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Personal and professional drivers of wearable technology use: a model-based analysis among physical education teachers

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ABSTRACT

This study examines the factors influencing wearable technology adoption among physical education teachers by integrating the Theory of Planned Behavior (TPB), Technology Acceptance Model (TAM), and Self-Determination Theory (SDT). The research investigates how intrinsic motivational factors (perceived competence, autonomy, and relatedness from SDT) and behavioral intentions (from TPB and TAM) together affect educators' decisions to adopt wearable technologies. Using Structural Equation Modeling (SEM), data from 338 physical education teachers were analyzed to evaluate the proposed theoretical model. Results indicate that internal motivational dynamics significantly shape teachers' openness to and intentions toward integrating wearable devices, alongside perceptions of the technology's ease of use and usefulness. The findings underscore the importance of aligning technological tools with educators' professional motivations and educational objectives to promote successful technology integration. This research advances the theoretical understanding of technology adoption in education and offers practical insights for designing professional development and policy initiatives. Targeted strategies should address both motivational and behavioral dimensions to support holistic and sustainable technology adoption in educational contexts.

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Wearable technology adoption; educational technology integration; motivational dynamics; structural equation modeling; teacher behavioral intentions

1. Introduction

In the dynamic and ever-evolving field of physical education, the integration of innovative technologies plays a crucial role in revolutionizing teaching methodologies and augmenting student engagement (Calderón et al., 2020; Wallace et al., 2023). Among these advancements, wearable technologies stand out as transformative tools (Almusawi et al., 2021). These devices, which can be seamlessly integrated into clothing or worn directly on the body, offer a range of functionalities – from health monitoring and fitness tracking to communication and entertainment (Meena et al., 2023). Their versatility and practicality make them particularly suitable for the active, movement-based context of physical education, where real-time data and feedback can significantly enhance the instructional quality and learning outcomes (Ding et al., 2020; Lin et al., 2023). As such, wearable technologies are not only gaining traction within the realm of sports and health industries but are also making a profound impact in educational settings (Chu et al., 2023; Meena et al., 2023). In educational settings, wearable technologies have been recognized for their potential to create more interactive, personalized, and data-driven approaches to learning, supporting both teachers and students in achieving better educational outcomes (Chu et al., 2023; Meena et al., 2023).

This research delves into the adoption of wearable technologies by physical education teachers, focusing specifically on how these innovative tools are integrated into their instructional practices. The primary objective of this study is to meticulously identify and analyze the various factors that influence teachers' utilization of these technologies. The significance of this inquiry lies in the unique capabilities of wearable technologies to transform the educational landscape. By furnishing teachers with real-time data, these devices not only facilitate immediate feedback and adjustments during physical activities but also significantly enhance interactive and engaging learning experiences (Camacho et al., 2020; Kay et al., 2020). Moreover, wearable technologies support personalized education strategies by allowing for the customization of activities and lessons to meet individual student needs based on real-time physiological and performance data (Almusawi

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et al., 2021). Given these capabilities, understanding the facilitators and barriers to technology integration in PE is essential for maximizing the educational benefits of wearables.

Despite the recognized value of wearable technologies, a notable gap persists in the literature: most prior research has focused on general digital tools or technology use in broader educational contexts, rather than the distinctive challenges and opportunities associated with wearable technology adoption by physical education teachers (Almusawi et al., 2021; Ba & Hu, 2023). Moreover, existing studies rarely provide a comprehensive, model-based analysis that incorporates motivational, attitudinal, and behavioral perspectives in this field. As such, little is known about how these factors interact to shape PE teachers' intentions and behaviors regarding wearable technology use. Addressing this gap is crucial for both theory and practice, as it can inform more effective, sustainable, and contextually relevant integration of wearable technologies in PE instruction.

To rigorously address the research objective, this study harnesses the insights of three well-established theoretical frameworks: Self-Determination Theory (SDT), the Theory of Planned Behavior (TPB), and the Technology Acceptance Model (TAM). Each framework provides a distinct lens through which to examine the complex dynamics of technology adoption among physical education teachers. SDT explains the motivational aspects of technology adoption by focusing on intrinsic motivations, such as the genuine interest and satisfaction derived from using the technology, and extrinsic motivations, like external rewards or pressures (Deci & Ryan, 1985a; 2002). TPB, on the other hand, delves into the psychological and social determinants of behavioral intentions, emphasizing attitudes toward technology use, subjective norms, and perceived behavioral control (Ajzen, 1991; Ajzen & Schmidt, 2020). TAM highlights the importance of perceived ease of use and perceived usefulness as central drivers of technology adoption (Davis et al., 1989; Khong et al., 2023).

The rationale for integrating SDT, TPB, and TAM is rooted in the complexity of technology adoption behaviors in educational settings. While each framework individually contributes valuable theoretical and empirical insights, their combination enables a more holistic and robust analysis. Specifically, SDT addresses the underlying motivational processes, TPB incorporates the influence of attitudes and perceived social pressures, and TAM focuses on the technological characteristics that affect acceptance. Integrating these models allows for a comprehensive exploration of how personal motivation, social context, and technology perceptions collectively shape teachers' intentions and behaviors regarding wearable technology use. Previous studies have rarely synthesized these perspectives, which may limit explanatory power and practical guidance. This integrative approach is therefore necessary to capture the multifaceted nature of wearable technology adoption among PE teachers, providing a richer and more actionable understanding than any single framework could achieve.

This approach not only identifies the determinants of adoption but also informs strategies to foster effective integration of wearable technologies into teaching practices. This study endeavors to significantly enhance the existing body of knowledge by meticulously identifying the factors that either facilitate or hinder the adoption of wearable technologies among physical education teachers. The comprehensive theoretical framework – incorporating motivational, behavioral, and technological dimensions – aims to dissect these factors and provide actionable insights for educational administrators, policymakers, and technology developers. Strategies for promoting effective integration may include addressing barriers such as insufficient training, perceived complexity of technology, or lack of support structures, while leveraging facilitators like ease of use, perceived usefulness, and positive social influences. The ultimate goal of this research is to enrich the educational landscape by ensuring that wearable technologies align with the instructional objectives of physical education, thereby enhancing student engagement and outcomes. This involves fostering interactive and personalized learning environments, enabling real-time data-driven instruction, and equipping teachers with effective tools to augment their teaching practices. By addressing these multifaceted factors, the study contributes to advancing dynamic and impactful physical education practices that promote both teacher effectiveness and student success.

The study is structured around several key objectives that guide the inquiry into wearable technology adoption among physical education teachers. The primary goal is to develop a comprehensive theoretical model by integrating elements of SDT, TPB, and TAM. This integrated model is designed to elucidate the multifaceted factors that influence teachers' intentions to adopt wearable technologies in their teaching practices. A crucial aspect of this research is to evaluate and compare the effectiveness of the integrated SDT, TPB, and TAM framework against the application of each individual theory. This comparison aims to verify the superiority of the combined model in explaining the behavioral intentions of physical education teachers towards technology adoption, thereby enhancing our understanding of the theoretical underpinnings that govern such decisions. This analysis will help to understand how different groups perceive and interact with wearable technology in educational settings. Finally, the research intends to identify and prioritize the various constructs within the combined model that significantly affect physical education teachers' intentions to utilize wearable technologies. By pinpointing the key drivers and barriers within this context, the study aims to offer valuable insights into the effective integration of technology in physical education, facilitating targeted interventions and policy-making that promote technology adoption in educational practices. To guide this investigation, the study is structured around the following research questions:

1. What are the factors influencing physical education teachers' intentions to adopt wearable technologies?
2. How do the constructs of the SDT, TAM, and TPB individually and collectively explain technology adoption among physical education teachers?
3. What is the effectiveness of an integrated model combining SDT, TAM, and TPB compared to the application of each theoretical framework individually in predicting wearable technology adoption?
4. Which constructs within the integrated model most significantly impact physical education teachers' behavioral intentions to adopt wearable technologies?

2. Literature review and hypothesis development

2.1. Overview of wearable technologies in education

Wearable technologies are increasingly used in educational settings due to their portability and ability to seamlessly collect and transmit real-time data (He & Lee, 2021). Devices such as fitness trackers, smartwatches, heart rate monitors, and smart clothing enable the monitoring of physiological and activity metrics, thereby supporting a variety of teaching and learning applications (McCann & Bryson, 2022; Prieto-Avalos et al., 2022; Shei et al., 2022; Sucharitha et al., 2022).

Across disciplines, wearables facilitate innovative approaches to instruction. In science classes, for example, students use wearable devices to gather experimental data or engage with augmented reality (AR) models (Alvarez et al., 2016). In subjects like history and geography, AR-enabled wearables can make abstract concepts more tangible by providing immersive experiences (Ometov et al., 2021). Additionally, wearables play an important role in health monitoring within education, enabling the tracking of vital signs and physical activity for data-driven, individualized support (Ghent et al., 2020; Jin et al., 2022; Soon et al., 2020). These devices also allow for immediate feedback and more responsive teaching, which can increase student motivation and participation through features such as gamification (Bower & Sturman, 2015; Bustos-Lopez et al., 2022; Chu et al., 2023).

In physical education specifically, wearable technologies provide detailed motion tracking and biofeedback, supporting accurate assessment and tailored instruction (Giraldo-Pedroza et al., 2020; Huhn et al., 2022; Song et al., 2021). By enabling personalized and timely interventions, wearables encourage self-monitoring and active involvement, leading to improved learning outcomes (Borthwick et al., 2015; Chu et al., 2023; Papalia et al., 2018). As these technologies evolve, their integration in education is expected to further enhance digital literacy and adaptive learning practices, underscoring their growing importance in contemporary pedagogy (Almusawi et al., 2021; Ding et al., 2020; Lin et al., 2023).

2.2. Theoretical frameworks and hypotheses underpinning technology adoption

Understanding the adoption of wearable technologies in educational settings necessitates a robust and well-established theoretical foundation. This study draws on three widely recognized models – SDT, the TAM, and the TPB – to construct a comprehensive framework for analyzing physical education teachers' behavioral intentions regarding wearable technology adoption. By integrating these theoretical perspectives, the study not only builds upon existing literature but also advances the proposed model by evaluating its applicability within a novel educational context.

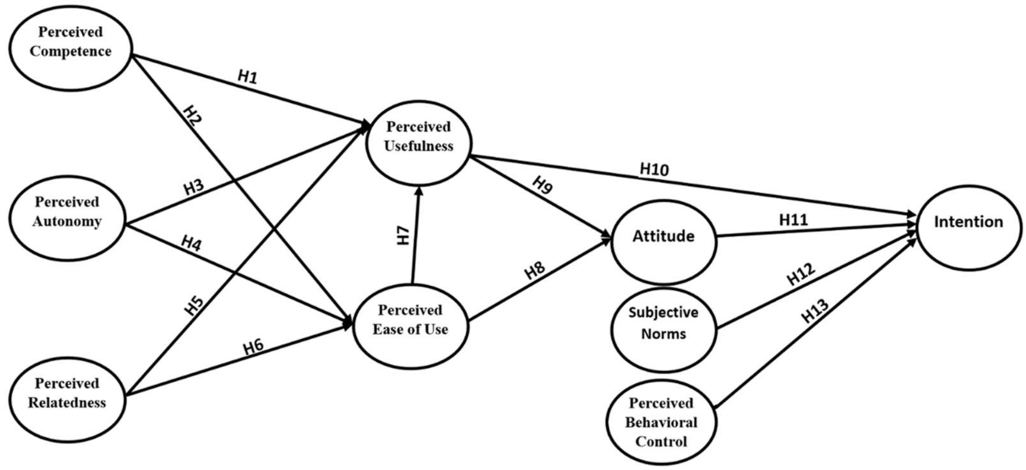

Figure 1. The proposed model.

The theoretical framework employed in this study (Figure 1) is adapted from the conceptual model proposed by Ateş and Gündüzalp (2024), which synthesizes motivational constructs from SDT, perceived ease of use and usefulness from TAM, and attitudinal and social constructs from TPB. This integrated approach provides a nuanced lens through which to explore the multifaceted dynamics of technology adoption. This approach underscores the dynamic and evolving nature of these theoretical frameworks, which have consistently demonstrated their explanatory power across a range of contexts.

The originality of this study lies in its application of the integrated SDT-TAM-TPB framework to the field of physical education, where technology adoption is influenced by a distinct combination of motivational, cognitive, and social factors. Specifically, the model posits that motivational constructs such as perceived competence, autonomy, and relatedness (SDT), when combined with technology-specific factors like perceived ease of use and usefulness (TAM), and attitudinal and normative constructs (TPB), collectively shape teachers' behavioral intentions. By testing the robustness and applicability of this integrated framework, the study aims to identify critical drivers of technology adoption in physical education while providing insights for refining and adapting the model to other technological and disciplinary contexts.

2.2.1. Self-determination theory

SDT provides a valuable framework for understanding how intrinsic and extrinsic motivations influence teachers' attitudes toward adopting new technologies (Ateş & Yilmaz, 2024). Intrinsic motivations refer to doing an activity for its inherent satisfaction or pleasure, such as the joy and engagement a teacher might find in using innovative tools to enhance learning (Sørebø et al., 2009). Extrinsic motivations, on the other hand, involve performing an activity to achieve separable outcomes, such as rewards or recognition from using new technologies (Chiu, 2022). According to SDT, when teachers perceive that technology enhances their autonomy, competence, and relatedness in their professional roles, their intrinsic motivation increases (Nikou & Economides, 2017). This increase in intrinsic motivation positively can affect their willingness to adopt and integrate wearable technologies into their teaching practices. Conversely, extrinsic motivators, such as institutional mandates or peer pressure, can also play a significant role but might not sustain long-term adoption unless they align with the teachers' values and needs.

SDT posits that intrinsic motivation is more effectively fostered when three basic psychological needs are satisfied: autonomy, competence, and relatedness (Deci & Ryan, 1985a). Perceived autonomy refers to the need to feel control over one's actions and the freedom to make choices (Deci & Ryan, 1985b). Perceived autonomy in the adoption of wearable technologies can be crucial. In the context of wearable technology, when teachers feel they have a choice in using these technologies and that these choices are aligned with their teaching methodologies, their perceived autonomy is enhanced. Teachers who feel that they have the freedom to integrate technology as they see fit are more likely to embrace these tools enthusiastically. Perceived competence involves feeling effective and capable of achieving desired outcomes (Nikou & Economides, 2017). Teachers' perceptions of their ability to use technology effectively boost their confidence and likelihood of ongoing use. Perceived relatedness reflects the need to feel connected to others and supported within a community (Deci et al., 1991; Haw et al., 2024). Perceived relatedness can influence technology adoption (Han & Xu, 2024). In other words, teachers who perceive strong support from colleagues and administrators are more likely to find technological integration worthwhile.

Prior studies have further elucidated the influence of intrinsic and extrinsic motivations on technology adoption among educators. For instance, Sørebø et al. (2009) found that teachers who derived personal satisfaction from the use of innovative tools were more inclined to adopt such technologies in their teaching. Chiu (2022) demonstrated that extrinsic rewards, like recognition from peers or administrators, can motivate teachers to use new technologies, although this effect may diminish over time if not aligned with deeper professional values and needs. Moreover, Nikou and Economides (2017) highlighted that teachers' perceptions of enhanced autonomy, competence, and relatedness due to technology use significantly boost their intrinsic motivation, making them more open to adopting new technologies. Petty et al. (2023) and Zhang and Zhou (2023) further reinforced that a sense of connectedness and support within the educational community plays a pivotal role in encouraging technology integration, aligning with findings by Ateş and Gündüzalp (2024) that perceived relatedness significantly influences technology adoption decisions. These studies collectively affirm the complex interplay of motivational factors as outlined by SDT and underscore the importance of satisfying psychological needs to foster sustainable technology adoption in educational settings. In applying SDT to wearable technology adoption in physical education, it is hypothesized that:

H1: There is a positive correlation between physical education teachers' perceived competence in using wearable technologies and their perceived usefulness of these technologies.

H2: There is a positive correlation between physical education teachers' perceived competence in using wearable technologies and their perceived ease of use of these technologies.

H3: There is a positive correlation between physical education teachers' perceived autonomy in using wearable technologies and the perceived usefulness of these technologies.

H4: There is a positive correlation between physical education teachers' perceived autonomy in using wearable technologies and the perceived ease of use of these technologies.

H5: There is a positive correlation between the level of perceived relatedness and the perceived usefulness of wearable technologies among physical education teachers.

H6: There is a positive correlation between the level of perceived relatedness and the perceived ease of use of wearable technologies among physical education teachers.

2.2.2. Technology acceptance model

The TAM, a pivotal framework in the study of technology adoption, posits that the primary predictor of technology usage is the user's behavioral intention (Davis et al., 1989). This intention is influenced by two core beliefs: perceived usefulness and perceived ease of use. In the context of wearable technologies in physical education, perceived usefulness is defined as the belief that using such technologies will enhance a teacher's ability to conduct effective and engaging physical education classes, thereby improving job performance through increased efficiency, better student learning outcomes, and personalized feedback (Almusawi et al., 2021; Almusawi & Durugbo, 2024). Perceived ease of use, on the other hand, refers to the belief that these technologies will be user-friendly and integrate seamlessly into daily teaching activities, minimizing effort and maximizing utility (Talukder et al., 2019).

Extensive validation of TAM in various educational technology contexts – from mobile learning and augmented reality to distance education platforms – underscores its adaptability and robustness (e.g. Marto et al., 2023; Papakostas et al., 2023). For instance, studies have shown that after targeted training in technology-based education, teachers exhibit significantly enhanced perceptions of both perceived usefulness and perceived ease of use (Sungur Gül & Ateş, 2023). This enhancement, in turn, positively affects their attitudes and intentions toward implementing such technologies in their educational practices.

In physical education, where real-time data and interactive learning environments are crucial, the predictive power of TAM can be particularly insightful. For example, if wearable technologies are perceived as easy to use, they are also likely to be viewed as useful, aligning with Davis et al.'s (1989) assertion in the foundational TAM studies. The ease of integration and the immediate benefits provided by wearable technologies can foster a positive attitude towards their adoption among physical education teachers (Almusawi et al., 2021; Almusawi & Durugbo, 2024).

Numerous studies have provided empirical support for the TAM in the context of educational technology adoption, demonstrating its utility and predictive accuracy. For example, Almusawi et al. (2021) and Almusawi and Durugbo (2024) emphasized how perceived usefulness significantly enhances teachers' motivations to employ wearable technologies in physical education, citing improved job performance and student outcomes. Similarly, Talukder et al. (2019) found that ease of use is a critical determinant that simplifies the integration of technology into daily teaching routines, thereby encouraging its adoption. Further research in diverse educational settings has corroborated these findings. Iqbal and Sidhu (2022) and Suliman et al. (2024) have shown that TAM applies effectively across different types of educational technologies, including mobile learning and augmented reality platforms. Their findings suggest that both perceived usefulness and ease of use are fundamental in shaping teachers' behavioral intentions and actual usage patterns. A specific instance of TAM's application was reported by Sungur Gül and Ateş (2023), who observed that targeted training significantly boosts teachers' perceptions of the usefulness and ease of use of new technologies. This, in turn, leads to more favorable attitudes towards technology adoption and a greater likelihood of practical implementation in educational practices. These studies reinforce the notion that understanding and enhancing perceptions of usefulness and ease of use can greatly facilitate the acceptance and integration of innovative technologies like wearable devices in physical education environments. Given the established relevance of TAM in various educational settings, and considering the unique aspects of physical education, the following hypotheses are proposed for this study:

H7: The perceived ease of use of wearable technologies is positively associated with their perceived usefulness as reported by physical education teachers.

H8: The ease with which wearable technologies can be used influences physical education teachers' attitudes towards their adoption.

H9: The greater the perceived usefulness of wearable technologies, the more positive the attitudes of physical education teachers towards integrating these technologies into their teaching practices.

H10: If wearable technologies are perceived as useful by physical education teachers, this perception is likely to influence their intentions to adopt these technologies in their professional activities.

2.2.3. Theory of planned behavior

The TPB stands as a critical framework within the domain of social psychology, offering profound insights into the dynamics of human behavior in the context of decision-making (Batool et al., 2023). Developed from Ajzen' (1991) s seminal work, TPB builds on the foundation of the Theory of Reasoned Action by Ajzen and Fishbein (1975), introducing a broader spectrum of influences on behavioral intentions. In the specific context of wearable technology adoption in physical education, the TPB can provide a comprehensive framework that suggests a teacher's intention to use such technologies is influenced by three interconnected factors: attitudes, subjective norms, and perceived behavioral control.

Attitudes towards wearable technology play a crucial role; they reflect the teachers' overall evaluation of integrating these tools into their teaching practice. When teachers believe that wearable technologies will enhance their instructional effectiveness or deepen student engagement, they tend to have more favorable attitudes. This positivity significantly boosts their intentions to incorporate these technologies into their classrooms. Moreover, these intentions are also shaped by subjective norms, which involve the perceived social pressures teachers feel regarding the adoption or rejection of wearable technologies. This factor encompasses the influences from significant others within their professional circles – peers, administrators, and the broader educational community. The support or opposition from these key figures can profoundly influence a teacher's decision-making process regarding the adoption of new technologies. Lastly, perceived behavioral control is a critical aspect of TPB in this context. It highlights a teacher's perception of the ease or difficulty associated with using wearable technologies, including their self-assessment of their ability to overcome potential obstacles, such as a lack of training or technical support. A higher level of perceived control can significantly increase the likelihood of technology adoption, as teachers who feel more competent and

Table 1. Comparison of key findings from SDT, TPB, and TAM studies in educational technology and PE settings.

Study / Reference	Context & Participants	Models	Key constructs	Key findings
Chiu (2022)	122 school teachers (22-month mixed-methods)	SDT	Needs satisfaction (autonomy, competence, relatedness); motivation; persistence	School learning support (leader, expert, peer) increased teachers' needs satisfaction, enhancing high-quality (student-centered) tech integration and sustaining both high – and low-quality practices. Highlights importance of supporting psychological needs to motivate and sustain technology use.
Chiu et al. (2024)	370 school teachers (mixed-methods)	SDT	Needs satisfaction; school learning support; personal-ethic and professional competencies	School learning support positively affected digital competence development; needs satisfaction fully mediated this effect. Twelve strategies for digital policies that satisfy SDT needs were identified.
Chiu et al. (2021)	60 teachers, 358 students (PD program, STEM)	SDT	Autonomy, structure, involvement; intrinsic motivation	SDT-based design thinking in teacher PD benefited teacher practice and student motivation more than non-SDT approaches. Sustained PD, feedback, and reflection were essential.
Wang et al. (2025)	K-12 mathematics teachers, China (n = 230)	TAM + TPB (+AI Awareness)	Perceived usefulness, ease of use, attitude, subjective norm, perceived behavioral control, AI awareness	Attitudes, subjective norms, and PBC directly affect GenAI use. AI awareness influences usefulness, ease of use, and attitudes, and indirectly affects usage. Enhancing AI awareness improves adoption.
Tang et al. (2025)	K-12 mathematics teachers, China (n = 1,173)	TAM + TPB (+STEAM Literacy)	Usefulness, subjective norm, attitude, intention, STEAM literacy	Usefulness and subjective norm are critical for intention to implement STEAM. STEAM literacy influences intention and adoption. Integration highlights roles of attitudes, resources, and subject literacy.
Lv et al. (2025)	Clinical medicine undergraduates, China (n = 387)	TAM + TPB	System quality, course quality, usefulness, ease of use, attitude, intention, PBC, subjective norm, self-efficacy	System and course quality influence usefulness and ease of use, which shape attitudes and intentions. PBC is a critical predictor; subjective norms and self-efficacy not significant. Improving quality and support recommended.
Bali et al. (2025)	499 low-achieving university students, Taiwan	SDT + TAM + TPB	Perceived autonomy, relatedness, ease of use, usefulness, attitude, subjective norm, PBC, intention	Perceived autonomy, relatedness, and ease of use predict usefulness. Attitude, subjective norm, and PBC predict ease of use. Both usefulness and ease of use increase behavioral intention for Mobile English Learning.
Zhang et al. (2024)	494 secondary school science teachers, Taiwan	TPB (latent class approach)	Adoption styles (rich/selective/minimalist), attitude, subjective norm, PBC, intention	Three adoption styles identified: Technology Rich, Selective, Minimalist. For Selective and Minimalist Adopters, intention to use TBAs predicted by attitude, PBC, subjective norm; for Rich Adopters, intention not associated with subjective norms. Antecedents' effects on PBC and norms varied by group.

supported are more inclined to integrate new technologies into their teaching. Together, these factors create a dynamic interplay that directly impacts teachers' behavioral intentions towards using wearable technologies in physical education, suggesting that a supportive environment, along with positive attitudes and a sense of control, are key to successful technology integration.

Earlier research utilizing the TPB has consistently demonstrated its effectiveness in understanding and predicting technology adoption behaviors in various educational contexts. For instance, a study by Al-Emran et al. (2023) specifically applied TPB to the adoption of wearable technologies in physical education, finding that intentions to use these technologies were significantly influenced by their attitudes, the subjective norms from their professional community, and their perceived behavioral control over the technology. This study confirmed that positive attitudes towards the technology – believing that it can enhance instructional effectiveness and student engagement – were the most influential in driving adoption intentions. Moreover, the role of subjective norms was highlighted in research where peer influence and administrative support were shown to either encourage or discourage people from integrating new technologies into their curriculum. These findings suggest that encouragement and approval from stakeholders can be crucial in shaping individuals' openness to adopting innovative tools. Additionally, perceived behavioral control, which encompasses self-efficacy in using the technology and their ability to manage challenges, has been identified as a key determinant of technology adoption. Studies have shown that when teachers feel confident in their abilities to use the technologies and supported by adequate training and resources, they are more likely to adopt and sustain the use of these innovations in their teaching practices (e.g. Al Breiki et al., 2023; Habibi et al., 2023). Collectively, these studies reinforce TPB's applicability to educational technology adoption, demonstrating how each component of the theory – attitudes, subjective norms, and perceived behavioral control – interacts to influence teachers' behavioral intentions. This body of evidence supports the utility of TPB in crafting strategies and interventions aimed at enhancing the integration of wearable technologies in educational settings, particularly in disciplines such as physical education where the potential impact of such technologies is significant. Reflecting on the effectiveness of the TPB in various educational settings, and based on its proven predictive power, the following hypotheses are adapted to the study of wearable technologies in physical education:

H11: Teachers with more favorable attitudes towards wearable technologies are more likely to adopt these technologies in their physical education practices.

H12: Teachers who perceive a higher level of social encouragement and less opposition from their peers and superiors are more likely to adopt wearable technologies in their teaching.

H13: Teachers who perceive a higher level of control over using wearable technologies, indicating ease of use and overcoming challenges, are more likely to integrate these technologies into their physical education curriculum.

To synthesize and contrast prior empirical findings using each theoretical framework, Table 1 summarizes key studies applying SDT, TAM, and TPB to educational technology adoption, with an emphasis on physical education contexts where available.

Together, these theoretical frameworks provide a comprehensive lens through which to analyze and understand the factors influencing the adoption of wearable technologies in education. By integrating insights from SDT, TPB, and TAM, this study aims to develop a nuanced understanding of the complex interplay between motivational, cognitive, and contextual factors that drive or deter this technological integration in educational settings. The detailed combined proposed model that illustrates the interactions among the constructs being examined is depicted in Figure 1.

3. Method

3.1. Data collection process

To ensure participants could meaningfully engage with wearable technologies and provide authentic feedback, the study began with a brief orientation session focused solely on the essential operational features of the devices used in physical education. The wearable devices introduced included smartwatches, fitness trackers, heart rate monitors, and pedometers – all commonly used in educational and fitness contexts. During the orientation, participants were shown how to perform basic functions such as tracking steps, monitoring heart rate, recording physical activity duration, and accessing automated feedback reports.

To contextualize these functions within educational practice, general illustrative use cases were provided. For example, teachers were shown how a fitness tracker could be used to monitor student activity during a class relay, how heart rate monitors might provide real-time feedback on exertion levels during aerobic activities, and how pedometers could facilitate goal-setting or group challenges to encourage movement throughout the lesson. All training content and delivery were designed to be strictly neutral, avoiding any language or examples that could influence participants' perceptions of the technology's educational value or anticipated outcomes. No prescriptive statements or recommendations were offered – only operational demonstrations and general, non-directive examples.

To further minimize the risk of social desirability bias and confirmation bias, several methodological safeguards were implemented throughout the data collection process. The orientation, supporting materials, and any demonstrations emphasized basic usability rather than benefits, outcomes, or best practices. Participants were informed that the research aimed to explore teachers' experiences and intentions regarding new instructional tools, but no specific hypotheses or expected advantages of wearable technology were disclosed.

Training was deliberately minimalistic, consisting of a short, non-directive online tutorial and a brief demonstration in a simulated setting. This approach was intended to equip participants with just enough operational knowledge to independently explore the devices, encouraging self-directed learning rather than guided performance. Additionally, an online discussion platform was offered as an optional resource for participants to share neutral observations, discuss technical or practical challenges, and exchange reflections. Participation in this forum was entirely voluntary, and facilitators took care to avoid influencing the direction or tone of any discussions.

Technical support was limited strictly to troubleshooting, such as addressing device malfunctions via a hotline and offering brief virtual office hours for basic operational questions. Importantly, no pedagogical guidance or advocacy for the technology was provided. Furthermore, participants' reflections and experiences were periodically summarized in anonymous, aggregated reports. These reports were shared with the group to facilitate reflection on shared challenges, but individual contributions were not highlighted, minimizing conformity pressures or external influence.

By adopting a streamlined and neutral support structure – focused on providing foundational operational knowledge while prioritizing participant autonomy and independence – this study was able to assess the authentic willingness and behavioral intentions of physical education teachers to adopt wearable technologies, while minimizing the potential for social desirability or confirmation bias.

3.2. Participants

Data for this investigation were gathered from physical education teachers working in urban public schools across the five largest cities in Turkey. The sampling approach was convenience-based, targeting schools and teachers that were accessible to the research team. While this method does not yield a fully random or nationally representative sample, it does capture a cross-section of teachers from diverse, densely populated metropolitan areas, thereby reflecting current practices in major urban educational centers.

Prior to data collection, ethical approval was obtained from the relevant institutional ethics committee. All participants were fully briefed about the study's objectives, procedures, and their rights – including the right to withdraw at any stage without penalty. Informed consent was obtained, and strict protocols were followed to ensure data confidentiality and participant anonymity, with all responses anonymized and securely stored.

The survey was conducted over a six-week period between January and March 2024. To ensure consistency, the principal investigator provided standardized instructions on the purpose and structure of the questionnaire, which was designed for clarity and could be completed within approximately 30 minutes. The questionnaire was administered through a secure online platform.

A total of 345 physical education teachers were initially recruited. After rigorous data cleaning, which included addressing missing responses and outliers, 338 valid responses were retained, yielding a 98% response rate. This high participation rate reflects the strong engagement of the target group and exceeds typical benchmarks for survey research (Deutskens et al., 2004).

Demographically, the sample included teachers from urban public schools equipped with advanced educational infrastructure (e.g. interactive smartboards, modern classrooms, well-resourced laboratories). The gender distribution was balanced (43.5% female, 56.5% male), and the average professional experience was 7.74 years. Most participating schools served student populations with relatively homogeneous socioeconomic backgrounds, which helped reduce potential confounding variables.

Regarding wearable technology use, the study revealed a diverse spectrum of adoption among participants. Specifically, 58.6% of teachers reported using wearable technologies on a daily basis, whereas 46.7% indicated that they actively integrated these tools into their instructional practices. This discrepancy suggests that while a majority of teachers are familiar with or regularly use wearable devices, a smaller proportion leverage them for pedagogical purposes. Several factors may account for this gap. For instance, some teachers may primarily utilize wearables for personal health monitoring or professional development rather than for direct classroom application. Moreover, integrating wearable technologies into instruction often requires additional curricular planning, adaptation, and institutional support, which may pose practical

Table 2. Demographic characteristics and wearable technology usage patterns of participants.

Category	Frequency (n)	Percentage (%)
Gender Distribution		
Females	147	43.5
Males	191	56.5
Age Range (years)		
24–30	135	40.0
31–40	95	28.0
41–50	58	17.0
51 and above	50	15.0
Teaching Experience (mean, years)	–	7.74
School Type		
Urban Public Schools	338	100.0
Geographic Region		
Marmara Region	128	38.0
Central Anatolia Region	98	29.0
Aegean Region	74	22.0
Mediterranean Region	38	11.0
Daily Wearable Technology Use		
Less than 1 h	185	54.7
1–4 h	105	31.1
5–8 h	36	10.7
More than 9 h	12	3.6
Active Integration into Instructional Practices	158	46.7

or logistical challenges even for teachers who are comfortable with the devices in other contexts. Additionally, certain teachers might be in an exploratory phase – experimenting with wearables on a personal basis before fully adopting them in their teaching routines. Barriers such as lack of training, limited perceived relevance, or classroom management concerns may also impede broader instructional integration. Further analysis of usage patterns showed that 54.7% of teachers reported using wearables for less than one hour daily, 31.1% used them for one to four hours, 10.7% for five to eight hours, and only 3.6% reported usage exceeding nine hours each day. These findings highlight the varied extent to which wearable technologies are incorporated into both personal and professional routines among physical education teachers. A detailed summary of these distributions appears in Table 2.

3.3. Data collection tools

In this study, the selection of measurement items was conducted with a rigorous emphasis on previously validated instruments known for their high reliability and applicability across a range of contexts. For assessing user motivation factors associated with the adoption of wearable technologies in physical education, we employed measurement items derived from Davis et al. (1989) and Venkatesh and Davis (2000), foundational to the TAM. These items adeptly capture perceived usefulness and perceived ease of use, both of which are critical in understanding technology adoption. For evaluating both volitional and non-volitional factors, as well as behavioral intentions as per the TPB, we integrated three items each from Ajzen (2006), Lu et al. (2009), and Taylor and Todd (1995). These items facilitate a comprehensive understanding of the attitudinal, normative, and control beliefs that shape educators' intentions to incorporate wearable technologies into their practice. Moreover, to assess elements related to SDT, we adopted items from Baard et al. (2004), McAuley et al. (1989), Deci and Ryan (1985a), and Nikou and Economides (2017). These constructs play a significant role in enhancing intrinsic motivation, which is pivotal for the sustained adoption of new technologies. All measurement items were precisely tailored to align with the specific context of physical education, ensuring they effectively captured the unique aspects of wearable technology adoption among educators. To mitigate common method bias and enhance the robustness of our findings, a diverse array of scales from various scholarly sources was meticulously selected. For the quantitative evaluation of these factors, we utilized a 5-point Likert scale, ranging from "strongly disagree" to "strongly agree," to assess the intensity of agreement or disagreement with the presented statements. As detailed in Table 3, a total of 28 items were utilized to explore the factors influencing teachers' intentions to adopt wearable technologies. A full list of measurement items used for each construct is provided in Appendix A. This comprehensive methodological approach in developing our data collection tools ensures that the study's findings are both reliable

Table 3. Measurement scales, reliability, and validity metrics for constructs in wearable technology adoption in physical education.

Constructs	Items	FL	Reliability	AVE	CR
Perceived Ease of Use	It is easy to use wearable technology tools in the teaching process.	0.75	0.80	0.57	0.80
	It is easy for me to become proficient in using wearable technology tools in the teaching process.	0.79			
	The use of wearable technology tools in the teaching process is clear and understandable.	0.72			
Perceived Usefulness	I believe that wearable technology tools will contribute to my teaching process.	0.71	0.77	0.56	0.71
	I believe that using wearable technology tools will increase the learning effectiveness in my teaching process.	0.78			
Attitude	I believe that integrating wearable technology tools into my teaching process will be beneficial.	0.75	0.79	0.60	0.82
	I enjoy using wearable technology tools in my teaching activities.	0.82			
	Using wearable technology tools in my work provides me with a pleasant experience.	0.76			
Subjective Norm	People whose opinions I value advise me to use wearable technology tools in my teaching process.	0.75	0.82	0.56	0.71
	People I respect support my use of wearable technology tools in my work.	0.74			
Perceived Behavioral Control	The decision to use wearable technology in the teaching process is entirely up to me.	0.82	0.77	0.65	0.85
	I have the necessary skills and knowledge to integrate wearable technology into the teaching process.	0.75			
	I am confident that I can effectively use wearable technology in the teaching process.	0.85			
Perceived Competence	I see myself as competent in using wearable technology in the teaching process.	0.82	0.83	0.61	0.86
	Compared to other teachers, I feel competent in using wearable technology in the teaching process.	0.79			
	As I gain experience, I feel quite competent towards using wearable technology in the teaching process.	0.75			
	Using wearable technology in the teaching process is an area where I demonstrate superior competence.	0.77			
Perceived Autonomy	Teaching with wearable technology gives me a sense of freedom.	0.82	0.77	0.62	0.87
	I feel pressured when integrating wearable technology into my lessons.	0.79			
	Teaching with wearable technology offers me attractive options and opportunities.	0.75			
	I have unlimited freedom in how to approach wearable technology in education.	0.80			
Perceived Relatedness	Teaching with wearable technology-based methods enables me to connect with other educators.	0.83	0.79	0.62	0.83
	When I use wearable technology in the teaching process, I feel close to my colleagues.	0.79			
	Using wearable technology in the teaching process helps me create a common bond and a sense of community among my peers.	0.74			
	When I participate in discussions on wearable technology in the teaching process, I feel close to my colleagues.	0.81			
Intention	I plan to continue using wearable technology tools in the teaching process in the future.	0.88	0.89	0.69	0.87
	I plan to increase the use of wearable technology tools for teaching purposes in the future.	0.79			
	In the future, I am open to exploring new methods with wearable technology tools in the teaching process.	0.82			

and profoundly informative, offering valuable insights into the dynamics driving wearable technology adoption in the field of physical education.

3.4. Data analysis

In this study, all statistical analyses were conducted using SPSS 27 and AMOS 24. To ensure construct validity and reliability in the present context, a preliminary application was carried out with a pilot group of 113 physical education teachers.

Prior to analysis, the dataset was carefully screened for missing values, outliers, and normality. Cases with substantial missing data (i.e. participants who failed to complete key sections of the survey) were excluded from further analysis. For the remaining dataset, the amount of missing data was minimal (<2%). In these cases, missing values were addressed using listwise deletion, such that only cases with complete data for all variables included in the analyses were retained. This approach was adopted to preserve the integrity of the analyses and avoid potential biases due to data imputation.

To address the potential for common method variance (CMV), both procedural and statistical remedies were employed. Procedurally, the survey assured participant anonymity, varied the order of items across constructs to reduce response patterning, and used clear, concise language to minimize item ambiguity. Statistically, Harman's single-factor test was performed by entering all measurement items into an unrotated exploratory factor analysis. The results indicated that the first (largest) factor accounted for 24.8% of the total

Table 4. Descriptive statistics, validity measures, and correlation values.

Constructs	PEU	PU	ATT	SN	PBC	PC	PA	PR	INT
PEU	**0.76**								
PU	0.52	**0.75**							
ATT	0.48	0.45	**0.78**						
SN	0.42	0.39	0.35	**0.75**					
PBC	0.39	0.32	0.41	0.36	**0.81**				
PC	0.35	0.35	0.22	0.37	0.42	**0.78**			
PA	0.44	0.39	0.35	0.41	0.38	0.41	**0.79**		
PR	0.42	0.31	0.41	0.44	0.39	0.40	0.34	**0.79**	
INT	0.39	0.38	0.38	0.43	0.42	0.38	0.37	0.41	**0.83**
M	3.42	3.12	3.42	3.69	3.44	3.58	3.02	3.87	3.63
SD	0.99	0.92	1.02	1.11	1.09	1.01	1.12	1.08	0.78

Note: The bold diagonal values indicate the square root of AVE for each construct, highlighting discriminant validity.

variance, which is well below the recommended threshold of 50%, suggesting that common method bias is not a serious concern in this study.

Path analysis was performed through a structural equation modeling (SEM) approach, consisting of two primary phases: evaluation of the measurement model and assessment of the structural model. In the measurement model phase, confirmatory factor analysis (CFA) with maximum likelihood estimation was utilized. The CFA yielded satisfactory model fit indices ($\chi^2 = 1028.5$, df = 425, $p < 0.05$; $\chi^2/df = 2.42$; GFI = 0.94; TFI = 0.94; IFI = 0.94; TLI = 0.93; CFI = 0.93; RMSEA = 0.05; SRMR = 0.04). All of these values exceeded commonly recommended thresholds for good model fit: CFI and TLI > 0.90, RMSEA < 0.08, and SRMR < 0.08.

All items exhibited acceptable standardized factor loadings (all ≥ 0.70, or above the conventional minimum of 0.50), and thus no items were dropped from the model. Moreover, no modification indices were consulted or used, as the initial model provided satisfactory fit without post hoc adjustments.

For reliability and validity:

- Composite reliability (CR) values for all constructs ranged from 0.71–0.87 (cut-off: > 0.70), supporting internal consistency.
- Average variance extracted (AVE) values ranged from 0.56–0.69 (cut-off: > 0.50), indicating adequate convergent validity.
- Cronbach's alpha (α) values for all constructs were above 0.70 (cut-off: > 0.70), further supporting reliability.

For convergent and discriminant validity:

The square roots of the AVE values for each construct were higher than the corresponding inter-construct correlations, confirming both convergent and discriminant validity as recommended.

A detailed overview of the CFA results, including factor loadings and fit statistics, is provided in Tables 3 and 4. The full list of measurement items and their loadings are reported in Appendix A for transparency and reproducibility.

Following confirmation of the measurement model, SEM was used to test the hypothesized relationships among constructs. The structural model was evaluated using the same fit indices, and all relevant results are presented in the subsequent Findings section.

4. Findings

4.1. Analysis of model fit and interpretative power

In this study, we aimed to examine the intentions of physical education teachers to adopt wearable technologies by employing an integrated model that combines the TPB, TAM, and SDT. The integration was strategic; while TPB and TAM directly assess behavioral intentions toward technology use, SDT was incorporated to explore motivational dimensions without a direct hypothetical link to intention. This holistic approach allowed us to explore the complementary effects of these theories in understanding technology adoption.

Table 5. Evaluation of model fit and predictive efficacy.

	χ^2	df	χ^2/df	GFI	IFI	TLI	CFI	RMSEA	SRMR	R^2	Adjusted R^2
TPB	447.7	185	2.42	0.94	0.91	0.91	0.90	0.05	0.05	0.43	0.42
TAM	453.12	177	2.56	0.91	0.90	0.90	0.90	0.05	0.06	0.40	0.40
Combined Model	466.62	202	2.31	0.96	0.94	0.93	0.92	0.03	0.03	0.51	0.50

SEM was utilized to analyze the fit and explanatory power of the models, both individually and collectively. The analysis began with assessing the fit of the standalone TPB and TAM models, which both showed acceptable fit indices, albeit with room for improvement. The TPB model achieved a chi-square to degrees of freedom ratio (χ^2/df) of 2.42, and the TAM model slightly less optimal at 2.56. However, the combined model, which merged TPB, TAM, and the motivational constructs from SDT, demonstrated a significantly better fit with a χ^2/df of 2.31.

This superior fit indicates that the amalgamation of behavioral, attitudinal, and motivational factors offers a more nuanced understanding of the dynamics involved in the adoption of new technologies. Beyond the χ^2/df values, other fit indices further validated the combined model's robustness, including a GFI of 0.96, CFI of 0.92, and RMSEA of 0.03.

Furthermore, the explanatory power of the models was thoroughly examined. The combined model reported an R-squared (R^2) of 0.51, suggesting that it explained 51% of the variance in teachers' intentions to use wearable technologies. This was a noticeable improvement over the standalone models, with R^2 values of 0.43 for TPB and 0.40 for TAM. To provide a more meaningful comparison, Adjusted R^2 values were also calculated, as they account for the number of predictors in each model. The Adjusted R^2 for the combined model was 0.500, compared to 0.421 for TPB and 0.389 for TAM.

These findings highlight the value of integrating diverse theoretical perspectives to capture the complex interplay of factors influencing technology adoption in educational settings. The combined model's superior fit and explanatory power underscore the importance of addressing not only behavioral intentions but also motivational drivers. By weaving together these elements, the study provides deeper insights into why teachers choose to embrace or reject wearable technologies and enhances the theoretical underpinnings of technology adoption research in the field of physical education. The fit indices and predictive efficacy of the TPB, TAM, and combined models are detailed in Table 5.

As seen in Table 5, the combined model outperformed both the TPB and TAM models on all major fit indices and explained variance, offering a much more comprehensive and robust account of technology adoption intentions among physical education teachers.

4.2. Utilizing SEM for insightful analysis

The structural equation modeling (SEM) analysis provided robust insights into the magnitude and significance of the relationships among constructs in the integrated model. In SEM, the standardized path coefficients (β) serve as effect sizes, indicating the strength and practical importance of each hypothesized relationship (Kline, 2016).

Perceived Competence, Perceived Autonomy, and Perceived Relatedness – key motivational constructs from SDT – demonstrated moderate to substantial positive effects on Perceived Ease of Use ($\beta = 0.29$, 0.27, and 0.40, respectively; all $p < .01$). These values indicate that, for example, a one standard deviation increase in Perceived Relatedness is associated with a 0.40 standard deviation increase in Perceived Ease of Use, representing a practically meaningful effect.

Similarly, these SDT constructs also exerted significant positive effects on Perceived Usefulness (Perceived Competence: $\beta = 0.21$; Perceived Autonomy: $\beta = 0.51$; Perceived Relatedness: $\beta = 0.26$; all $p < .01$), with Perceived Autonomy displaying a particularly large effect size.

Within the Technology Acceptance Model (TAM) domain, Perceived Ease of Use had a strong effect on both Perceived Usefulness ($\beta = 0.39$, $p < .001$) and Attitude toward using wearable technology ($\beta = 0.51$, $p < .001$), reinforcing their central roles in technology acceptance. Perceived Usefulness also showed substantial effects on Attitude ($\beta = 0.38$, $p < .01$) and especially on Intention to use wearable technology ($\beta = 0.49$, $p < .001$), with these effect sizes reflecting both statistical and practical significance.

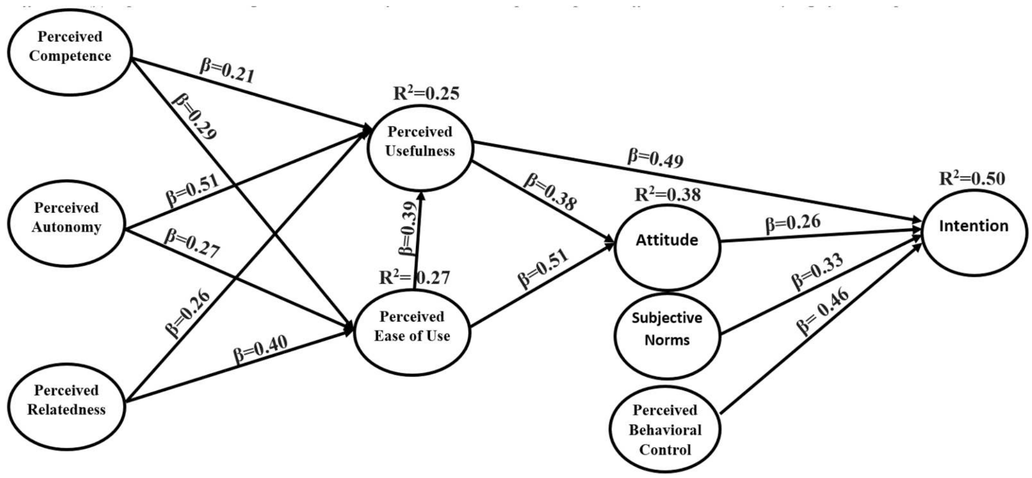

Figure 2. Path diagram of the final SEM model with standardized coefficients and R^2 values. All illustrated paths are statistically significant ($p < .05$).

Furthermore, the influences of Attitude, Subjective Norms, and Perceived Behavioral Control on Intention were all positive and meaningful (Attitude: $\beta = 0.26$; Subjective Norms: $\beta = 0.33$; Perceived Behavioral Control: $\beta = 0.46$; all $p < .01$), indicating that these factors are important drivers of teachers' intentions to adopt wearable technologies.

The model's explanatory power – another indicator of effect size – was also considerable. The key predictors accounted for 25% of the variance in Perceived Usefulness, 27% in Perceived Ease of Use, 38% in Attitude, and fully 50% in Intention to adopt wearable technology (as shown by R^2 values). These results demonstrate not only statistically significant relationships but also meaningful explanatory contributions.

Figure 2 presents a comprehensive path diagram of the final SEM model, clearly displaying the standardized path coefficients (effect sizes) and R^2 values for all endogenous variables. Table 6 summarizes all standardized coefficients, t-values, and significance levels for each hypothesized direct effect, explicitly noting that every tested path was statistically significant ($p < .05$).

Together, these visual and statistical representations underscore both the practical and theoretical significance of the findings, offering a transparent account of the magnitude and importance of the observed relationships.

4.3. Analysis of indirect effects in structural equation modeling

The SEM analysis detailed in Table 7 offers a comprehensive view of the indirect effects influencing both attitudes towards technology and the intention to adopt it in an educational context. Our investigation revealed nuanced pathways through which perceived ease of use and perceived usefulness mediate the

Table 6. SEM outputs for the integrated behavioral model.

Hypothesis	Relationship	Beta Coefficient (β)	t-Value	Significance	Hypothesis Situation
H1	Perceived Competence → Perceived Usefulness	0.21	2.01	$p < .05$	Supported
H2	Perceived Competence → Perceived Ease of Use	0.29	4.10	$p < .05$	Supported
H3	Perceived Autonomy → Perceived Usefulness	0.51	13.98	$p < .05$	Supported
H4	Perceived Autonomy → Perceived Ease of Use	0.27	3.22	$p < .05$	Supported
H5	Perceived Relatedness → Perceived Usefulness	0.26	3.01	$p < .05$	Supported
H6	Perceived Relatedness → Perceived Ease of Use	0.40	8.74	$p < .05$	Supported
H7	Perceived Ease of Use → Perceived Usefulness	0.39	8.01	$p < .05$	Supported
H8	Perceived Ease of Use → Attitude	0.51	14.42	$p < .05$	Supported
H9	Perceived Usefulness → Attitude	0.38	7.52	$p < .05$	Supported
H10	Perceived Usefulness → Intention	0.49	12.89	$p < .05$	Supported
H11	Attitude → Intention	0.26	2.88	$p < .05$	Supported
H12	Subjective Norms → Intention	0.33	5.12	$p < .05$	Supported
H13	Perceived Behavioral Control → Intention	0.46	11.88	$p < .05$	Supported

Note: All hypothesized paths were supported and statistically significant; no non-significant effects were found. Standardized path coefficients (β) represent the strength and direction of each relationship. All reported effects are statistically significant at $p < .05$.

Table 7. Indirect relationships in SEM analysis.

	Effect on Attitude	Effect on Intention
Perceived Usefulness	-	β = 0.29*
Perceived Ease of Use	β = 0.31*	β = 0.24*
Perceived Competence	β = 0.25*	β = 0.19**
Perceived Autonomy	β = 0.22**	β = 0.17**
Perceived Relatedness	β = 0.28*	β = 0.23*

Note: *$p < 0.01$, **$p < 0.05$

relationship between fundamental psychological constructs and technology adoption behaviors. Firstly, the analysis showed that perceived ease of use significantly affects educators' attitudes towards technology utilization, mediated by its influence on perceived usefulness, with a beta coefficient of 0.31 ($p < 0.01$). This indicates that when technology is easier to use, it is also perceived as more useful, which in turn positively influences attitudes toward its use. Furthermore, both perceived usefulness and perceived ease of use were found to have a substantial indirect impact on the intention to use technology. Perceived usefulness displayed a beta of 0.29 ($p < 0.01$) and perceived ease of use a beta of 0.24 ($p < 0.01$), indicating that these factors enhance the intention to adopt technology indirectly by improving attitudes towards technology use. Additionally, the study explored the indirect effects of SDT constructs – perceived competence, perceived autonomy, and perceived relatedness – on attitude, mediated by both perceived usefulness and perceived ease of use. It was observed that perceived competence had a beta of 0.25 ($p < 0.01$), perceived autonomy a beta of 0.22 ($p < 0.05$), and perceived relatedness a beta of 0.28 ($p < 0.01$). These results underscore the significance of these motivational factors in shaping positive attitudes towards technology through the enhancement of perceived usefulness and ease of use. Lastly, the impact of these SDT constructs on the intention to use technology was also significant, mediated by perceived usefulness. Perceived competence influenced intention with a beta of 0.19 ($p < 0.05$), perceived autonomy with a beta of 0.17 ($p < 0.05$), and perceived relatedness with a beta of 0.23 ($p < 0.01$). This indicates that the more educators feel competent, autonomous, and connected through the use of technology, the more likely they are to intend to integrate it into their teaching practices, primarily due to the increased perceived usefulness of the technology.

5. Discussions

This study explored the intentions of physical education teachers to adopt wearable technologies through the integration of three well-established theoretical frameworks: the TPB, the TAM, and SDT. By combining these perspectives, our research moves beyond traditional models of technology adoption and captures the essential role of psychological motivation – namely, teachers' needs for autonomy, competence, and relatedness – in shaping attitudes and intentions toward new educational technologies.

The integration of motivational constructs from SDT, alongside the established TAM and TPB factors, demonstrates that internal drivers are just as critical as external or practical considerations. This approach offers a more nuanced understanding of technology adoption, revealing that teachers' willingness to embrace wearables is influenced not only by perceived usefulness or social norms, but also by the degree to which these technologies support their intrinsic needs and sense of professional agency.

Importantly, our findings underscore the practical significance of targeting these motivational dimensions in both policy and practice. By emphasizing interventions that build teachers' confidence, autonomy, and sense of connection, educational leaders can create more supportive environments for technology adoption. Although all hypothesized relationships were statistically significant in this context – suggesting strong alignment among theory, measurement, and context – it is important to recognize that other educational settings or populations may yield different patterns of results. Continued research across diverse contexts is essential for refining these models and ensuring their broad applicability.

5.1. Theoretical implications

The primary theoretical implication of this study is the development of a comprehensive model that integrates SDT as a source of motivational influence, TAM for technological perceptions, and TPB for behavioral intentions, specifically within the context of wearable technology adoption in physical education. This approach uniquely highlights how the internal motivational factors emphasized by SDT interact with the cognitive (perceived usefulness, perceived ease of use) and normative (subjective norms, perceived behavioral control) elements of TAM and TPB, providing a richer and more holistic account of teachers' technology adoption processes.

This study provides both statistical and practical evidence that intrinsic motivational factors – autonomy, competence, and relatedness – are central to technology adoption. For example, when teachers experience autonomy – that is, when they feel they have meaningful choices and agency in how they use technology – they are more open to experimentation and innovation in their teaching practices. Perceived competence is equally crucial; teachers who feel skilled and effective in using wearable technologies are more likely to engage with and persist in integrating these tools, supporting the sustained use and deeper pedagogical integration of technology. Relatedness, or the sense of belonging and social support from peers, helps educators overcome apprehension about new technologies, fostering collaborative environments that make ongoing technology use more likely.

Within this integrated model, TAM constructs such as perceived usefulness and perceived ease of use are shown to mediate the effects of motivational factors on attitudes and intentions: when teachers perceive wearable technologies as both valuable and user-friendly – perceptions that are themselves enhanced by higher levels of autonomy and competence – their attitudes toward adoption are more positive, and their intention to use the technology increases. Similarly, TPB constructs such as attitude, subjective norms, and perceived behavioral control are influenced both by motivational and cognitive factors; however, the results of this study indicate that intrinsic motivation and perceptions of usefulness exert a stronger influence than external social pressures or normative expectations.

Importantly, the effect sizes observed in this study (e.g. the strong direct effect of perceived autonomy on perceived usefulness) underscore that supporting autonomy, competence, and relatedness is not merely theoretically sound but yields meaningful, real-world impacts on adoption behaviors. This suggests that interventions which directly address these motivational needs – such as offering teachers meaningful choice, building their technological competence, and fostering supportive peer networks – may be more effective than those focused solely on external mandates or compliance with normative expectations.

Reflecting this growing focus on practical implementation, Ahmadi et al. (2023) developed a detailed classification system of teacher motivational behaviors that align with self-determination theory, using a Delphi method to reach international expert consensus on specific actions that nurture autonomy, competence, and relatedness. This taxonomy includes a comprehensive and clearly defined set of 57 need-supportive teacher behaviors, providing educators and researchers with a practical toolkit to design, implement, and evaluate interventions that foster psychological need satisfaction. By incorporating such evidence-based frameworks, future interventions and professional development programs can be more precisely tailored to address the diverse motivational dynamics identified in this study. Moreover, using a standardized classification system allows for greater consistency and comparability across studies, thereby strengthening the overall evidence base for motivationally informed technology integration strategies in education (Ahmadi et al., 2023).

These findings are consistent with a growing body of theoretical and philosophical scholarship emphasizing the primacy of personal agency, intrinsic motivation, and professional autonomy in educational innovation. Classic models of technology acceptance (e.g. Davis et al., 1989; Ajzen, 1991) have traditionally highlighted external and cognitive determinants of behavior; however, more recent perspectives – drawing from self-determination theory (Deci & Ryan, 2002) and the philosophy of agency (Biesta, 2010) – underscore that sustainable change emerges when teachers experience environments that support their psychological needs for autonomy, competence, and meaningful relationships. Such an orientation not only aligns with contemporary theories of motivation and human flourishing in education (Nussbaum, 2011; Ryan & Deci, 2000), but also reflects empirical findings across diverse educational contexts that highlight the limitations of externally driven or compliance-focused approaches to technology integration.

Further, this study extends the work of Deci and Ryan (2002) and recent research (e.g. Ateş & Gündüzalp, 2024; Ateş & Yilmaz, 2024) by providing empirical support for the distinct roles of competence, autonomy, and relatedness in shaping technology adoption intentions. Teachers who feel competent and autonomous are more likely to view wearable technologies as beneficial for personalizing instruction and enhancing student engagement. Conversely, when teachers lack institutional support or resources, external constraints and mandates may become more salient (An et al., 2023). These findings reinforce the idea that technology adoption is shaped by both individual volition and environmental context (Al Breiki et al., 2023; Almusawi et al., 2021; Almusawi & Durugbo, 2024; Ateş & Garzón, 2023; Habibi et al., 2023; Han et al., 2024; Huang et al., 2021). The alignment between our results and international studies is notable. Similar research in other countries has consistently found that teachers' intrinsic motivations and psychological needs are critical drivers of technology adoption across educational settings. For instance, studies from North America, Europe, and East Asia have all emphasized the importance of autonomy, competence, and relatedness (Deci & Ryan, 2002; Han et al., 2024; Huang et al., 2021). However, our findings diverge from some international literature in that the effects of external pressures – such as subjective norms – were less pronounced among our participants, possibly reflecting contextual differences in Turkish public education or the specific professional culture of physical education teachers. This suggests that while the foundational psychological drivers may be universal, the influence of external or institutional factors can vary depending on cultural and organizational context. These findings imply that effective strategies for technology adoption – whether in Turkey or internationally – should not only provide technical training but also prioritize support for teachers' intrinsic motivations. Policymakers and school leaders should therefore design interventions that cultivate autonomy, professional competence, and meaningful peer connections, as these are likely to have the greatest practical and sustainable impact on technology integration in education.

By validating and extending these theoretical frameworks with robust empirical evidence and citing relevant literature, this study enriches our understanding of how and why physical education teachers decide to integrate or reject wearable technologies, providing a strong foundation for future research and practice.

5.2. Practical implications

The findings of this study offer concrete guidance for school administrators, policymakers, and teacher educators aiming to foster the effective adoption of wearable technologies in physical education. Crucially, the results demonstrate that simply providing access to technology is insufficient; rather, successful integration depends on supporting teachers' psychological needs – especially autonomy, competence, and relatedness – as well as addressing practical and organizational factors.

To begin with, professional development initiatives should go beyond basic technical instruction. Administrators are encouraged to design training programs that include hands-on workshops, allowing teachers to experiment with wearable devices in realistic physical education scenarios. These opportunities help teachers build competence and confidence in using new technologies. Moreover, granting teachers the flexibility to choose how they implement these tools in their classes promotes a sense of autonomy and ownership over the innovation process. Establishing structured opportunities for peer collaboration – such as mentoring programs or collaborative lesson planning – can further enhance teachers' motivation by supporting a sense of relatedness and community.

Ongoing and personalized support is also essential for sustaining technology use. Schools can benefit from designating a technology coach or innovation lead who provides individualized assistance as teachers encounter challenges. Periodic refresher sessions, peer "showcase" lessons, and online forums where teachers can share experiences and solutions can further sustain motivation and collective learning. Ensuring that teachers have ongoing access to support, both in-person and virtually, reduces frustration and builds resilience during the adoption process.

Infrastructure and access form another crucial pillar for successful implementation. School leaders should invest in reliable Wi-Fi, accessible devices, and robust technical support to minimize barriers related to logistics or equipment malfunctions. Planning for regular maintenance and replacement of wearable devices, as well as allocating dedicated time within teachers' schedules for professional learning and experimentation, can also facilitate smooth integration.

Recognition and a supportive school culture play important roles in motivating teachers to adopt new technologies. Administrators should consider introducing recognition programs or incentives for innovative uses of wearable technology and integrate technology adoption into school improvement plans. Creating an environment that values experimentation – and where learning from setbacks is encouraged – can help foster a culture of innovation and professional growth.

Additionally, fostering communities of practice within and across schools enables teachers to collaborate, share resources, and support each other as they adopt wearable technologies. Partnerships with external organizations, such as universities, NGOs, or ed-tech companies, can further enrich professional learning and provide access to new resources and expertise tailored to physical education contexts.

Finally, ongoing feedback mechanisms are vital for the continued success of technology initiatives. Schools should regularly solicit feedback from teachers through surveys, interviews, or focus groups, using this information to inform future purchasing decisions, support structures, and professional development agendas. By maintaining a responsive approach and continuously adapting to teachers' needs, administrators and policymakers can ensure that wearable technology integration remains aligned with classroom realities and leads to meaningful, sustained change.

5.3. Limitations and suggestions for future studies

While this study advances understanding of wearable technology adoption in physical education, several limitations should be acknowledged. First, the research relied on self-report questionnaires, which are subject to potential biases such as social desirability and inaccuracies in recall. To mitigate these limitations in future studies, researchers should consider incorporating objective data sources (e.g. usage logs or observational measures) to triangulate self-report findings and provide a more accurate picture of technology adoption.

Second, the cross-sectional design limits causal inference and the ability to track how teachers' motivations, perceptions, or behaviors might evolve over time. Longitudinal or experimental designs would be valuable for examining the dynamics and causal relationships underlying technology adoption, as well as the sustainability of adoption as teachers gain experience or as technology matures.

A further limitation concerns the sample context: the present research was conducted exclusively among physical education teachers from urban public schools in Turkey's largest cities. These schools are generally better resourced and provide more access to technological infrastructure compared to rural or under-resourced settings. As a result, the transferability and generalizability of the findings to other regions, less affluent schools, or rural environments may be limited. Teachers in under-resourced or rural contexts may face different barriers – such as lack of reliable internet access, insufficient technical support, or competing priorities – which could alter both the feasibility and the motivational dynamics of technology adoption. Therefore, future research should deliberately seek to include more diverse samples, such as teachers from rural, peri-urban, or low-resource educational environments, as well as international comparisons to assess the impact of varying educational and cultural contexts.

Fourth, the perspectives of other stakeholders – such as students, administrators, and parents – were not included. Incorporating these viewpoints could provide a more comprehensive understanding of the contextual and organizational factors affecting technology integration in education.

Fifth, the study was limited to wearable technologies. Expanding research to include other forms of educational technology, such as augmented reality or virtual reality, would reveal whether similar motivational and adoption patterns emerge. Comparative and multi-technology studies could identify context-specific or technology-specific drivers and barriers.

Sixth, qualitative methods (e.g. interviews, focus groups) are recommended for future work to provide richer insights into the lived experiences, motivations, and challenges faced by educators adopting new technologies. Such approaches, combined with quantitative analysis, would strengthen the evidence base for effective technology integration strategies.

Finally, although this study collected detailed demographic data (e.g. gender, years of teaching experience, and daily technology usage), the analyses did not examine whether the observed relationships differed across these subgroups. Future research is encouraged to employ multi-group or moderator analyses to investigate whether demographic factors shape the pathways of technology adoption among physical education teachers.

6. Conclusion

This study makes a substantial contribution to understanding technology adoption in educational settings, focusing on the context of physical education. By integrating the TPB, TAM, and SDT, the research provides a comprehensive framework that elucidates the complex interplay of behavioral, motivational, and attitudinal factors influencing physical education teachers' intentions to adopt wearable technologies. The findings reveal that internal motivational factors – particularly perceived competence, autonomy, and relatedness – play critical roles in shaping educators' attitudes and intentions toward technology adoption. These factors, combined with perceived ease of use and usefulness, produced a model with robust predictive power. For example, perceived autonomy demonstrated a strong standardized effect on perceived usefulness, while perceived relatedness and perceived ease of use also exhibited substantial effects on key outcomes. The model explained 50% of the variance in teachers' intentions to adopt wearable technologies, which is notable for studies in educational contexts. Such effect sizes not only support the statistical significance of the relationships but also underscore their practical relevance for intervention design and policy. Notably, while motivational factors strongly influenced the adoption process, external factors such as subjective norms and perceived behavioral control were found to be less impactful in this context, suggesting that intrinsic and personal motivators may outweigh external pressures for these educators. This insight is particularly valuable for practitioners and policymakers aiming to design professional development programs and support structures that genuinely resonate with teachers' motivations and needs. The study's implications thus extend beyond theory. Understanding these motivational drivers can guide the development of effective interventions, school policies, and technology design, fostering environments where technology integration is not only feasible but also sustainable and meaningful for teachers. Educational institutions that prioritize the enhancement of teachers' autonomy, competence, and sense of relatedness are more likely to succeed in promoting technology adoption and maximizing educational benefits. However, several limitations must be acknowledged. The sample focused on physical education teachers in urban schools with relatively advanced resources, which may limit generalizability. The cross-sectional design restricts the ability to assess changes over time or causal relationships. Reliance on self-report data introduces potential bias, though future studies can address this by incorporating objective usage data or multi-informant perspectives. Expanding research to include diverse educational settings, longitudinal approaches, and a wider range of technologies would deepen understanding and strengthen the evidence base. In summary, this research underscores the importance of considering both psychological and contextual factors – alongside demonstrated effect sizes and practical significance – when promoting technology adoption in education. Tailored interventions that align with teachers' intrinsic motivations are likely to yield more effective and enduring outcomes. As technology continues to evolve, so too should our approaches to integrating these tools, ensuring they meet the diverse needs, motivations, and realities of educators.

Disclosure statement

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

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Appendix A. Full list of measurement items

Perceived Ease of Use

1. It is easy to use wearable technology tools in the teaching process.
2. It is easy for me to become proficient in using wearable technology tools in the teaching process.
3. The use of wearable technology tools in the teaching process is clear and understandable.

Perceived Usefulness

4. I believe that wearable technology tools will contribute to my teaching process.
5. I believe that using wearable technology tools will increase the learning effectiveness in my teaching process.

Attitude

6. I believe that integrating wearable technology tools into my teaching process will be beneficial.
7. I enjoy using wearable technology tools in my teaching activities.
8. Using wearable technology tools in my work provides me with a pleasant experience.

Subjective Norm

9. People whose opinions I value advise me to use wearable technology tools in my teaching process.
10. People I respect support my use of wearable technology tools in my work.

Perceived Behavioral Control

11. The decision to use wearable technology in the teaching process is entirely up to me.
12. I have the necessary skills and knowledge to integrate wearable technology into the teaching process.
13. I am confident that I can effectively use wearable technology in the teaching process.

Perceived Competence

14. I see myself as competent in using wearable technology in the teaching process.
15. Compared to other teachers, I feel competent in using wearable technology in the teaching process.
16. As I gain experience, I feel quite competent towards using wearable technology in the teaching process.
17. Using wearable technology in the teaching process is an area where I demonstrate superior competence.

Perceived Autonomy

18. Teaching with wearable technology gives me a sense of freedom.
19. I feel pressured when integrating wearable technology into my lessons. *(reverse coded)*
20. Teaching with wearable technology offers me attractive options and opportunities.
21. I have unlimited freedom in how to approach wearable technology in education.

Perceived Relatedness

22. Teaching with wearable technology-based methods enables me to connect with other educators.
23. When I use wearable technology in the teaching process, I feel close to my colleagues.
24. Using wearable technology in the teaching process helps me create a common bond and a sense of community among my peers.
25. When I participate in discussions on wearable technology in the teaching process, I feel close to my colleagues.

Intention

26. I plan to continue using wearable technology tools in the teaching process in the future.
27. I plan to increase the use of wearable technology tools for teaching purposes in the future.
28. In the future, I am open to exploring new methods with wearable technology tools in the teaching process.