Concerns About Negative Effects on Children's Social Relationships

22% of science teachers are worried that social robots could negatively impact children's social relationships, whereas 62% have no such concerns. The percentage of female and male teachers who shared this concern was 22% for both genders, indicating no gender difference (see Table 12).

Table 12

Concerns About Negative Effects on Children's Social Relationships

	Disagree		Undecided		Disagree	
Total	f	%	f	%	f	%
	62	62	16	16	22	22
Gender						
Male	22	61	6	17	8	22
Female	40	63	10	16	14	22

Fear of Job Loss

As illustrated in Table 13, 52% of teachers expressed concern that social robots could replace their jobs, whereas 28% did not. Among female teachers, 43% feared job loss, compared with 77% among male teachers. Consequently, male teachers showed greater concern about losing their jobs than female teachers.

Table 13

Fear of Job Loss

	Disagree		Undecided		Disagree	
Total	f	%	f	%	f	%
	28	28	20	20	52	52
Gender						
Male	4	11	8	22	24	77
Female	24	38	12	19	28	43

Barriers in Schools

An analysis of Figure 4 shows that the top barriers to using social robots in children's education are high cost (77%), concerns about diminishing the teacher's role (76%), and limited teacher skills (70%). These are followed by technical failures and reliability issues (67%) and data privacy and ethical concerns (58%). Moderately reported obstacles include curriculum and time constraints (44%) and a lack of support from school administration or parents (40%). Less frequently reported barriers involve potential negative impacts on children's social relationships (35%), social and cultural resistance (31%), and increased teacher workload (28%). The least common barrier was inadequate technical infrastructure (16%). Gender-specific analysis reveals that male teachers mainly cited concerns about weakening the teacher's role (80%), high cost (78%), and limited skills (64%). Female teachers most frequently reported high costs (76%), limited skills (74%), and concerns about diminishing their role (73%). For both groups, inadequate technical infrastructure was the least reported barrier, with 25% among males and 11% among females.

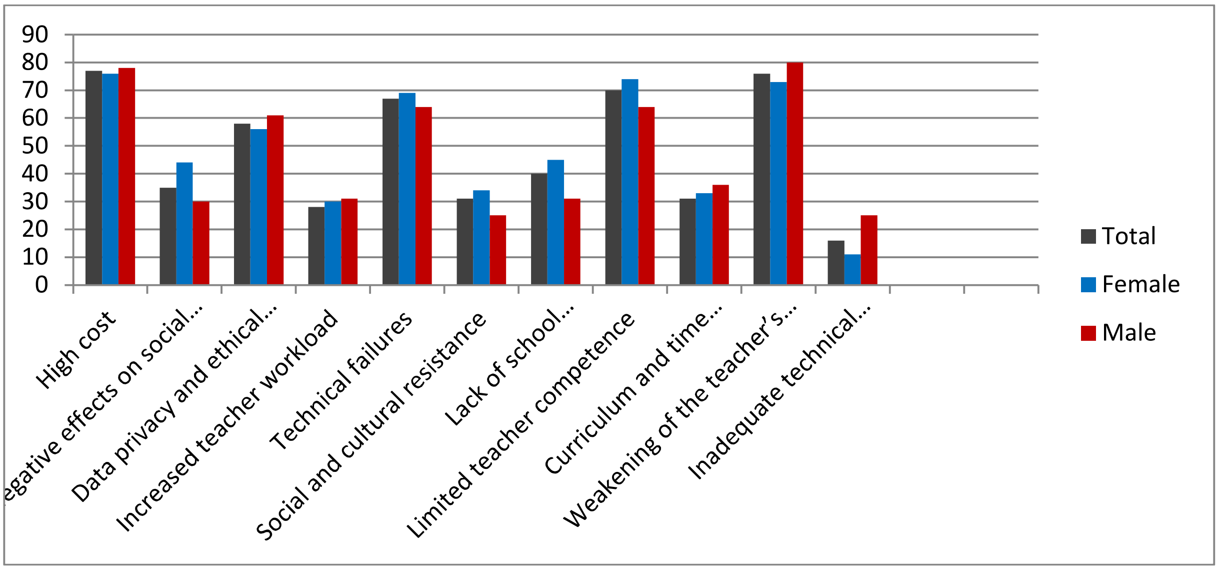

Figure 4. *Barriers in Schools*

Adoption in Schools in Türkiye

Many science teachers in Türkiye expect social robots to be adopted in schools within the next few decades. Specifically, 27% think this could happen in less than 10 years, 35% between 10 and 20 years, and 21% within 20 years. Only 9% believe it will take longer, such as 40 years or more. When looking at gender differences, 60% of female teachers and 60% of male teachers have similar short-term expectations for adoption (see Figure 5).

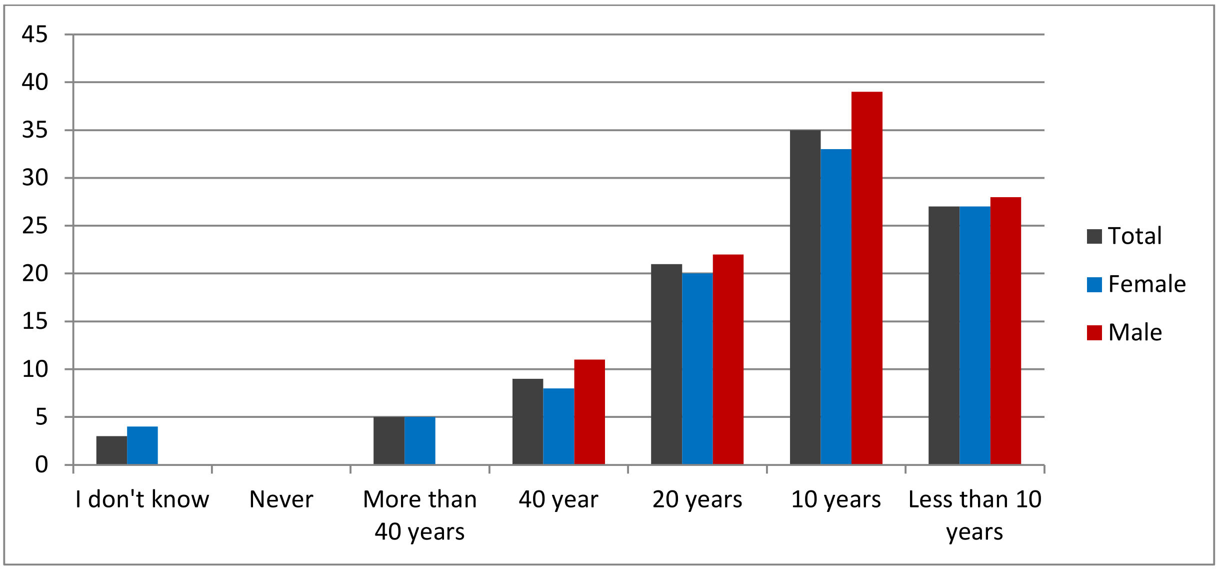

Figure 5 *Timeline for the Adoption of Social Robots in Schools*

General Views

In science teachers' overall evaluations of social robots, the most common theme was the need for human supervision (f = 20), as shown in Table 14. Following this, there were expectations of pedagogical benefits (f = 15), a cautious or conditional acceptance (f = 15), and the importance of maintaining the teacher's role (f = 14). Implementation challenges such as technical and infrastructural deficiencies (f = 10), concerns over cost and sustainability (f = 8), and the requirement for in-service training (f = 8) also appeared prominently. Moderately expressed themes included ethical and data privacy issues (f = 8) and concerns about social interactions (f = 7). Less frequently mentioned were topics like age appropriateness (f = 4), the robot's limited pedagogical autonomy (f = 4), and societal acceptance (f = 4). The least common concern was uncertainty about long-term effects (f = 3).

When analyzing the data by gender, it was found that female teachers were more prominently represented in codes related to the need for human supervision (f = 13; f = 7), expectations of pedagogical benefits (f = 10; f = 5), and cautious acceptance or conditional approval (f = 10; f = 5). Conversely, among male teachers, themes such as maintaining the teacher's role (f = 3; f = 11) and concerns about ethics and data privacy (f = 2; f = 6) were more prevalent. The themes of technical and infrastructural inadequacies (f = 5; f = 5) and the need for in-service training (f = 4; f = 4) showed a balanced distribution.

Table 14

General Views on Social Robots

Code	*Total (f)*	*Female (f)*	*Male (f)*	*Teachers (T1–100)*	*Sample Statements;*
Need for human supervision	20	13	7	T2(F), T7(M), T11(F), T18(F), T23(M), T29(F), T34(F), T41(M), T47(F), T52(F), T58(M), T63(F), T67(M), T71(F), T76(M), T82(F), T88(F), T91(M), T96(F), T100(F)	T71(F): "I do not find it appropriate to use social robots in the classroom without teacher supervision… A robot only does what it is programmed to do; it cannot make decisions."
Expectation of pedagogical benefits	15	10	5	T4(F), T9(F), T14(M), T21(F), T27(M), T33(F), T38(F), T45(M), T50(F), T56(F), T62(M), T69(F), T74(F), T85(M), T98(F)	T33(F): "…If it is designed properly, it can support learning. Of course, it requires a great deal of support…"
Conditional acceptance/ cautious approach	15	10	5	T1(F), T6(M), T12(F), T20(F), T26(M), T31(F), T37(M), T44(F), T49(F), T57(M), T64(F), T70(F), T78(M), T84(F), T93(F)	T44(F): "It may be possible if the necessary conditions are met, but at the moment it is too early."
Preservation of the teacher's role	14	3	11	T6(M), T8(M), T9(F), T14(M), T15(M), T32(M), T37(M), T53(F), T56(F), T61(M), T67(M), T68(M), T79(F), T90(M)	T32(M): "…A robot cannot replace a teacher… Teaching cannot be reduced to merely delivering information."
Technical and infrastructural inadequacies	10	5	5	T3(M), T10(F), T17(M), T24(F), T35(M), T42(F), T48(F), T55(M), T66(F), T90(M)	T42(F): "The technical infrastructure is inadequate… There are small classrooms… If a robot breaks down, technical personnel are needed for repairs…"
Concerns about cost and sustainability	8	5	3	T5(F), T15(M), T28(F), T36(M), T46(F), T59(F), T73(M), T87(F)	T59(F): "Purchase and maintenance costs are high… School budgets are limited- very limited…"
Need for in-service training	8	4	4	T30(F), T60(F), T83(M), T12(F), T41(M), T67(M), T78(M), T96(F)	T30(F):"…Teacher training is essential to explain the benefits and risks of social robots… That is, in-service

					training, but provided by experts…”
Ethical and data privacy concerns	8	2	6	T13(F), T25(M), T46(M), T53(F), T55(M), T67(M), T68(M), T78(M),	T68(M): “Data privacy is not clear… Even data on mobile phones are not truly secure…”
Concerns about social interaction	7	5	2	T12(F), T16(F), T20(F) T39(M), T72(F), T89(M)	T72(F):“…Peer interaction may decrease… Children may become socially withdrawn…”
Age appropriateness	4	3	1	T22(F), T51(F), T65(M), T92(F)	T51(F): “It may not be appropriate for every age group, or would there need to be different robots for different levels? That seems rather difficult…”
Limited pedagogical autonomy of the robot	4	2	2	T37(M), T66(F), T7(M), T84(F)	T37(M): “…It does only what is programmed into it; it cannot do anything else… This is quite concerning…”
Societal acceptance	4	3	1	T21(F), T9(F), T54(F), T55(M)	T55(M): “In a society like ours in the East, this may be difficult; our social criteria are very different from those of Western societies…”
Uncertainty regarding long-term effects	3	2	1	T34(F), T75(M), T97(F)	T75(M): “It is a long-term investment… The effects are uncertain…”

Discussion

This section presents the study's findings, grounded in relevant literature and aligned with the two research sub-problems. For Sub-problem 1, it explores science teachers’ attitudes toward social robots, perceptions of acceptability and appropriateness, potential roles as instructional tools, and concerns or barriers to their educational use, organized into four main themes. In Sub-problem 2, these findings are also described in detail by gender.

Science Teachers’ Attitudes Toward Social Robots

All who volunteered for my study reported an interest in science and technology (see Table 2). This strong interest provides a good foundation for openness to innovation and a positive view of technology, both essential for introducing social robots into education. However, attitudes toward social robots are more evenly split: 50% see them positively, 30% are neutral, and 20% are negative (see Table 3). This suggests that while the benefits of social robots are recognized, concerns about trust, control, role-sharing, and implementation limit support (Belpaeme et al., 2018; Ceha et al., 2022; Edwards et al., 2016; Neumann, 2023). Koksalan et al. (2024) found that teachers neither fully reject nor fully accept social robots; most views are neutral or slightly positive. For example, statements like “If it is designed properly, it can support learning. Of course, a great deal of support is needed…” (T33) indicate that expectations of educational benefits are linked to a conditional acceptance. Likewise, teachers' cautious stance aligns with research showing that effective robot use in schools requires pedagogical design, teacher guidance, and classroom adaptations (Mubin et al., 2013).

One potential reason for teachers' cautious approach is that none have experience with social robots at home, at work, or elsewhere (see Table 4). This suggests that, in the Turkish context, social robots have yet to become part of daily life or schools, and teachers' views are mostly based on hypothetical situations. From the standpoint of technology acceptance models (such as perceived usefulness and ease of use), the lack of practical experience likely increases uncertainty and ethical concerns. Similarly, Ewijk et al. (2020) found that although most teachers had never worked with social robots, they still highlighted the robots' potential benefits, especially for personalized instruction, repetition, and motivation.

While 59% of teachers believe social robots can be used in schools alongside other technologies, 23% remain undecided, and 19% disagree (see Table 5). Regarding conditions of use, human supervision is a key factor: about two-thirds of teachers support using social robots in schools under human supervision (see Table 6), whereas 79% do not find their use without supervision appropriate (see Table 7). This suggests that social robots are seen not as autonomous instructors but as tools or assistants that operate under teacher oversight. A statement from the general views section -"I do not find it appropriate to use it in the classroom without teacher supervision… A robot only does what it is programmed to do; it cannot make decisions…" (T71)- emphasizes that pedagogical control and decision-making should stay with the teacher. The statement "It may be possible if the necessary conditions are met, but at the moment it is too early…" (T44) implies acceptance may grow once certain infrastructural and pedagogical conditions are implemented. Most teachers (74%) believe social robots will positively impact learning in the long run, though 14% foresee negative effects and 11% expect no impact (see Table 9).

Most science teachers (77%) see social robots not only as classroom tools but also as supplementary learning aids for home activities like homework and reinforcement exercises (see Table 8). Expectations for their long-term impact are similarly high in the home environment (77%) (see Table 10). These findings suggest a generally optimistic outlook on their potential benefits, while some teachers also express uncertainty about long-term effects, as reflected in the comment, "It is a long-term investment… The effects are uncertain…" (T75). Overall, these results align closely with the Almere model, which explains social robot acceptance by emphasizing perceptions such as perceived usefulness (belief that the robot aids instruction), perceived control (perception that users can manage and oversee the robot easily and predictably), and anxiety (worries about risk or discomfort) (Heerink et al., 2010). The model's core assumption is that these perceptions influence the intention to use, which, in turn, affects actual use. The preference for teacher supervision and responsibility aligns with policy documents advocating ethical governance and human oversight in educational technology (UNESCO, 2025). To improve social robot acceptance in schools, it's crucial to develop use cases grounded in a design rationale that enhance the teacher's role, support classroom management, and achieve measurable learning outcomes. Studies by Belpaeme et al. (2018), Mubin et al. (2013), and Woo et al. (2021) further emphasize that, for social robots to be effective educational tools, they should not be designed as autonomous agents that replace teachers. Instead, they should serve as tools aligned with pedagogical goals, integrated into the classroom, and supporting teacher control.

Teachers mainly see social robots as instructional tools (100%) and multifunctional devices (78%), with 77% considering them as instructional assistants. Only a small percentage (11%) see robots as teachers or as fully autonomous entities (see Figures 1 and 3; Table 11).

This suggests that social robots are viewed not as fully autonomous actors but as supporting assistants in teaching (Smakman et al., 2021). This view is confirmed by a participant statement: “A robot cannot replace the teacher… Teaching cannot be reduced to merely providing information” (T32). Studies by Ewijk, Smakman, and Konijn (2020) and Neumann (2023) also indicate that teachers find autonomous decision-making by robots problematic, emphasizing the need for human oversight due to ethical concerns, the potential for mistakes, and loss of control in classroom management.

When assessed individually, all teachers (100%) agree that social robots can be useful for teaching foreign languages. Similarly, high approval levels are seen in music (87%), Turkish language arts (82%), geography (70%), and history (68%). Conversely, the perceived suitability of social robots in STEM subjects, such as science (33%), mathematics (29%), and technology and design (24%), remains around one-third of the respondents (see Figure 2). This pattern indicates that teachers see social robots as more beneficial in areas that involve communication, interaction, and emotional support. In STEM education, robots are viewed more as supplementary tools. Supporting this view, a content analysis by Belpaeme et al. (2018) shows that most educational robot applications focus on language learning and interaction activities. In STEM fields, robots are most effective at structured tasks such as problem-solving, coding, and experimental support. Additionally, evaluations suggest that teachers tend to see robots as instructional aides or mediating tools, roles they believe are more practical for classroom management and pedagogical planning (Koksalan et al., 2024; Mubin et al., 2013).

Perceived concerns and barriers to educational use include high costs (77%), worries about diminishing the teacher’s role (76%), and limited teacher skills (70%). These are followed by technical malfunctions or reliability issues (67%) and data privacy or ethical concerns (58%). Curriculum and time limitations (44%) and support from school administration and parents (40%) are seen as moderate barriers, while inadequate technical infrastructure is reported at a lower rate (16%) (see Figure 4). Additionally, half of the teachers (52%) worry that social robots might “take away their jobs” (see Figure 3; Table 13).

Teachers’ statements in Table 14 further clarify these findings. The comment “Purchase and maintenance costs are high… School budgets are limited…” (T59) emphasizes the cost aspect. The remark “Technical infrastructure is insufficient… If the robot breaks down, technical personnel are needed for repair…” (T42) points to implementation challenges. The statement “Data privacy is not clear…” (T68) highlights concerns about data security. Regarding social interaction, the comment “Peer interaction may decrease…” (T72) suggests that emotional and social issues remain a concern. These observations support the first- and second-order barriers framework in technology integration (Hew & Brush, 2007). For social robots, these barriers intersect with a third layer involving ethical data governance and child safety.

UNESCO (2025) highlights the importance of data privacy, child protection, and human oversight, while Johnston (2023) stresses the need to enhance privacy and transparency standards in schools. In this study, the statement “Data privacy is not clear…” (T68) shows that teachers’ concerns are well-founded (see Table 19). Teachers’ opinions on how social robots should be integrated into children’s education are closely tied to concerns about control and safety. Consistent with this, 41% recommend “moderate” use, 34% see robots as an “important instructional technology tool,” and 17% advocate for limiting usage to “very special cases” (see Figure 3). Only 5% view social robots as an “educational agent and part of the teaching staff” (see Figure 3). According to Kennedy et al. (2016), teachers usually see social robots as supportive tools; this tendency is confirmed by both the quantitative data and qualitative codes in this study (see Table 14). In Turkey, forecasts about the widespread use of social robots in schools suggest a gradual adoption process. Teachers estimate this will happen within 10 years (35%), less than 10 years (27%), or within 20 years (21%) (see Figure 5). This indicates that adoption will depend not only on attitudes but also on infrastructure investments, maintenance ecosystems, teacher training, and institutional or policy support. The emphasis on "In-service training… by experts…" (T30) further underscores that successful adoption depends on improving teachers' skills and support systems (see Table 19).

Discussion of Attitudes Toward Social Robots According to Gender

All female and male science teachers participating in my study indicated an interest in science and technology (see Table 2). The notable interest in both groups and the lack of gender differences in technological interest may partly result from the sample being drawn from individuals willing to engage in TÜBİTAK-supported projects. Regarding attitudes toward social robots, the majority in both groups hold a positive view; however, this is more pronounced among female teachers (48%) than among male teachers (44%). Neutral attitudes are found in 14% of male teachers and 39% of female teachers, whereas negative attitudes are reported by 19% of male teachers and 14% of female teachers (see Table 3). This pattern indicates that, beyond overall attitude tendencies, the degree of indecision or neutrality may vary between genders.

Previous research suggests that gender differences in attitudes towards robots may be linked to factors like technology-related anxiety, past experiences, and socially constructed gender roles (Nomura, 2020). Additionally, studies on technology acceptance indicate that gender influences acceptance in various ways, such as through performance expectations and social influence (Venkatesh et al., 2003). In this context, the higher incidence of neutral attitudes among female teachers might stem from limited information or exposure to classroom roles and the possible outcomes of social robots, causing teachers to take a cautious, "wait-and-see" approach.

Regarding the approval of school-based use under human supervision, 75% of female teachers and 69% of male teachers participate (see Table 6). In contrast, both genders strongly reject using social robots without supervision (female: 80%; male: 78%; see Table 7). This indicates that, despite slight gender differences, teacher supervision is a key condition for acceptance. This aligns with the higher representation of female teachers under the "need for human supervision" category in Table 14 (Female f = 13; Male f = 7). Participant T71 (female) emphasized this point by stating "Without teacher control…"-highlighting the importance of supervision due to the robot's limited decision-making ability. Linking acceptability to supervision also aligns with ethical guidelines that call for human-centered AI design with clear responsibility chains (UNESCO, 2025). Additionally, acceptance models suggest that trust and anxiety significantly influence acceptance (Heerink et al., 2010), so the small gender differences may reflect subtle variations in trust and anxiety levels.

Perceptions of social robots as instructional assistants are nearly identical among female (77%) and male (78%) teachers (see Figure 1). Regarding subject areas, both genders strongly emphasize foreign languages, music, and Turkish language arts, while use in STEM subjects such as science (31-33%), mathematics (25–28%), and technology and design (31-33%) is more limited (see Figure 2). Reviews of educational robotics show that robots are more frequently employed in language learning and interaction-driven activities, with teachers adopting these technologies more rapidly in such areas (Belpaeme et al., 2018; Lampropoulos, 2025).

Research on teachers' use of technology in classrooms highlights that adoption depends on perceived usefulness, ease of use, and teachers' confidence in integrating technology in line with pedagogical goals (Tondeur et al., 2017; Venkatesh et al., 2003). In this context, the lower use of STEM subjects may be due to limited availability of social robot activities in science and math classes, along with teachers' domain-specific experience and self-efficacy perceptions, which have not yet been sufficiently developed (Ertmer & Ottenbreit-Leftwich, 2010; Wangdi et al., 2023).

43% of female teachers and 77% of male teachers worry that social robots might displace their jobs (see Table 14). Concerning school-related barriers, high costs, fears of diminishing the teacher's role, and limited teaching skills are the most significant issues for both genders. Nevertheless, worries about the teacher's role decline are more common among males (80%), while limited teaching skills (74%) and lack of support from administrators and parents (45%) are more significant concerns for females (see Figure 4).

These findings are reinforced by the code distributions shown in Table 14. Notably, the code "preservation of the teacher's role" appears more prominently among male teachers (Female f = 3; Male f = 11). Participant T32's remark, "A robot cannot replace the teacher…"- highlights concerns about the potential erosion of the teacher's role. Conversely, the codes "expectation of pedagogical benefit" and "conditional acceptance" are more frequently noted among female teachers (Female f = 10; Male f = 5), indicating that acceptance depends more on meeting specific conditions and having sufficient support mechanisms (see Table 14).

Gender-based differences in anxiety are consistent with prior findings indicating that negative attitudes and concerns toward robots may be associated with demographic variables (Nomura, 2020). At the same time, technology acceptance research emphasizes that gender may influence acceptance through factors such as performance expectancy and social influence (Venkatesh et al., 2003). Accordingly, the substantial gap in job-loss anxiety may be related to perceptions that social robots could redefine the teacher's professional role. To mitigate this concern, it may be necessary to clearly articulate the robot's role as a supportive assistant, enhance teacher competencies through pilot implementations, and make ethical and privacy frameworks more visible and explicit.

Furthermore, the observed gender differences related to job loss and role ambiguity are consistent with existing research. Studies exploring social robot integration in education indicate that female teachers often adopt more cautious and anxiety-driven views about how technological changes could affect their professional roles. In contrast, male teachers tend to see technology primarily as a functional or instrumental innovation (Nomura et al., 2006; Heerink et al., 2010). In educational environments where teaching involves care, guidance, and emotional support, female teachers may become more concerned that social robots could replace these roles (Gardenghi & Gherardi, 2024). To address these concerns, establishing clear frameworks that affirm the teacher's pedagogical authority and decision-making in human–robot collaboration can help lessen gender-based fears and promote viewing social robots as supportive tools rather than substitutes (Majgaard, 2015; Rosanda et al., 2025).

Conclusions and Implications

Drawing on the discussion of the study's findings in relation to existing literature, the following conclusions emerge.

Although science teachers show strong interest in science and technology, their attitudes toward social robots tend to be more of "conditional acceptance" rather than full acceptance. This acceptance depends on factors such as the need for human oversight, the preservation of the teacher's role, pedagogical design, and teacher competence for successful use, along with considerations of cost, sustainability, and technical support (Gardenghi & Gherardi, 2024; Majgaard, 2015; Rosanda et al., 2025). To address this, it is recommended that: (i) more examples be provided where social robots are seen not as "autonomous teachers" but as instructional tools or assistants that fit into teachers' pedagogical plans and can be adapted to various learning goals, especially aligned with STEM outcomes (Majgaard, 2015); (ii) structured in-service training programs be developed to ensure robots are not merely viewed as "attention-grabbing" gadgets or entertainment, but as devices that teach programming, operation, classroom management, and pedagogy, while also giving teachers sufficient time and resources (Gardenghi & Gherardi, 2024); and (iii) robot-supported lessons be integrated smoothly into the regular curriculum, closely connected with learning outcomes, and, if possible, evaluated through comparative studies to empirically assess how robot integration benefits learning (Rosanda et al., 2025).

Furthermore, the gender-related results of this study are especially relevant regarding concerns about "job loss" and "role ambiguity," aligning with certain aspects of the existing research. Studies on integrating social robots into educational environments find that female teachers may exhibit more cautious, anxiety-driven attitudes toward how technological changes could affect professional roles, while male teachers often view technology more as a practical, functional tool (Heerink et al., 2010; Nomura et al., 2006). Additionally, research in educational settings suggests that when teaching involves care, guidance, and emotional support, female teachers may be more concerned that social robots could replace these roles (Gardenghi & Gherardi, 2024). Therefore, in collaborative scenarios with social robots, establishing clear frameworks that specify teachers' pedagogical authority and decision-making can help reduce gender-based concerns and foster the view that technology is a "complementary" tool rather than a substitute (Majgaard, 2015; Rosanda et al., 2025).

Disclosure Statement

No potential conflict of interest was reported by the author(s).

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