



# From play to practice: unpacking preschool teachers' adoption of robotic toys through a multi-framework perspective

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## Abstract

The incorporation of robotic toys in early childhood education has the potential to enrich learning through play, foster cognitive and social development, and lay the groundwork for foundational STEM skills. Yet, despite increasing recognition of their educational value, the integration of robotic toys by preschool teachers remains limited and inconsistent. This study adopts an integrated approach, combining the Task Technology Fit (TTF) and Theory of Planned Behavior (TPB) frameworks, to systematically investigate the factors influencing preschool teachers' intentions to adopt robotic toys in classroom practice. Drawing on survey data from 742 preschool teachers across diverse institutional contexts, the study employs structural equation modeling to evaluate both technological and behavioral predictors of teachers' intention to adopt robotic toys. The results reveal that both task-technology alignment, reflecting the perceived fit of robotic toys with play based and collaborative learning goals, and psychological constructs such as attitude, subjective norm, and perceived behavioral control, significantly shape teachers' adoption intentions. Task technology fit emerged as a particularly strong driver, highlighting the importance of designing robotic toys that resonate with early childhood pedagogies. In addition, social encouragement and teachers' confidence in their technological abilities play vital roles in enabling adoption. The study advances theoretical understanding by illustrating the synergistic influence of technological and behavioral determinants on teachers' intention to adopt robotic toys, and offers practical recommendations for policymakers, curriculum designers, and educational technology developers seeking to promote meaningful and sustainable integration of robotics in preschool education.

**Keywords** Early childhood education · Preschool teachers · Robotic toys · Play-based learning · Technology adoption · Task technology fit · Theory of planned behavior

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## 1 Introduction

The rapid advancement of educational technology has brought innovative tools into early childhood classrooms, among which robotic toys stand out as a promising means to foster hands-on, play based learning and essential twenty first century skills in preschool children (Kewalramani et al., 2021a; Torpegaard et al., 2022). These interactive tools have been shown to support cognitive development, problem-solving abilities, and social collaboration when integrated effectively into preschool curricula (Kewalramani et al., 2021b). As global education systems increasingly prioritize STEM (Science, Technology, Engineering, and Mathematics) learning from an early age, the pedagogical potential of robotic toys has become an important topic for educators and policymakers (Ateş & Gündüzalp, 2024; Hu et al., 2024).

Despite increasing recognition of these benefits, existing research lacks an integrated and contextualized theoretical perspective for understanding preschool teachers' adoption of robotic toys. Specifically, prior studies have not yet developed a comprehensive model that integrates both the functional aspects of technology, namely the extent to which robotic toys align with core teaching tasks, and the behavioral dimensions that shape teachers' intentions and confidence to adopt them. Most previous work has focused either on the technical affordances of robotic toys or on children's engagement and learning outcomes, leaving teachers' adoption processes underexplored. Moreover, widely used frameworks such as the Technology Acceptance Model (TAM) (Davis, 1989), the Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2003), and its extended version UTAUT2 (Venkatesh et al., 2012) primarily emphasize perceived ease of use, usefulness, and user experience, offering limited insight into the pedagogical and contextual factors that define early childhood education settings.

Consequently, what remains insufficiently examined is how the alignment between technology and pedagogical tasks interacts with teachers' attitudes, perceived norms, and sense of control to influence their intention to adopt educational innovations. While a few studies have addressed either technical or psychological determinants in isolation (Almusawi & Durugbo, 2024; Kim & Song, 2022), a comprehensive, integrative framework that captures both the functional and behavioral dimensions of teachers' intention to adopt technology in preschool contexts is still lacking. Addressing this limitation, the present study advances an integrated model that combines the Task–Technology Fit (TTF) and the Theory of Planned Behavior (TPB) to offer a holistic understanding of preschool teachers' intention to adopt robotic toys.

The present study directly addresses the identified theoretical limitation by applying and empirically testing an integrated framework that combines the Task–Technology Fit (TTF) model (Goodhue & Thompson, 1995) with the Theory of Planned Behavior (TPB) (Ajzen, 1991). While previous research has occasionally combined these two perspectives in other technology adoption domains, their joint application has not yet been extended to the underexplored context of preschool teachers' intention to adopt robotic toys. Through this integration, the study bridges functional and behavioral perspectives to provide a contextualized understanding of how pedagogical fit and teacher motivation jointly influence teachers' intention to adopt robotic toys. The TTF perspective facilitates an in depth examination of how well robotic

toys align with the pedagogical tasks and developmental goals of early childhood education, moving beyond generalized notions of usefulness to emphasize contextual fit. Meanwhile, the TPB component highlights the influence of teachers' attitudes, perceived social norms, and sense of control in shaping adoption intentions, acknowledging that even pedagogically suitable technologies may encounter resistance without sufficient behavioral motivation (Wu et al., 2022).

By integrating TTF and TPB, this study offers a novel, dual perspective approach that captures both the technological and behavioral complexities of robotic toy adoption among preschool teachers. This represents a contribution largely absent from existing research. This integrated model not only clarifies the distinct and combined influence of pedagogical fit and behavioral intention, but also provides actionable insights into the key enablers and barriers at play in early childhood technology integration.

The specific contributions of this study are as follows:

1. It bridges a major gap in the literature by jointly analyzing the functional fit of robotic toys and the behavioral intentions of preschool teachers, rather than examining these dimensions in isolation.
2. It empirically tests the explanatory power of a combined TTF-TPB framework relative to each model alone, thereby advancing theoretical understanding of technology adoption in early childhood settings.
3. It identifies the most salient technological, pedagogical, and psychological factors that enable or hinder teachers' willingness to integrate robotic toys, providing nuanced evidence for both researchers and practitioners.
4. It generates practical implications for teacher training, curriculum design, and policy development, supporting more effective and sustainable adoption of educational robotics in preschool contexts.

By addressing these objectives, the study makes an original contribution to the literature on educational technology adoption in early childhood education. Its findings are expected to inform both future research and the design of interventions that empower preschool teachers to harness the full potential of robotic toys for developmental and curricular innovation.

## 2 Literature review

### 2.1 Robotic toys in early childhood education

Robotic toys have gained increasing recognition in early childhood education for their ability to foster playful, hands-on learning and support cognitive, social, and emotional development (Kewalramani et al., 2021a, b; Torpegaard et al., 2022). These educational technologies are designed to offer interactive experiences that promote problem-solving, collaboration, and creativity in young children through tangible manipulation and digital engagement (Komis et al., 2021). As a result, robotic

toys are viewed as valuable tools for introducing foundational STEM concepts and computational thinking at the preschool level (Hu et al., 2024; Prasad & Pandey, 2025).

A growing body of empirical evidence, as synthesized in recent review studies, demonstrates the benefits of robotics for children's learning outcomes, such as enhanced logical reasoning, increased engagement, and improved peer collaboration (Gerosa et al., 2022; Rapti et al., 2025; Sapounidis et al., 2025). For example, Rapti et al. (2025) present a comprehensive thematic review of robotics-based interventions that target the development of the commonly referenced 4Cs communication, collaboration, critical thinking, and creativity among kindergarteners. Through an analysis of 16 studies selected via a PRISMA guided process from an initial pool of 349, the authors highlight both the promise and limitations of current educational robotics practices. Their findings reveal that while some interventions have successfully incorporated robotics to foster these essential 21st-century skills, the field still lacks a systematic framework or standardized model to guide educators in designing and implementing such activities effectively. Furthermore, the review underscores the sporadic and often undocumented nature of robotics activities used in early childhood settings, calling attention to the need for clearer pedagogical guidelines and empirically validated approaches.

Despite these positive findings, the actual classroom integration of robotic toys remains limited and inconsistent. Barriers such as insufficient teacher training, lack of curricular alignment, and concerns about developmental appropriateness have been cited as significant obstacles (Kewalramani et al., 2021a). Notably, much of the literature has focused on student outcomes or technical affordances (Grubišić & Crnokić, 2024), with far less attention devoted to understanding the determinants of teachers' adoption intentions. As teachers are central to the successful implementation of educational technologies in preschool, this gap limits the scalability and sustainability of robotics initiatives.

## 2.2 Factors influencing technology adoption among preschool teachers

The adoption of new technologies by preschool teachers constitutes a multifaceted process, shaped not only by individual beliefs and competencies but also by the broader institutional and sociocultural environment, as well as the perceived alignment between technological tools and pedagogical objectives (Şakir, 2025a; Hoareau et al., 2021; Hong et al., 2021). In the scholarly literature, much of the early work examining technology integration in early childhood education has relied on established theoretical frameworks such as the Technology Acceptance Model (TAM) (Davis, 1989) and the UTAUT (Venkatesh et al., 2003). These models primarily emphasize constructs such as perceived usefulness, ease of use, and the role of external facilitating conditions, thereby providing foundational insights into teachers' willingness to engage with novel educational technologies (Ateş & Polat, 2025; Şakir, 2025b). Subsequent extensions, such as UTAUT2 (Venkatesh et al., 2012), have incorporated additional predictors, including hedonic motivation, price value, and habit, to enhance explanatory power at the individual level. However, these models remain largely generic and do not sufficiently capture the pedagogical and contextual nuances that shape technology adoption in early childhood education.

Complementary to these technology acceptance models, Rogers' (2003) Diffusion of Innovations (DOI) theory has also been widely applied to explain the spread of educational technologies. DOI emphasizes the roles of innovation characteristics, such as relative advantage, compatibility, complexity, trialability, and observability, as well as communication channels and social systems in shaping adoption decisions. While this perspective provides valuable insight into the social diffusion process and the influence of peer networks or institutional cultures, it similarly underrepresents the pedagogical alignment and task-specific dimensions that are central to early childhood education. Consequently, although DOI offers an important macro-level understanding of how innovations diffuse within educational systems, it does not by itself explain how individual teachers evaluate the pedagogical fit of specific tools, such as robotic toys, within the curriculum.

However, a critical limitation of these models is their tendency to underrepresent the distinctive pedagogical and developmental imperatives of early childhood education. Specifically, they do not sufficiently account for the unique instructional modalities and learning outcomes prioritized in preschool settings, such as play-based, exploratory, and socially collaborative learning experiences (Şakir, 2025a). Although it is well-established that alignment between technology and curriculum is pivotal for effective adoption, there remains a paucity of empirical research explicitly investigating how and to what extent robotic toys are compatible with the core instructional tasks characteristic of early childhood pedagogy.

Beyond theoretical limitations, several practical and contextual barriers to technology adoption in preschool environments have been documented. These include inadequate opportunities for targeted professional development, insufficient curricular integration and resource allocation, apprehensions regarding increased screen time, and lingering uncertainty about the educational efficacy of robotics and digital tools in fostering meaningful learning experiences (Jordan & McDaniel, 2014; Vrontis et al., 2023). Furthermore, research indicates that teachers' intentions are not formed in a vacuum; rather, they are significantly mediated by broader social and institutional dynamics, including collegial support, leadership advocacy, and parental attitudes (Antonietti et al., 2022). Nevertheless, the extant literature predominantly investigates these determinants in isolation, without sufficiently exploring the complex interplay among individual, organizational, and societal factors that collectively shape preschool teachers' adoption of educational technologies such as robotic toys.

In sum, while previous scholarship has identified a range of factors influencing preschool teachers' adoption of technology, there remains a critical need for integrative models that account for the interdependencies among pedagogical fit, personal beliefs, and contextual influences, particularly in the context of robotic toys. Addressing this gap is essential for developing effective strategies to support meaningful and sustainable technology integration in early childhood education.

### **2.3 Integrating task technology fit and theory of planned behavior**

The TTF framework, proposed by Goodhue and Thompson (1995), provides critical insights into how well technology satisfies users' specific task requirements. In early childhood education, it is vital for teachers to select technologies, such as robotic

toys, that facilitate pivotal instructional activities like hands-on exploration, storytelling, and collaborative play. Recent research highlights that when educators perceive a strong match between the capabilities of technological tools and their pedagogical tasks, their intention to adopt these technologies significantly increases (Seol et al., 2016; Yu & Yu, 2010). This relationship underscores the importance of task-technology alignment in enhancing educational outcomes, particularly in preschool educational settings where interactive engagement is crucial (Al-Rahmi et al., 2020).

Despite the explanatory power of TTF, it does not fully encompass the psychological and sociocultural factors that influence teachers' decisions to adopt technology. This limitation can be addressed by employing the TPB (Ajzen, 1991), which elucidates the roles of attitudes, subjective norms, and perceived behavioral control in shaping behavioral intentions. Within the context of early childhood education, research demonstrates that favorable attitudes toward technology, the presence of supportive colleagues and administrators, and self-efficacy regarding technological skills all contribute to the likelihood of adopting educational technologies (Ejigu & Yeshitela, 2024; Seol et al., 2016). Conversely, perceived barriers such as negative attitudes or low confidence can obstruct adoption, irrespective of the technology's fit (Yu & Yu, 2010).

Although both TTF and TPB are robust theoretical frameworks, previous research has demonstrated the benefits of integrating these models to explain technology adoption across various educational and digital learning contexts (Yu & Yu, 2010; Wan et al., 2020; Alturki & Aldraiweesh, 2023). Such studies highlight that combining functional and behavioral perspectives offers a more comprehensive understanding of technology use than employing either model independently. Building on this established foundation, the present study extends the integrated TTF-TPB framework to the underexplored context of preschool teachers' adoption of robotic toys. This application represents a contextual advancement rather than a theoretical innovation, recognizing that early childhood education presents distinct pedagogical goals, developmental considerations, and institutional constraints compared with previous research domains. By contextualizing an existing theoretical integration within this unique educational setting, the study provides a deeper, domain-specific understanding of teachers' technology adoption processes.

## 2.4 Research model and hypotheses

Addressing these gaps, the present study develops and tests an integrative model that combines the TTF and TPB frameworks to examine the determinants of preschool teachers' intentions to adopt robotic toys. The model posits that the perceived fit of robotic toys with core pedagogical tasks (TTF) and the behavioral, social, and psychological determinants outlined in TPB jointly influence adoption intentions. By empirically evaluating the relative contributions and interrelations of these factors, the study seeks to identify the most salient enablers and barriers to technology integration in preschool settings.

### 2.4.1 Task-technology fit

The TTF framework, as established by Goodhue and Thompson (1995), posits that technology is most likely to be adopted when its features align closely with the requirements of users' core tasks. Within early childhood education, two dimensions, task characteristics (e.g., play-based learning, hands-on exploration) and technology characteristics (e.g., interactivity, adaptability, ease of integration), play pivotal roles in shaping teachers' perceptions of how well a given technology fits their instructional needs (Dishaw & Strong, 1999; Goodhue & Thompson, 1995).

Empirical research suggests that when teachers recognize that robotic toys effectively support key pedagogical activities, such as fostering child engagement, facilitating curriculum alignment, and enabling collaborative or individualized learning, they are more likely to incorporate these tools into their teaching practice (Ateş & Gündüzalp, 2024; Ateş & Polat, 2025). This fit between technology capabilities and pedagogical requirements is essential, as early childhood classrooms often emphasize experiential and interactive learning. The literature consistently highlights that without a strong alignment, even advanced technological tools may fail to gain traction among educators (Chai et al., 2024; Kong et al., 2024; Sanusi et al., 2024).

Despite these insights, prior studies in the context of educational robotics have often examined either the technological affordances or classroom practices in isolation, rarely investigating how specific features of robotic toys complement the unique instructional approaches prevalent in preschool education. Furthermore, there is limited empirical work that quantifies the pathways through which both task and technology characteristics contribute to overall task-technology fit and, in turn, to teachers' adoption intentions (Almusawi & Durugbo, 2024; Dahri et al., 2024).

To address these gaps, the following hypotheses are proposed:

**H1:** Task characteristics positively influence task-technology fit in preschool teachers' adoption of robotic toys.

**H2:** Technology characteristics positively influence task-technology fit in preschool teachers' adoption of robotic toys.

**H3:** Task-technology fit positively influences preschool teachers' intentions to adopt robotic toys.

### 2.4.2 Theory of planned behavior

The TPB, developed by Ajzen (1991), offers a comprehensive framework for analyzing the psychological and social determinants of technology adoption in educational contexts. TPB posits that an individual's intention to perform a behavior is shaped by three core constructs (Conner & Armitage, 1998): attitude (the extent to which an individual holds a favorable or unfavorable evaluation of adopting robotic toys), subjective norm (the perceived social expectations and support from colleagues, administrators, and the broader school community), and perceived behavioral control (the individual's belief in their capacity to successfully implement the technology, given available resources and skills) (Ateş & Garzón, 2023; Huang et al., 2025; Leung & Cheung, 2025).

While the influence of technical and infrastructural factors has been well-documented in previous studies on educational robotics (Vasou et al., 2024), there has been comparatively less attention paid to the psychological readiness of teachers and the complex interplay of social influences within preschool settings. Recent research indicates that even in environments where technological tools are well-matched to pedagogical needs, adoption may be impeded by negative attitudes, insufficient peer or institutional support, or low self-efficacy (Ateş & Garzón, 2022). Thus, focusing on these psychological and contextual factors is essential for understanding the real drivers and barriers to technology integration in early childhood education.

Nevertheless, one of the major limitations of TPB lies in the so-called intention–behavior gap, the discrepancy between an individual’s intention to adopt a technology and their actual implementation behavior (Sheeran, 2002; Armitage & Conner, 2001). In educational settings, teachers may express strong intentions to use technological innovations yet fail to translate these intentions into practice due to contextual barriers, competing priorities, or limited institutional support (Teo, 2011; Ertmer & Ottenbreit-Leftwich, 2010). This limitation is particularly relevant in preschool education, where classroom management demands, developmental appropriateness, and curricular flexibility all affect teachers’ ability to enact their intentions. Recognizing this limitation, the present study integrates the TTF perspective with TPB to strengthen the link between intention and actual adoption, positing that when teachers perceive a strong alignment between robotic toys and pedagogical tasks, their intentions are more likely to result in real classroom implementation.

By empirically examining these TPB constructs in the context of robotic toy adoption, this study aims to fill a notable gap in the literature. It provides a more nuanced understanding of how motivational and social dynamics interact with technological fit to influence teachers’ intention to adopt robotic toys. This, in turn, offers theoretical and practical insights that can inform professional development, policy initiatives, and leadership strategies to translate teachers’ intentions into actual classroom adoption and promote sustainable technology integration.

Based on this theoretical framework and the identified gaps in prior research, the following hypotheses are proposed:

**H4:** Attitude positively influences preschool teachers’ intentions to adopt robotic toys.

**H5:** Subjective norm positively influences preschool teachers’ intentions to adopt robotic toys.

**H6:** Perceived behavioral control positively influences preschool teachers’ intentions to adopt robotic toys.

By advancing an integrated TTF–TPB framework, this study moves beyond previous research that has typically examined technological or behavioral determinants in isolation. The proposed model thus offers a comprehensive, empirically grounded perspective on the factors shaping preschool teachers’ adoption of robotic toys, as illustrated in Fig. 1.

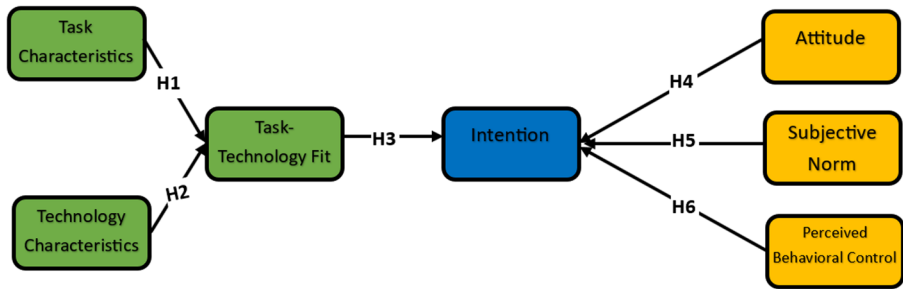


Fig. 1 Integrated TTF-TPB Conceptual model for preschool teachers' adoption of robotic toys

### 3 Method

#### 3.1 Data collection process

This study employed a carefully structured process to gather quantitative data from preschool teachers regarding their perceptions and intentions to adopt robotic toys in early childhood education. The approach was designed to maximize response accuracy, support participant understanding, and ensure the data's relevance to real classroom environments.

To begin, all potential participants, who were current preschool teachers employed at public and private early childhood education centers, received an informational email describing the purpose and scope of the research. The invitation clarified that participation was voluntary and confidential, and that it was limited to preschool educators who were actively practicing.

Prior to completing the survey, participants accessed a brief digital orientation package created specifically to ensure consistent understanding of key study terms and procedures. The package included neutral descriptions of educational robotic toys, with examples (e.g., Bee-Bot, Cubetto, LEGO® Education kits) to clarify what was meant by the term “robotic toys.” It also provided general information about how the survey would proceed and how to interpret item wording. The materials intentionally avoided evaluative or persuasive language about robotics; instead, their purpose was to ensure terminological clarity and minimize misinterpretation, particularly for teachers with limited prior exposure to such technologies.

After completing the orientation, participants proceeded to an online survey developed using established measurement scales from the TTF and TPB frameworks, adapted to the context of preschool education. Survey items explored teachers' perceptions of the alignment between robotic toys and their instructional goals, as well as their attitudes, perceived social support, self-efficacy, and intentions toward adoption. The survey was delivered in the local language and reviewed for clarity and appropriateness by early childhood education experts prior to administration.

To promote high response rates and data quality, the survey platform allowed participants to pause and resume their responses as needed. Teachers received up to two gentle reminders via email, spaced one week apart, encouraging completion for those who had not responded. Technical assistance was available throughout the data col-

lection period, with participants able to contact the research team directly for support or clarification regarding survey content.

All study procedures received approval from the institutional ethics review board. Participation was anonymous, and informed consent was obtained digitally before survey access was granted.

### 3.2 Sample

The sample for this study consisted exclusively of preschool teachers currently employed in early childhood education institutions across multiple regions of Turkey. Data collection occurred between February and June 2025, targeting educators who had direct, ongoing experience with preschool-aged children and daily classroom practice. This approach ensured that participants' perspectives reflected the realities of current early childhood education environments and the authentic challenges of integrating new technologies such as robotic toys.

A total of 742 preschool teachers participated in the study. Teachers were recruited from a mix of public and private preschools, encompassing urban, suburban, and rural settings to maximize diversity in teaching contexts, school resources, and exposure to educational technology. Selection was facilitated through collaboration with local education authorities and school administrators, who distributed the study invitation to eligible teachers within their networks.

Participants represented a wide range of professional backgrounds. The majority held a Bachelor's degree in early childhood education or a related field (78%), while others reported postgraduate qualifications (19% Master's, 3% Doctorate). Teaching experience among participants varied considerably: 21% had between 2 and 5 years of experience, 56% had 6 to 15 years, and 23% had more than 15 years of continuous classroom service. This range enabled the study to explore how professional longevity influences openness to technological innovation and classroom adaptation.

The sample was predominantly female (91%), consistent with national statistics for the preschool teaching workforce in Turkey, with the remaining 9% identifying as male. The age distribution was as follows: 18% were under 30 years old, 49% were aged 30 to 39, 28% were 40 to 49, and 5% were 50 years or older. This diversity provided insights into generational differences in attitudes toward technology adoption.

To understand the impact of institutional context, 62% of participants were employed in urban preschools, 27% in suburban schools, and 11% in rural settings. Notably, 58% of teachers reported regular access to computers or tablets in their classrooms, while 42% indicated limited or no direct access to digital learning devices. Prior exposure to educational robotics was low: only 14% had previously used robotic toys in any instructional activity, while 86% had not incorporated such technologies before participating in this study.

### 3.3 Data collection tools

The development of measurement instruments for this study followed a systematic and context-sensitive process to ensure the validity, reliability, and appropriateness of the scales used to assess preschool teachers' intentions to adopt robotic toys. In

this study, the term “robotic toys” refers to interactive, programmable, or semi-programmable educational tools designed to promote play-based, hands-on learning in early childhood settings. This category encompasses commonly used educational robots such as Bee-Bot, Cubetto, and LEGO® Education kits, as well as similar programmable devices that enable young children to engage in tangible exploration, sequencing, or introductory coding activities (Kewalramani et al., 2021b; Torpegaard et al., 2022). The questionnaire employed this general label “robotic toys” to capture a broad spectrum of tools relevant to preschool contexts, without distinguishing between variations in technological sophistication or specific product types, a methodological consideration further addressed in the Limitations section. All constructs were informed by established theoretical foundations, namely, the TTF and TPB frameworks, and were carefully adapted to the pedagogical realities of early childhood education.

The instrument construction began with a thorough review of prior research on technology adoption in early childhood settings, specifically focusing on robotic and digital technologies relevant to preschool classrooms. Existing measurement items for each construct (task characteristics, technology characteristics, task-technology fit, attitudes, subjective norm, perceived behavioral control, and intention to adopt) were identified from seminal and recent studies (e.g., Ajzen, 2006; Al-Emran et al., 2025; Faqih & Jaradat, 2021; Goodhue & Thompson, 1995). These items were then adapted to reflect the context of preschool education, with an emphasis on play-based learning, collaboration, and classroom practicality.

To ensure content and face validity, an expert panel consisting of two early childhood education faculty and two specialists in educational technology reviewed the draft instrument. Their feedback guided the rewording of several items to better match the vocabulary, routines, and classroom challenges familiar to preschool teachers.

The adapted items were then pilot-tested with a sample of preschool teachers ( $n=289$ ). The pilot phase aimed to identify ambiguities, assess item clarity, and check for cultural appropriateness. Based on the feedback, several modifications were made, including simplifying complex terms, adding context-specific examples, and adjusting response anchors for better comprehension by the target population.

Given the Turkish educational context, the finalized survey was translated using a forward-backward translation process to ensure linguistic accuracy. An initial translation from English to Turkish was completed by a bilingual researcher, followed by an independent back-translation. Discrepancies were resolved collaboratively by the research team to preserve the intended meanings and ensure cultural relevance.

Each construct was measured using multiple items, with responses captured on a seven-point Likert scale (1 = Strongly Disagree, 7 = Strongly Agree). The scale covered the following domains:

1. Task characteristics: e.g., “Robotic toys support essential play-based activities in my classroom.”
2. Technology characteristics: e.g., “Robotic toys can be integrated smoothly into daily routines.”
3. Task-technology fit: e.g., “Robotic toys are well-suited to the educational goals of preschool.”

4. Attitude: e.g., “Using robotic toys in preschool is beneficial for young children’s development.”
5. Subjective norm: e.g., “My colleagues and supervisors support the use of robotic toys in our school.”
6. Perceived behavioral control: e.g., “I am confident in my ability to manage robotic toy activities in class.”
7. Intention to adopt: e.g., “I intend to regularly incorporate robotic toys into my teaching.”

Consistent with prior research on educational robotics and technology adoption, all questionnaire items employed the general term “robotic toys” rather than specifying particular brands, models, or levels of technological complexity. This approach ensured conceptual breadth and comparability across diverse preschool contexts in which various programmable or semi-programmable tools (e.g., Bee-Bot, Cubetto, LEGO® Education kits) are commonly used. Nonetheless, this broad operationalization may not fully capture potential differences in teachers’ perceptions arising from variations in the complexity, interactivity, or instructional affordances of specific robotic toys, a limitation acknowledged in the study’s discussion and proposed for further investigation in future research.

Table 1 summarizes the constructs and example measurement items. Reliability and construct validity were subsequently confirmed through confirmatory factor analysis and calculation of Cronbach’s alpha for each scale.

### 3.4 Data analysis

Data analysis for this study was conducted using a rigorous, multi-stage approach to ensure both the validity and reliability of the findings regarding preschool teachers’ intentions to adopt robotic toys. All statistical analyses were performed using IBM SPSS Statistics (version 26) for descriptive and reliability analyses, and AMOS (version 24) for confirmatory factor analysis (CFA) and structural equation modeling (SEM).

Initially, descriptive statistics, including means, standard deviations, and frequency distributions, were calculated for all demographic variables and primary study constructs. This provided an overview of participants’ general attitudes, perceived norms, behavioral control, and intentions toward integrating robotic toys in preschool classrooms. The data were screened for outliers, missing values, and normality; no significant violations were detected, allowing for parametric analysis (Tabachnick & Fidell, 2019).

The validity and reliability of the measurement instruments were rigorously evaluated prior to hypothesis testing. Internal consistency for each construct was assessed using Cronbach’s alpha ( $\alpha$ ), with all values exceeding the recommended threshold of 0.70, indicating strong reliability. Convergent validity was evaluated through three criteria: (1) standardized factor loadings, which all exceeded 0.70; (2) Composite Reliability (CR), with all constructs above 0.80; and (3) Average Variance Extracted (AVE), with all values above the 0.50 benchmark. These results confirmed that the

**Table 1** Constructs, example items, and measurement metrics for TTF and TPB in preschool robotic toy adoption

Construct	Example Item	No. of Items	Factor Loading	Mean	SD	AVE	CR	$\alpha$	Sources
<b>TTF Constructs</b>									
Task Characteristics	Robotic toys support essential play-based activities in my classroom.	3	0.82	4.31	1.09	0.71	0.88	0.87	Goodhue and Thompson (1995); Faqih and Jaradat (2021)
	Robotic toys help facilitate hands-on learning for preschool children.		0.85	4.44	1.01				
	I use robotic toys to encourage collaboration among students.		0.80	4.18	1.12				
Technology Characteristics	Robotic toys are easy to set up in the preschool environment.	3	0.81	4.12	1.07	0.68	0.86	0.85	Goodhue and Thompson (1995); Faqih and Jaradat (2021)
	Robotic toys are reliable for daily classroom activities.		0.84	4.09	1.10				
	Robotic toys can be integrated smoothly into teaching routines.		0.79	4.25	1.06				
Task-Technology Fit	Robotic toys align well with preschool educational goals.	3	0.83	4.29	1.08	0.72	0.90	0.89	Goodhue and Thompson (1995); Faqih and Jaradat (2021)
	The features of robotic toys meet the needs of my instructional practices.		0.87	4.35	1.04				
	Overall, robotic toys are a good fit for my teaching style.		0.85	4.21	1.10				
<b>TPB Constructs</b>									
Attitude	Using robotic toys in preschool is a good idea.	3	0.88	4.41	1.13	0.75	0.92	0.91	Ajzen (2006); Al-Emran et al. (2025)
	I enjoy teaching with robotic toys.		0.84	4.38	1.09				
	Robotic toys make lessons more engaging for young children.		0.87	4.40	1.12				

**Table 1** (continued)

Construct	Example Item	No. of Items	Factor Loading	Mean	SD	AVE	CR	$\alpha$	Sources
<b>TTF Constructs</b>									
Subjective Norm	My school leadership encourages the use of robotic toys.	2	0.80	4.15	1.10	0.68	0.86	0.88	Ajzen (2006); Al-Emran et al. (2025)
	My colleagues think robotic toys should be used in preschool.		0.83	4.08	1.06				
Perceived Behavioral Control	I feel confident in my ability to use robotic toys in my class.	3	0.86	4.10	1.08	0.74	0.91	0.90	Ajzen (2006); Al-Emran et al. (2025)
	I have sufficient resources to implement robotic toys in my classroom.		0.85	3.97	1.13				
	I can solve problems related to robotic toy activities if they arise.		0.87	4.05	1.10				
Intention to Adopt	I plan to regularly use robotic toys in my preschool teaching.	3	0.89	4.23	1.14	0.78	0.93	0.91	Ajzen (2006); Al-Emran et al. (2025)
	I will look for opportunities to integrate robotic toys into my lessons.		0.91	4.28	1.08				
	I am committed to using robotic toys whenever possible.		0.88	4.19	1.11				

Note. *AVE* Average Variance Extracted, *CR* Composite Reliability,  $\alpha$  Cronbach's alpha, *SD* Standard Deviation

items adequately measured their intended latent variables (Byrne, 2016; Kline, 2016; Nunnally & Bernstein, 1994).

Discriminant validity was examined by comparing the square root of the AVE for each construct to the corresponding inter-construct correlations, following Fornell and Larcker (1981). As summarized in Table 2, the diagonal values were consistently higher than the inter-construct correlations, demonstrating that each construct was empirically distinct from the others within the TTF-TPB framework.

The hypothesized structural model was then evaluated using SEM in AMOS. Multiple goodness-of-fit indices were used to determine the adequacy of the model fit, including the Chi-square to degrees of freedom ratio ( $\chi^2/df$ ), Goodness of Fit Index (GFI), Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), Incremental Fit Index (IFI), Root Mean Square Error of Approximation (RMSEA), and Standardized Root Mean Square Residual (SRMR). The obtained indices all met or surpassed accepted cutoff values (e.g.,  $\chi^2/df < 3$ ; GFI, CFI, IFI, TLI  $> 0.90$ ; RMSEA, SRMR  $< 0.08$ ), indicating a robust fit of the proposed model to the data.

**Table 2** Inter-construct correlations and discriminant validity

Construct	TC	TEC	TTF	ATT	SN	PBC	INT
Task Characteristics (TC)	<b>0.85</b>						
Technology Characteristics (TEC)	0.41	<b>0.83</b>					
Task-Technology Fit (TTF)	0.38	0.46	<b>0.84</b>				
Attitude (ATT)	0.43	0.39	0.42	<b>0.86</b>			
Subjective Norm (SN)	0.35	0.38	0.36	0.40	<b>0.82</b>		
Perceived Behavioral Control (PBC)	0.39	0.36	0.40	0.43	0.42	<b>0.83</b>	
Intention to Adopt (INT)	0.54	0.52	0.51	0.55	0.50	0.53	<b>0.88</b>

Note. The diagonal values (bold) represent the square root of the AVE for each construct, providing evidence of discriminant validity. Off-diagonal values are inter-construct correlations

**Table 3** Comparative model fit indices and predictive strength for robotic toy adoption

Model	$\chi^2$	df	$\chi^2/df$	GFI	AGFI	CFI	TLI	IFI	RMSEA	SRMR	$R^2$
Task-Technology Fit	998.15	396	2.52	0.89	0.85	0.91	0.90	0.90	0.064	0.047	0.49
Theory of Planned Behavior	943.78	355	2.66	0.90	0.87	0.93	0.92	0.92	0.060	0.045	0.53
Integrated TTF-TPB	771.22	327	2.36	0.95	0.91	0.97	0.95	0.96	0.051	0.038	0.61

Note. *GFI*=Goodness of Fit Index, *AGFI* Adjusted Goodness of Fit Index, *CFI* Comparative Fit Index, *TLI* Tucker-Lewis Index, *IFI* Incremental Fit Index, *RMSEA* Root Mean Square Error of Approximation, *SRMR* Standardized Root Mean Square Residual,  $R^2$  variance explained in intention to adopt robotic toys

## 4 Findings

### 4.1 Comparative evaluation of model performance: task, behavioral, and integrated approaches

In order to rigorously assess the explanatory capacity of competing theoretical perspectives, structural equation modeling was utilized to examine the fit and predictive power of three conceptual models: the TTF model, the TPB model, and a unified model that synthesizes both frameworks. This analysis was conducted to determine which approach most effectively accounts for preschool teachers' intentions to incorporate robotic toys into their classroom practices.

Table 3 presents the results of the comparative model evaluation. Each model yielded statistically acceptable fit indices; however, the integrated TTF-TPB framework consistently demonstrated superior performance on key benchmarks. Specifically, the unified model achieved a chi-square to degrees of freedom ratio ( $\chi^2/df$ ) of 2.36, outperforming the TTF ( $\chi^2/df=2.52$ ) and TPB ( $\chi^2/df=2.66$ ) models. Furthermore, indices such as the Goodness of Fit Index ( $GFI=0.95$ ), Comparative Fit Index ( $CFI=0.97$ ), and Root Mean Square Error of Approximation ( $RMSEA=0.051$ ) confirmed the integrated model's closer alignment with the empirical data.

Crucially, the explanatory power for "Intention to Adopt Robotic Toys" was markedly higher for the integrated framework ( $R^2 = 0.61$ ) than for the models based on TTF ( $R^2 = 0.49$ ) or TPB alone ( $R^2 = 0.53$ ). This finding underscores the value of com-

binning both technological and motivational determinants when seeking to understand how innovative educational tools are embraced by early childhood educators.

These outcomes collectively reinforce the merit of a dual-lens perspective, as the integrated model delivers a more nuanced and holistic account of the mechanisms underlying technology adoption in preschool education.

## 4.2 Pathways to robotic toy integration: structural equation modeling of the TTF model

### 4.2.1 Examining task-technology fit among preschool teachers

To unravel the mechanisms underlying preschool teachers' openness to integrating robotic toys into early childhood education, the TTF model was tested using structural equation modeling. This approach allowed for a focused investigation of how well the functional characteristics of robotic toys intersect with the instructional realities of preschool classrooms.

The model revealed that task characteristics, such as the degree to which play-based, collaborative, and exploratory activities are valued, exerted a significant and substantial influence on perceived task-technology fit ( $\beta=0.44$ ,  $p<0.001$ ). This indicates that teachers who prioritize active, child-centered learning are more likely to recognize the compatibility of robotic toys with their daily pedagogical practices.

Similarly, technology characteristics, including the toys' adaptability, ease of use, and ability to engage young learners, were found to meaningfully predict perceived fit ( $\beta=0.41$ ,  $p<0.001$ ). Preschool teachers expressed higher task-technology fit scores when robotic toys were perceived as intuitive, reliable, and capable of supporting differentiated instruction.

Crucially, task-technology fit emerged as a key determinant of adoption intentions ( $\beta=0.48$ ,  $p<0.001$ ). When educators judged robotic toys to be well-matched to the dynamic, hands-on learning goals of preschool, they reported greater willingness to adopt and sustain their use in classroom routines.

These results underscore the importance of designing and promoting robotic toys that resonate with the unique instructional objectives of early childhood education, rather than focusing solely on generic technological advancements (Table 4).

**Table 4** Structural equation model results: Task-technology fit pathways for robotic toy adoption

Relationship	Standardized Estimate ( $\beta$ )	Standard Error (SE)	Critical Ratio (CR)	$p$ -value
Task Characteristics $\rightarrow$ Task-Technology Fit	0.44	0.06	7.33	<0.001
Technology Characteristics $\rightarrow$ Task-Technology Fit	0.41	0.05	7.02	<0.001
Task-Technology Fit $\rightarrow$ Intention to Adopt	0.48	0.07	6.86	<0.001

#### 4.2.2 Social-psychological drivers of robotic toy adoption: TPB model analysis

To further illuminate the determinants of robotic toy adoption among preschool teachers, the TPB model was tested to disentangle the effects of attitude, subjective norm, and perceived behavioral control on educators' intentions. This model foregrounds the social-psychological context in which technology-related decisions are made in early childhood classrooms.

As presented in Table 5, attitude toward robotic toys, encompassing beliefs about their educational value, enjoyment, and perceived benefit for young children, was a significant predictor of teachers' willingness to adopt ( $\beta=0.39, p<0.001$ ). Preschool teachers who regarded robotic toys as playful, enriching, and developmentally appropriate reported stronger intentions to integrate them into daily activities.

Subjective norm, reflecting the perceived expectations and encouragement from colleagues, administrators, and parents, also positively influenced adoption intention ( $\beta=0.36, p=0.002$ ). The results suggest that a culture of support and shared enthusiasm within early childhood education communities can meaningfully enhance openness to new instructional technologies.

Finally, perceived behavioral control, the degree to which teachers felt capable of managing and facilitating robotic toy activities, had a robust effect on adoption intention ( $\beta=0.42, p<0.001$ ). Teachers' confidence in their skills, combined with the availability of training and resources, played a decisive role in shaping their commitment to utilizing robotic toys.

Together, these findings highlight the essential role of psychological and social enablers, beyond simple technological readiness, in fostering innovative teaching practices in preschool education.

#### 4.2.3 Synthesizing technological and behavioral drivers: results from the integrated model

The integrated analysis combined both technological alignment and social-psychological dimensions to provide a comprehensive understanding of what propels preschool teachers to embrace robotic toys. Structural equation modeling revealed that the interplay between task demands, technology features, and motivational beliefs offers the most robust explanation for teachers' intentions to adopt robotic toys.

Task characteristics, such as how well robotic toys support playful exploration and interactive group work, demonstrated a strong, positive effect on perceived task-technology fit ( $\beta=0.41, t=5.85, p<0.001$ ). Technology characteristics, including

**Table 5** Structural equation model results: social-psychological predictors of robotic toy adoption

Relationship	Standardized Estimate ( $\beta$ )	Standard Error (SE)	Critical Ratio (CR)	<i>p</i> -value
Attitude $\rightarrow$ Intention to Adopt	0.39	0.08	4.88	<0.001
Subjective Norm $\rightarrow$ Intention to Adopt	0.36	0.09	4.09	0.002
Perceived Behavioral Control $\rightarrow$ Intention to Adopt	0.42	0.07	6.00	<0.001

ease of use, adaptability, and classroom reliability, similarly promoted perceptions of fit ( $\beta=0.37$ ,  $t=5.11$ ,  $p<0.001$ ).

Task–technology fit itself emerged as a key lever for increasing willingness to adopt ( $\beta=0.45$ ,  $t=6.70$ ,  $p<0.001$ ), affirming that technology must genuinely resonate with preschool educators' pedagogical aims to gain traction.

Turning to motivational and social factors, attitude toward robotic toys, teachers' belief in their value and appropriateness for early learners, significantly elevated adoption intentions ( $\beta=0.38$ ,  $t=5.29$ ,  $p<0.001$ ). Subjective norm ( $\beta=0.32$ ,  $t=4.11$ ,  $p<0.001$ ) confirmed the critical role of community and leadership encouragement, while perceived behavioral control ( $\beta=0.35$ ,  $t=4.93$ ,  $p<0.001$ ) highlighted the importance of self-confidence and institutional support.

A closer inspection of the standardized coefficients reveals that task–technology fit ( $\beta=0.45$ ) exerts the strongest direct influence on teachers' intentions, emphasizing that pedagogical alignment outweighs psychological or social considerations in predicting adoption. Attitude ( $\beta=0.38$ ) and perceived behavioral control ( $\beta=0.35$ ) follow as moderate yet meaningful predictors, suggesting that positive evaluations and confidence in technological competence further enhance willingness to adopt. In contrast, subjective norm ( $\beta=0.32$ ), while significant, emerged as the weakest predictor, implying that peer or administrative encouragement alone is insufficient to drive adoption without intrinsic and pedagogical alignment.

Collectively, these findings indicate that preschool teachers' technology adoption decisions are most powerfully shaped by how well robotic toys fit their instructional goals, supplemented by supportive attitudes and perceived control rather than by external normative pressures.

As presented in Table 6; Fig. 2, all hypothesized pathways were statistically significant and in the predicted direction, reinforcing the need for both technological and motivational alignment to promote sustainable technology integration in early childhood education.

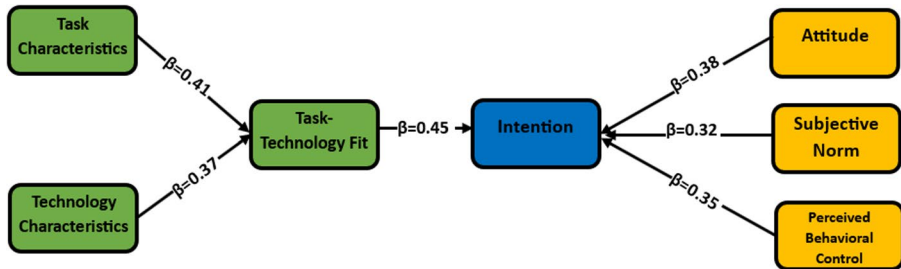
## 5 Discussion

This research proposed and empirically tested a comprehensive framework that integrates task-based and motivational perspectives to explain preschool teachers' willingness to adopt robotic toys. The findings demonstrate that the integrated model, encompassing both the TTF and TPB dimensions, outperforms traditional, single-factor approaches in predicting teachers' intentions, offering a nuanced view of the conditions that foster technology integration in early childhood classrooms.

Analysis revealed that multiple factors operate in tandem to shape teachers' intention to adopt robotic toys. The alignment between robotic toys and the unique instructional demands of preschool education, reflected in features that support playful exploration, collaboration, and developmental appropriateness, was a central driver of perceived task–technology fit. Teachers who viewed robotic toys as well-matched to the realities of classroom practice expressed notably stronger intentions to incorporate them into their daily routines.

**Table 6** Structural equation modeling results: comparative path coefficients across models

Pathway	TTF ( $\beta$ )	TPB ( $\beta$ )	Inte- grated Model ( $\beta$ )	t value (TTF)	t value (TPB)	t value (Integrated)	Hypothesis	Sup- ported
Task Characteris- tics $\rightarrow$ Task-Tech Fit	0.44	-	0.41	3.92	-	5.85	H1	Yes
Tech Characteris- tics $\rightarrow$ Task-Tech Fit	0.41	-	0.37	3.27	-	5.11	H2	Yes
Task-Tech Fit $\rightarrow$ Intention to Adopt	0.48	-	0.45	4.68	-	6.70	H3	Yes
Attitude $\rightarrow$ In- tention to Adopt	-	0.39	0.38	-	5.72	5.29	H4	Yes
Subjective Norm $\rightarrow$ Intention to Adopt	-	0.36	0.32	-	4.91	4.11	H5	Yes
Perceived Be- havioral Control $\rightarrow$ Intention to Adopt	-	0.42	0.35	-	5.22	4.93	H6	Yes



**Fig. 2** Path analysis results for the integrated model of robotic toy adoption among preschool teachers

Beyond technological considerations, attitudinal, social, and control-related factors were found to exert significant influence. Positive attitudes toward the educational value and enjoyment of robotic toys, coupled with encouragement from colleagues and administrators, were associated with greater openness to adoption. Importantly, teachers’ confidence in their ability to successfully implement robotics activities, bolstered by access to resources and professional development, emerged as a key enabling factor.

However, the relative strength of these pathways reveals that task–technology fit exerted the most powerful direct effect on adoption intention, exceeding the influence of attitudinal and control-related factors. Subjective norm was the weakest predictor, indicating that social or administrative encouragement alone is less decisive than perceived pedagogical alignment and self-efficacy. This pattern underscores that currently employed preschool teachers’ decisions to adopt robotic toys are primarily

grounded in their evaluation of how well the technology supports their instructional goals rather than in external expectations.

Taken together, these results underscore the importance of considering both the functional alignment of technology with pedagogical goals and the motivational ecosystem surrounding teachers. The study advances understanding of how practical, psychological, and social factors converge to facilitate the meaningful use of innovative tools in preschool education. Its insights inform not only research but also the design of professional learning and policy strategies aimed at supporting the sustainable integration of robotics in early childhood settings.

## 5.1 Theoretical implications

This study extends the theoretical landscape of educational technology adoption by synthesizing the TTF framework (Goodhue & Thompson, 1995) with the TPB (Ajzen, 1991) to investigate the factors underlying preschool teachers' willingness to adopt robotic toys. While prior research has established the value of TTF in capturing the importance of technological alignment (Al-Rahmi et al., 2022; Alyoussef, 2021; Faqih & Jaradat, 2021) and TPB (Ateş & Yilmaz, 2024; Sungur-Gül & Ateş, 2021) in elucidating psychological determinants of behavioral intention (Fishbein & Ajzen, 2010), relatively few studies have operationalized an integrated framework in early childhood educational settings (Şakır 2025a; Konca et al., 2025).

By uniting TTF and TPB, this research addresses a gap noted by scholars who argue for more comprehensive models that reflect the multifaceted nature of technology adoption (Almusawi & Durugbo, 2024; Opoku et al., 2021; Venkatesh & Davis, 2000). The results corroborate findings from Ateş and Polat (2025) and Kim and Song (2022), demonstrating that both technological fit and behavioral motivation are indispensable predictors of adoption intention. The integrated model's superior explanatory power, compared to stand-alone approaches, reinforces calls for theoretical pluralism in educational technology research (Ahn et al., 2025; Venkatesh et al., 2012).

A particularly noteworthy finding is the comparatively muted effect of subjective norms in the preschool context, diverging from prior evidence in other domains where social influence exerts a strong impact (Habibi et al., 2023; Hou et al., 2022; Fishbein & Ajzen, 2010). This suggests that preschool teachers' adoption decisions may be more strongly shaped by intrinsic attitudes and perceived control, as seen in recent work on early childhood educators' agency (Hong et al., 2021; Merjoavaara et al., 2024; Rad et al., 2023). Consistent with this interpretation, the integrated model confirmed that task–technology fit ( $\beta=0.45$ ) was the most influential predictor of intention, while subjective norm ( $\beta=0.32$ ) contributed least, highlighting the predominance of pedagogical and efficacy-based determinants over normative pressure. One plausible explanation for this weaker social influence lies in the professional characteristics of the sample. As currently employed preschool teachers, participants are likely to have developed stable pedagogical beliefs and established classroom routines, which may reduce their reliance on external social pressures when making decisions about technology use. In such professional contexts, normative expectations from colleagues or institutions may already be internalized or taken for granted,

thereby diminishing their direct influence on behavioral intentions. Additionally, early childhood education in the Turkish context tends to emphasize individual responsibility for classroom practice and pedagogical autonomy (Şakir, 2025a), potentially reducing the salience of external social pressure. Cultural factors may also play a role. In collectivist yet hierarchical educational cultures, such as Turkey's, social influence often depends more strongly on directives from institutional leadership than on peer expectations. Given that robotic toy use remains an emerging practice with limited formal endorsement, subjective norms may not yet exert a consistent motivational force. Alternatively, this finding highlights the need to refine the operationalization of subjective norms to better capture contextually salient influencers, such as school leadership or professional learning communities, as suggested by Ahn et al. (2025), Ma and Lei (2024), Özdemir and Ateş (2025), and Zainal and Mohd Matore (2021).

The robust effect of perceived behavioral control aligns with prior research emphasizing teacher self-efficacy, digital competence, and resource access as core facilitators of technology integration (An et al., 2023; La Barbera & Ajzen, 2021). Yet, echoing critiques of the TPB, this study also surfaces the model's limitations in accounting for external, structural, or environmental barriers, such as institutional constraints and infrastructural deficits (Schade & Schuhmacher, 2022). Scholars have advocated augmenting TPB with constructs from the Technology-Organization-Environment (TOE) framework (Tornatzky & Fleischer, 1990) or employing mixed-methods designs (Opoku et al., 2021) to better capture the complexity of real-world adoption contexts.

The observed interaction between TTF and TPB components indicates that neither technological nor behavioral factors operate in isolation (Khoa et al., 2021). Rather, a strong alignment between technology and task can amplify the positive effects of attitudes and self-efficacy but is not sufficient to guarantee teachers' intention to adopt without supportive psychological and organizational climates. This dynamic interplay lends further support to calls for integrative and context-sensitive models in technology acceptance research (Al-Emran et al., 2025).

This work points to several important trajectories for theory development. Future research should explore under what conditions TPB components, particularly subjective norms, exert differential effects, and how external or contextual variables (e.g., leadership, policy, culture) can be more precisely modeled. Hybrid frameworks that further integrate TTF, TPB, and complementary theories such as Self-Determination Theory (SDT; Deci & Ryan, 2000) or UTAUT2 (Venkatesh et al., 2012) may yield a more complete account of technology adoption motivations and barriers. Cross-context validation and longitudinal research are also needed to test the stability and generalizability of these relationships across diverse early childhood environments (Opoku et al., 2021).

In sum, by providing empirical evidence for the value and limits of an integrated TTF-TPB model, this study contributes to a more nuanced and dynamic understanding of how technological and behavioral factors jointly shape teachers' intention to adopt technology in preschool education. These theoretical insights lay the foundation for further model refinement and cross-contextual inquiry in educational technology research, particularly studies seeking to bridge the gap between intention and actual classroom adoption.

## 5.2 Practical implications

The findings of this study provide several data-driven and context-specific implications for policymakers, teacher educators, curriculum designers, and technology developers seeking to advance the integration of robotic toys in early childhood education. The integrated model accounted for 61% of the variance in teachers' adoption intentions and revealed that task–technology fit ( $\beta=0.45$ ) and perceived behavioral control ( $\beta=0.35$ ) were the strongest predictors, followed by attitude ( $\beta=0.38$ ) and subjective norm ( $\beta=0.32$ ). These results underscore the need for practical interventions that enhance both the *functional alignment* of robotic toys with pedagogical goals and the *psychological empowerment* of teachers who use them.

### 5.2.1 Enhancing task–technology fit through pedagogical alignment

The strongest predictor of teachers' intention to adopt robotic toys was task–technology fit. This suggests that teachers are most willing to integrate robotics when they perceive a clear alignment between technological affordances and early childhood pedagogical goals such as play-based exploration, collaboration, and creativity. Professional development should therefore move beyond tool familiarization and focus on *curriculum-integrated design*. For example, training programs could require teachers to design short robotics activities mapped explicitly to national early learning standards, such as using Bee-Bot to reinforce spatial reasoning or sequencing skills. Reflection sessions where teachers evaluate how robotic toys meet developmental outcomes can further reinforce perceptions of fit. Developers and curriculum specialists should co-design robotic toys and teaching resources that naturally extend existing classroom routines, reducing cognitive and logistical barriers to implementation.

### 5.2.2 Strengthening perceived behavioral control through capacity-building and structural support

The second-strongest predictor, perceived behavioral control, highlights the importance of teachers' sense of capability and access to resources in shaping adoption intention. Rather than general encouragement to “build confidence,” training should incorporate *hands-on, iterative mastery experiences* that allow teachers to plan, test, and refine robotics activities in safe environments. Mentoring programs pairing novice and experienced teachers, as well as micro-credentialing systems that recognize robotics competence, can further enhance self-efficacy. Institutional policies should guarantee technical support, adequate preparation time, and access to functioning robotic kits, all tangible enablers of behavioral control. When teachers feel capable and supported, they are significantly more likely to adopt and sustain new practices.

### 5.2.3 Reinforcing positive attitudes and motivation toward robotics integration

Attitude toward robotic toys ( $\beta=0.38$ ) was also a meaningful determinant of adoption intention. Positive attitudes can be strengthened by showcasing evidence-based examples of successful robotics integration and by emphasizing observed devel-

omental benefits in peer classrooms. Professional development initiatives should therefore provide practicing preschool teachers with structured opportunities to engage with educational robotics in authentic instructional contexts, helping them associate robotic toys with pedagogical value rather than mere novelty. Furthermore, reflective professional dialogues that link robotics use to teachers' established professional identity, pedagogical beliefs, and educational philosophy may deepen intrinsic motivation and support sustained engagement.

#### **5.2.4 Leveraging social and institutional norms to build a culture of innovation**

Although subjective norm was the weakest predictor, it still exerts a meaningful influence on teachers' willingness to adopt new technologies. School leaders play a crucial role in transforming social support into an active driver of innovation. Administrators can cultivate positive normative climates by recognizing teachers who experiment with robotics, integrating technology goals into school improvement plans, and encouraging cross-classroom sharing of best practices. Additionally, engaging parents through open days or robotics exhibitions can normalize technology use and strengthen community buy-in, particularly important in cultures where parental attitudes shape early education priorities.

#### **5.2.5 Addressing equity and sustainability through systemic support**

Because both task–technology fit and behavioral control are influenced by contextual factors, policymakers should address disparities in access to robotics materials and professional learning opportunities. Strategic investment in hardware, maintenance, and digital infrastructure, especially in rural or under-resourced settings, is vital for ensuring that all preschool teachers can implement robotics equitably. Regular feedback mechanisms, such as teacher reflection logs or participatory design workshops, can ensure that policies remain responsive to classroom realities and that robotic toys continue to evolve alongside pedagogical needs.

### **5.3 Limitations and future research directions**

While this study sheds new light on the drivers of robotic toy adoption among preschool teachers, several limitations must be acknowledged. Articulating these limitations not only delineates the scope of the present research but also provides a roadmap for future inquiry into technology integration in early childhood education.

A primary limitation stems from the exclusive use of self-report survey data. Although this approach is widely employed in studies of technology acceptance, it may be susceptible to social desirability bias and subjective interpretation of survey items. Future research would benefit from complementing survey methods with classroom observations, digital usage analytics, and qualitative interviews or focus groups in order to capture authentic implementation practices and richer contextual detail.

Another limitation concerns the participant pool, which was restricted to preschool teachers. While this focus allows for an in-depth understanding of technology adop-

tion in early childhood education, it limits the generalizability of the findings to other educational levels or professional contexts. Future studies should consider comparative analyses across grade levels, subject areas, or cultural settings to identify both universal and context-specific determinants of technology adoption. Additionally, the use of convenience sampling, despite efforts to include a diverse range of institutions, may not fully capture the experiences of teachers working in rural or under-resourced environments. Employing stratified or randomized sampling strategies could enhance representativeness and external validity.

The study's theoretical approach, centered on the integration of the TTF and TPB frameworks, offers strong explanatory power but may overlook additional contextual influences. Neither framework explicitly accounts for organizational, policy-related, or infrastructural constraints that can shape technology integration in practice. Future research could extend this work by incorporating complementary perspectives, such as the Technology–Organization–Environment (TOE) framework or Self-Determination Theory (SDT), to better capture the interaction between institutional conditions, motivational processes, and teacher-level factors.

Moreover, although basic demographic variables (e.g., age, years of experience, prior technology exposure) were controlled for, their potential moderating effects were not systematically examined. Future studies should explore whether characteristics such as digital fluency, professional identity, or openness to innovation differentially influence relationships within the integrated adoption model.

Another limitation relates to the study's reliance on intention to adopt as the primary outcome variable, rather than on actual or sustained use of robotic toys in classroom practice. While behavioral intention is a well-established predictor of technology use, it does not necessarily translate into long-term implementation or pedagogical impact. Longitudinal and classroom-based research is therefore needed to examine how adoption intentions evolve over time and how robotic toy use affects children's cognitive, social, and emotional development.

In addition, the measurement of task–technology fit treated robotic toys as a unified construct and did not differentiate among specific features, such as programmability, collaborative affordances, or integration with digital applications. Future research should develop and validate more granular measurement instruments that assess how distinct robotic toy features align with varying instructional strategies and developmental goals.

Another potential limitation concerns the pre-survey orientation materials provided to participants. Although these materials were intended to standardize understanding of key concepts and ensure terminological clarity, they may have inadvertently influenced how participants conceptualized robotic toys or interpreted survey items. Future studies could reduce such priming effects by employing more neutral instructional materials, embedding comprehension checks, or including comparison groups without prior exposure to explanatory content.

Furthermore, the use of the broad term “robotic toys” across survey items may have obscured meaningful distinctions between tools of differing complexity, interactivity, and technological sophistication. For example, teachers may perceive simple programmable devices such as Bee-Bot differently from more advanced construction-based systems such as LEGO® Education kits. Future research should therefore

examine whether adoption intentions vary according to tool complexity and teachers' technological preparedness.

Finally, while this study focused on teachers' perspectives, future research should incorporate the voices and experiences of other stakeholders, including school leaders, policymakers, families, and children. Examining how student characteristics, learning styles, and engagement patterns interact with robotics-based learning environments will be essential for ensuring that technology integration remains equitable, developmentally appropriate, and pedagogically meaningful in early childhood education.

## 6 Conclusion

By integrating the TTF and TPB frameworks, the research moves beyond traditional, single-perspective models and provides a more nuanced understanding of how pedagogical needs, technological attributes, and psychological factors jointly shape teachers' intention to adopt technology in early childhood education.

The results clearly demonstrate that teachers are more likely to integrate robotic toys into their classrooms when these tools are perceived as closely aligned with play-based instructional goals, facilitate hands-on exploration, and foster meaningful child engagement. In addition, attitudes toward robotics, supportive social environments, and teachers' confidence in their technological capabilities emerged as crucial predictors of adoption intent. Notably, the interplay between these dimensions underscores the importance of considering both functional and motivational supports in any effort to foster innovation in preschool settings.

This research advances the theoretical landscape by validating the explanatory power of an integrated TTF–TPB model in early childhood education, a context that remains underexplored in technology adoption literature. It further highlights the dynamic interplay between individual, contextual, and organizational factors in shaping technology integration, pointing to the value of multi-theoretical approaches in future research.

From a practical perspective, the findings inform stakeholders about the critical role of ongoing professional development, curriculum-aligned design, and supportive institutional environments in ensuring the effective and sustainable use of robotic toys in preschool classrooms. By fostering both technological fit and positive motivational climates, educators and policymakers can unlock the transformative potential of robotics to enrich early learning experiences.

As educational technologies continue to evolve and the demands on early childhood educators grow more complex, ongoing research and practice must remain attentive to both the opportunities and challenges of innovation. This study provides a foundation for such efforts, guiding the development of strategies, policies, and future research that together can shape a more creative, equitable, and engaging landscape for young learners and their teachers.

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**Data availability** The datasets generated and analyzed during the current study are not publicly available due to privacy and ethical considerations but are available from the corresponding author on reasonable request and subject to necessary approvals.

## Declarations

**Conflict of interest disclosure** The authors declare no conflict of interest.

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## References

- Ahn, J., Flores, J., Welton, O., D., & Hackmann, D. G. (2025). Challenges in sustaining professional learning communities focused on equity. *Journal of Educational Change*, 26(1), 57–87.
- Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes*, 50(2), 179–211. [https://doi.org/10.1016/0749-5978\(91\)90020-T](https://doi.org/10.1016/0749-5978(91)90020-T)
- Ajzen, I. (2006). *Constructing a theory of planned behavior questionnaire*. <https://people.umass.edu/~ajzen/pdf/tpb.measurement.pdf>
- Al-Emran, M., Al-Sharafi, M. A., & Foroughi, B. (2025). Evaluating the influence of generative AI on students' academic performance through the lenses of TPB and TTF using a hybrid SEM-ANN approach. *Education and Information Technologies*, 30, 17557–17587. <https://doi.org/10.1007/s10639-025-13485-w>
- Al-Rahmi, A. M., Shamsuddin, A., Wahab, E., Al-Rahmi, W. M., Alturki, U., Aldraiweesh, A., & Almutairy, S. (2022). Integrating the role of UTAUT and TTF model to evaluate social media use for teaching and learning in higher education. *Frontiers in Public Health*, 10, Article 905968.
- Al-Rahmi, A., Shamsuddin, A., & Alismaiel, O. (2020). Task-technology fit model: The factors affecting students' academic performance in higher education. *Universal Journal of Educational Research*, 8(12), 6831–6843. <https://doi.org/10.13189/ujer.2020.081249>
- Almusawi, H. A., & Durugbo, C. M. (2024). Linking task-technology fit, innovativeness, and teacher readiness using structural equation modelling. *Education and Information Technologies*, 29(12), 14899–14928.
- Alturki, U., & Aldraiweesh, A. (2023). Integrated TTF and self-determination theories in higher education: The role of actual use of the massive open online courses. *Frontiers in Psychology*, 14, Article 1108325.
- Alyoussef, I. Y. (2021). Massive open online course (MOOCs) acceptance: The role of task-technology fit (TTF) for higher education sustainability. *Sustainability*, 13(13), 7374.
- An, X., Chai, C. S., Li, Y., Zhou, Y., Shen, X., Zheng, C., & Chen, M. (2023). Modeling English teachers' behavioral intention to use artificial intelligence in middle schools. *Education and Information Technologies*, 28(5), 5187–5208.
- Antonietti, C., Cattaneo, A., & Amenduni, F. (2022). Can teachers' digital competence influence technology acceptance in vocational education? *Computers in Human Behavior*, 132, 107266.
- Ateş, H., & Garzón, J. (2022). Drivers of teachers' intentions to use mobile applications to teach science. *Education and Information Technologies*, 27(2), 2521–2542.
- Ateş, H., & Garzón, J. (2023). An integrated model for examining teachers' intentions to use augmented reality in science courses. *Education and Information Technologies*, 28(2), 1299–1321.
- Ateş, H., & Gündüzalp, C. (2024). A unified framework for understanding teachers' adoption of robotics in STEM education. *Education and Information Technologies*, 29(11), 1–27.

- Ateş, H., & Polat, M. (2025). Exploring adoption of humanoid robots in education: UTAUT-2 and TOE models for science teachers. *Education and Information Technologies*, 30, 12765–12806.
- Ateş, H., & Yilmaz, R. M. (2024). A comprehensive model explaining teachers' intentions to use mobile-based assessment. *Interactive Learning Environments*, 32(8), 4063–4087.
- Armitage, C. J., & Conner, M. (2001). Efficacy of the theory of planned behaviour: A meta-analytic review. *British Journal of Social Psychology*, 40(4), 471–499. <https://doi.org/10.1348/014466601164939>
- Byrne, B. M. (2016). *Structural equation modeling with AMOS: Basic concepts, applications, and programming* (3rd ed.). Routledge.
- Chai, C. S., Liang, S., & Wang, X. (2024). A survey study of Chinese teachers' continuous intentions to teach artificial intelligence. *Education and Information Technologies*, 29(11), 14015–14034.
- Conner, M., & Armitage, C. J. (1998). Extending the theory of planned behavior: A review and avenues for further research. *Journal of Applied Social Psychology*, 28(15), 1429–1464.
- Dahri, N. A., Yahaya, N., Al-Rahmi, W. M., Almogren, A. S., & Vighio, M. S. (2024). Investigating factors affecting teachers' training through mobile learning: Task technology fit perspective. *Education and Information Technologies*, 29(12), 14553–14589.
- Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly*, 13(3), 319–340. <https://doi.org/10.2307/249008>
- Deci, E. L., & Ryan, R. M. (2000). The "what" and "why" of goal pursuits: Human needs and the self-determination of behavior. *Psychological Inquiry*, 11(4), 227–268.
- Dishaw, M. T., & Strong, D. M. (1999). Extending the technology acceptance model with task–technology fit constructs. *Information & Management*, 36(1), 9–21.
- Ejigu, A., & Yeshitela, K. (2024). Envisioning sustainable sanitation planning: A unified approach of diffusion of innovation and theory of planned behavior in predicting ecosan toilet adoption in Arba Minch City, Ethiopia. *Frontiers in Environmental Science*, 12, Article 1371659.
- Ertmer, P. A., & Ottenbreit-Leftwich, A. T. (2010). Teacher technology change: How knowledge, confidence, beliefs, and culture intersect. *Journal of Research on Technology in Education*, 42(3), 255–284. <https://doi.org/10.1080/15391523.2010.10782551>
- Faqih, K. M., & Jaradat, M. I. R. M. (2021). Integrating TTF and UTAUT2 theories to investigate the adoption of augmented reality technology in education: Perspective from a developing country. *Technology in Society*, 67, Article 101787.
- Fishbein, M., & Ajzen, I. (2010). *Predicting and changing behavior: The reasoned action approach*. Psychology Press.
- Fornell, C., & Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement error. *Journal of Marketing Research*, 18(1), 39–50. <https://doi.org/10.1177/00224378101800104>
- Gerosa, A., Koleszar, V., Tejera, G., Gómez-Sena, L., & Carboni, A. (2022). Educational robotics intervention to foster computational thinking in preschoolers: Effects of children's task engagement. *Frontiers in Psychology*, 13, Article 904761.
- Goodhue, D. L., & Thompson, R. L. (1995). Task-technology fit and individual performance. *MIS Quarterly*, 19(2), 213–236.
- Grubišić, V., & Crnokić, B. (2024). A systematic review of robotics' transformative role in education. In *International Conference on Digital Transformation in Education and Artificial Intelligence Application* (pp. 257–272). Cham: Springer Nature Switzerland.
- Habibi, A., Riady, Y., Samed Al-Adwan, A., & Awni Albelbisi, N. (2023). Beliefs and knowledge for pre-service teachers' technology integration during teaching practice: An extended theory of planned behavior. *Computers in the Schools*, 40(2), 107–132.
- Hoareau, L., Thomas, A., Tazouti, Y., Dinet, J., Luxembourger, C., & Jarlégan, A. (2021). Beliefs about digital technologies and teachers' acceptance of an educational app for preschoolers. *Computers & Education*, 172, Article 104264.
- Hong, X., Zhang, M., & Liu, Q. (2021). Preschool teachers' technology acceptance during the COVID-19: An adapted technology acceptance model. *Frontiers in Psychology*, 12, Article 691492.
- Hou, M., Lin, Y., Shen, Y., & Zhou, H. (2022). Explaining pre-service teachers' intentions to use technology-enabled learning: An extended model of the theory of planned behavior. *Frontiers in Psychology*, 13, Article 900806.
- Hu, C. C., Yang, Y. F., Cheng, Y. W., & Chen, N. S. (2024). Integrating educational robot and low-cost self-made toys to enhance STEM learning performance for primary school students. *Behaviour & Information Technology*, 43(8), 1614–1635.

- Huang, C. M., Huang, S. F., Chen, Y. T., Chang, C. H., Chien, H. C., Chang, Y. J., & Guo, J. L. (2025). Applicability of the decomposed theory of planned behavior for the evaluation of community-dwelling older adults' acceptance in continuous usage of robot-assisted board games for cognitive training. *Digital Health, 11*, 20552076241312576.
- Jordan, M. E., & McDaniel, R. R., Jr. (2014). Managing uncertainty during collaborative problem solving in elementary school teams: The role of peer influence in robotics engineering activity. *Journal of the Learning Sciences, 23*(4), 490–536.
- Kewalramani, S., Kidman, G., & Palaiologou, I. (2021a). Using artificial intelligence (AI)-interfaced robotic toys in early childhood settings: A case for children's inquiry literacy. *European Early Childhood Education Research Journal, 29*(5), 652–668.
- Kewalramani, S., Palaiologou, I., Dardanou, M., Allen, K. A., & Phillipson, S. (2021b). Using robotic toys in early childhood education to support children's social and emotional competencies. *Australasian Journal of Early Childhood, 46*(4), 355–369.
- Khoa, B. T., Kien, D. T., & Oanh, L. T. K. (2021). Students' learning management system adoption intention in COVID-19: An Integration of TPB and TTF Model. In *2021 7th International Conference on Education and Technology (ICET)* (pp. 187–193). IEEE.
- Kim, R., & Song, H. D. (2022). Examining the influence of teaching presence and task-technology fit on continuance intention to use MOOCs. *The Asia-Pacific Education Researcher, 31*(4), 395–408.
- Kline, R. B. (2016). *Principles and practice of structural equation modeling* (4th ed.). Guilford Press.
- Komis, V., Karachristos, C., Mourta, D., Sgoura, K., Misirli, A., & Jaillet, A. (2021). Smart toys in early childhood and primary education: A systematic review of technological and educational affordances. *Applied Sciences, 11*(18), 8653.
- Konca, A. S., Simsar, A., Alhajji, R., & Al Mansoori, A. (2025). Cross-cultural perspectives on AI adoption in teacher education: A comparative study of pre-service teachers in Turkey and the United Arab Emirates. *Interactive Learning Environments, 33*(10), 5820–5846. <https://doi.org/10.1080/10494820.2025.2488143>
- Kong, S. C., Yang, Y., & Hou, C. (2024). Examining teachers' behavioural intention of using generative artificial intelligence tools for teaching and learning based on the extended technology acceptance model. *Computers and Education: Artificial Intelligence, 7*, Article 100328.
- La Barbera, F., & Ajzen, I. (2021). Moderating role of perceived behavioral control in the theory of planned behavior: A preregistered study. *Journal of Theoretical Social Psychology, 5*(1), 35–45.
- Leung, L., & Cheung, M. (2025). The effects of technology readiness, risks, and benefits on smart home technology adoption: Extending the theory of planned behavior model. *Media Asia, 52*(1), 80–101.
- Ma, S., & Lei, L. (2024). The factors influencing teacher education students' willingness to adopt artificial intelligence technology for information-based teaching. *Asia Pacific Journal of Education, 44*(1), 94–111.
- Merjoavaara, O., Eklund, K., Nousiainen, T., Karjalainen, S., Koivula, M., Mykkänen, A., & Hämäläinen, R. (2024). Early childhood pre-service teachers' attitudes towards digital technologies and their relation to digital competence. *Education and Information Technologies, 29*(12), 14647–14662.
- Nunnally, J. C., & Bernstein, I. H. (1994). *Psychometric theory* (3rd ed.). McGraw-Hill.
- Opoku, M. P., Cuskelly, M., Pedersen, S. J., & Rayner, C. S. (2021). Applying the theory of planned behaviour in assessments of teachers' intentions towards practicing inclusive education: A scoping review. *European Journal of Special Needs Education, 36*(4), 577–592.
- Özdemir, A. M., & Ateş, H. (2025). Harnessing holographic technology in science education: An integrated GETAMEL-TOE model Analysis. *Interactive Learning Environments*, 1–29.
- Pandey, M. P. (2025). Exploring STEM (science, technology, engineering and mathematics) toys in kindergarten: Teachers' pedagogical approaches, perspective and effect on children's brain development: A systematic literature review. *International Journal of Child-Computer Interaction, 44*, Article 100736. <https://doi.org/10.1016/j.ijcci.2025.100736>
- Rad, D., Egerău, A., Roman, A., Dughî, T., Kelemen, G., Balaş, E., Redeş, A., Schipor, M.-D., Clîpa, O., Măţă, L., Maier, R., Rad, G., Runcan, R., & Kiss, C. (2023). On the technology acceptance behavior of Romanian preschool teachers. *Behavioral Sciences, 13*(2), Article 133.
- Rapti, S., Sapounidis, T., & Tselegkaridis, S. (2025). Review of robotics activities to promote kindergarteners' communication, collaboration, critical thinking, and creativity. *Information, 16*(4), 260.
- Rogers, E. M. (2003). *Diffusion of innovations* (5th ed.). Free Press.
- Şakir, A. (2025a). Augmented reality in preschool settings: A cross-sectional study on adoption dynamics among educators. *Interactive Learning Environments, 33*(4), 2954–2977.

- Şakir, A. (2025b). Influences on early childhood educators' adoption of gamified mobile learning tools: A multitheoretical analysis. *Interactive Learning Environments*, 1–24.
- Sanusi, I. T., Ayanwale, M. A., & Chiu, T. K. (2024). Investigating the moderating effects of social good and confidence on teachers' intention to prepare school students for artificial intelligence education. *Education and Information Technologies*, 29(1), 273–295.
- Sapounidis, T., Rapti, S., & Vaiopoulou, J. (2025). Effects of educational robotics on kindergarteners' collaboration, communication, critical thinking, and creativity: A meta-analysis. *Journal of Science Education and Technology*, 34(1), 73–87.
- Schade, P., & Schuhmacher, M. C. (2022). Digital infrastructure and entrepreneurial action-formation: A multilevel study. *Journal of Business Venturing*, 37(5), Article 106232.
- Seol, S., Lee, H., & Zo, H. (2016). Exploring factors affecting the adoption of mobile office in business: An integration of TPB with perceived value. *International Journal of Mobile Communications*, 14(1), 1–19. <https://doi.org/10.1504/ijmc.2016.073341>
- Sheeran, P. (2002). Intention–behavior relations: A conceptual and empirical review. *European Review of Social Psychology*, 12(1), 1–36. <https://doi.org/10.1080/14792772143000003>
- Sungur-Gül, K., & Ateş, H. (2021). Understanding pre-service teachers' mobile learning readiness using theory of planned behavior. *Educational Technology & Society*, 24(2), 44–57.
- Tabachnick, B. G., & Fidell, L. S. (2019). *Using multivariate statistics* (7th ed.). Pearson.
- Teo, T. (2011). Factors influencing teachers' intention to use technology: Model development and test. *Computers & Education*, 57(4), 2432–2440. <https://doi.org/10.1016/j.compedu.2011.06.008>
- Tornatzky, L., & Fleischer, M. (1990). *The process of technology innovation*. Lexington Books.
- Torpegaard, J., Knudsen, L. S., Linnet, M. P., Skov, M. B., & Merritt, T. (2022). Preschool children's social and playful interactions with a play-facilitating cardboard robot. *International Journal of Child-Computer Interaction*, 31, Article 100435.
- Vasou, M., Kyprianou, G., Amanatiadis, A., & Chatzichristofis, S. A. (2024). Transforming education with AI and robotics: potential, perceptions, and infrastructure needs. In *European, Mediterranean, and Middle Eastern Conference on Information Systems* (pp. 3–18). Cham: Springer Nature Switzerland.
- Venkatesh, V., & Davis, F. D. (2000). A theoretical extension of the technology acceptance model: Four longitudinal field studies. *Management Science*, 46(2), 186–204.
- Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. *MIS Quarterly*, 27(3), 425–478. <https://doi.org/10.2307/30036540>
- Venkatesh, V., Thong, J. Y. L., & Xu, X. (2012). Consumer acceptance and use of information technology: Extending the unified theory of acceptance and use of technology (UTAUT2). *MIS Quarterly*, 36(1), 157–178. <https://doi.org/10.2307/41410412>
- Vrontis, D., Christofi, M., Pereira, V., Tarba, S., Makrides, A., & Trichina, E. (2023). Artificial intelligence, robotics, advanced technologies and human resource management: A systematic review. *The International Journal of Human Resource Management*, 33(6), 1237–1266. <https://doi.org/10.1080/09585192.2020.1871398>
- Wan, L., Shoumei, X., & Shu, A. (2020). Toward an understanding of university students' continued intention to use moocs: When UTAUT model Meets TTF model. *Sage Open*, 10(3). <https://doi.org/10.1177/2158244020941858>
- Wu, P., Yang, L., Hu, X., Li, B., Liu, Q., Wang, Y., & Huang, J. (2022). How K12 teachers' readiness influences their intention to implement STEM education: Exploratory study based on decomposed theory of planned behavior. *Applied Sciences*, 12(23), Article 11989.
- Yu, T., & Yu, T. (2010). Modelling the factors that affect individuals' utilisation of online learning systems: An empirical study combining the task technology fit model with the theory of planned behaviour. *British Journal of Educational Technology*, 41(6), 1003–1017. <https://doi.org/10.1111/j.1467-8535.2010.01054.x>
- Zainal, M. A., & Mohd Matore, M. E. E. (2021). The influence of teachers' self-efficacy and school leaders' transformational leadership practices on teachers' innovative behaviour. *International Journal of Environmental Research and Public Health*, 18(12), Article 6423.

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