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Unveiling the factors influencing science teachers' adoption of eye-tracking technology through the GETAMEL framework

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Introduction: Eye-tracking technology offers valuable insights into learners' cognitive and behavioral engagement, yet its classroom adoption by science teachers remains limited. This study explores the factors affecting science teachers' readiness and intention to integrate eye-tracking into their instructional practices.

Methods: Using the General Extended Technology Acceptance Model for E-Learning (GETAMEL) as the theoretical framework, data were collected from 800 in-service science teachers via structured questionnaires. The analysis employed structural equation modeling to test hypothesized relationships among model constructs.

Results: Results indicate that subjective norm, perceived enjoyment, experience, self-efficacy, and anxiety significantly influence perceived usefulness ($R^2 = 0.38$) and perceived ease of use ($R^2 = 0.43$). These perceptions, in turn, affect attitudes and behavioral intentions ($R^2 = 0.52$) toward adopting eye-tracking technology.

Discussion: The findings underscore the importance of emotional, cognitive, and contextual factors in shaping teachers' adoption behavior. Implications are discussed for designing teacher training programs, educational policies, and curriculum strategies that support the integration of eye-tracking tools in science education.

KEYWORDS

eye-tracking technology, science education, technology adoption, GETAMEL framework, teacher training, behavioral intention

1 Introduction

Eye-tracking systems have emerged as transformative tools, providing insights into learners' cognitive and behavioral patterns (Jin et al., 2023; Wolf and Ueda, 2021). Eye-tracking technology records and analyzes eye movements, fixation durations, and gaze patterns, offering a window into learners' attention, comprehension, and engagement levels. Eye-tracking technology has been increasingly utilized in educational research to capture learners' unconscious processes during video-based learning (Bhatt et al., 2024; Liang et al., 2025). For instance, Deng and Gao (2022) highlight that empirical studies using eye-tracking have elucidated the mechanisms that facilitate video-based learning, revealing how learners interact with instructional videos. This technology allows researchers to analyze how attention is allocated during learning tasks, which is crucial for optimizing educational content and delivery methods. Furthermore, the systematic review by Lanna (2020) emphasizes the importance of multimodal learning analytics, including eye-tracking, in understanding the cognitive engagement of young learners. This suggests that eye-tracking can provide valuable data on how students process information, which is essential for developing effective educational strategies. Moreover, eye-tracking technology has been applied in various educational contexts, where it has been integrated into virtual environments to enhance learning experiences (Kuzminov, 2023). In the realm of science education, the insights gained from eye-tracking studies are particularly valuable (Chen et al., 2023). For example, Chen (2024) conducted a systematic review of 34 empirical studies from 2011 to 2023, exploring the application of eye-tracking technology in chemistry education to analyze its methodological implementations, research themes, and impacts, revealing its potential for enhancing learning processes, instructional design, and laboratory instruction.

However, despite its recognized potential to enhance educational practices, the adoption and integration of eye-tracking technology in classroom settings appear to be limited. Existing studies in science education have primarily focused on learner-centered applications in controlled experimental environments, with comparatively less attention given to the perspectives and practices of teachers—the key agents in enacting educational innovation (e.g., Jian, 2022; Özdemir and Tosun, 2024). Teachers are not merely facilitators of learning but also play a central role in selecting, adapting, and implementing emerging technologies. Nevertheless, their experiences, perceived challenges, and strategies for incorporating eye-tracking technology into authentic classroom settings are not yet fully understood. This ongoing disconnect between technological advancements and classroom realities suggests a need for more research focused on teacher adoption and classroom-level implementation.

Another critical gap in the literature lies in the lack of structured, teacher-centric frameworks for integrating advanced technologies into educational curricula. While numerous studies highlight the benefits of eye-tracking in understanding student behaviors, few provide actionable guidance for teachers to harness this technology effectively (Zang et al., 2022). This is particularly relevant to science education, where teachers' intentional use of technology can directly influence how complex topics are taught and learned. Understanding teachers' willingness and preparedness to adopt eye-tracking technology in their courses is crucial to bridging this gap. Addressing these issues is vital to ensuring that the potential of eye-tracking technology is not confined to research laboratories but extended to practical classroom applications, enabling meaningful learning experiences.

The General Extended Technology Acceptance Model for E-Learning (GETAMEL) developed by Abdullah and Ward (2016) offers a promising framework for addressing these challenges. Specifically, GETAMEL can be well-suited for examining science teachers' intentions to adopt eye-tracking technology by incorporating constructs. By providing structured guidance, the model equips teachers with the tools and confidence needed to navigate the complexities of adopting cutting-edge technologies in their courses. While GETAMEL has demonstrated efficacy in various educational technology contexts (e.g., Ateş et al., 2024; Ateş and Gündüzalp, 2025), its application to eye-tracking technology in science education appears to be limited, indicating the need for further research to understand and support teachers' intentional use of such innovations.

This study is needed to bridge these critical gaps and advance the practical application of eye-tracking technology in science education. It is particularly timely given the increasing emphasis on leveraging data-driven insights to enhance teaching and learning processes. Understanding how teachers can adopt eye-tracking tools effectively, the barriers they face, and the supports they require will contribute to a more holistic and inclusive approach to educational innovation. Accordingly, this study aims to investigate the factors influencing science teachers' intention and readiness to adopt and integrate eye-tracking technology into their teaching practices. Using the GETAMEL as its theoretical framework, the study explores key constructs in adopting this technology. By contributing to the emerging body of research on teacher-centered adoption of eye-tracking tools in science education, this study aims to help bridge the gap between technological innovations and practical classroom applications. Specifically, it examines the barriers and supports necessary for successful integration, offering valuable insights for educators and stakeholders. The study posits that the effective adoption of eye-tracking technology can enhance students' learning experiences through personalized engagement, improved attentional focus, and the facilitation of active learning. Through its findings, the study aims to contribute both theoretically and practically by expanding the applicability of the GETAMEL model and providing actionable guidelines for teacher training programs, policy decisions, and curriculum development in science education.

2 Literature review and hypotheses

2.1 Eye tracking technology in science education

Eye tracking technology has become a pivotal tool in science education, offering unique insights into cognitive processes and learning behaviors that traditional assessment methods may fail to capture (Jin et al., 2023; Wolf and Ueda, 2021). By capturing and analyzing eye movements, researchers can explore how students interact with educational materials and concepts, particularly in complex subjects such as chemistry and biology. This technology has been widely adopted to examine student engagement and information processing in science learning. For example, Muna (2023) demonstrated that eye tracking is increasingly employed to monitor students' engagement with chemistry content, helping to identify areas where they face difficulties in comprehension. Similarly, Williamson et al. (2013) utilized eye tracking to assess students' understanding of various chemical representations, shedding light on the cognitive strategies they use during learning. These findings underscore the potential of eye tracking to reveal the cognitive mechanisms underlying science education and to enhance teaching methodologies.

Eye tracking has also been effectively integrated into video-based learning environments, which are increasingly prevalent in educational settings. Deng and Gao (2022) emphasize that this technology can capture the moment-to-moment visual attention of learners as they interact with instructional videos, providing data on how visual stimuli influence comprehension and retention. This is especially relevant in science education, where students must interpret complex visual information. Eye tracking enables researchers to identify which elements of the visual materials engage students and facilitate deeper understanding, offering valuable guidance for optimizing instructional design.

Beyond video-based learning, eye tracking has been employed to evaluate the effectiveness of educational software and instructional strategies. Léger et al. (2018) argue that eye tracking data reveals the depth of learners' information processing, making it a critical tool for assessing educational interventions. This is particularly important in science education, where the intricacy of the content often necessitates tailored strategies to enhance engagement and understanding. For example, analyzing eye movement patterns can help identify whether students are effectively navigating and processing digital materials or require additional scaffolding.

The integration of eye tracking with immersive technologies, such as virtual reality (VR), has further expanded its applications in science education. Mikhailenko and Kurushkin (2021) highlight how eye tracking in VR environments enhances the learning experience by providing real-time feedback on student interactions with scientific concepts. This approach not only fosters a more interactive and engaging learning environment but also supports the visualization of abstract and complex concepts, which are often challenging to convey through traditional methods. The combination of eye tracking and VR represents a promising direction for experiential learning in science education.

Recent methodological advancements have also increased the accessibility and usability of eye tracking technology. Dostálová (2024) notes that webcam-based eye tracking is replacing traditional methods, making it easier to implement in diverse educational contexts. This technological shift has expanded the scope of eye tracking research to include a broader range of learners, including neurodivergent populations. Studies focusing on reading patterns and cognitive processes in these populations highlight the versatility of eye tracking in addressing diverse educational needs and supporting inclusive pedagogy.

2.2 The GETAMEL framework

The GETAMEL, developed by Abdullah and Ward (2016), is a comprehensive theoretical framework designed to explore the multifaceted factors influencing individuals' acceptance and utilization of e-learning technologies. As an extension of the foundational Technology Acceptance Model (TAM) (Davis, 1989), GETAMEL retains the core constructs of perceived usefulness and perceived ease of use as pivotal determinants of technology adoption while expanding the model to incorporate additional contextual and individual factors (Doleck et al., 2018).

One of the major advancements of GETAMEL is the inclusion of social influence, which reflects the extent to which individuals perceive their peers or colleagues as endorsing and utilizing e-learning technologies. Studies indicate that observing peer adoption can positively influence an individual's intention to adopt, underscoring the role of social dynamics in technology acceptance (Ateş et al., 2024). Additionally, the model incorporates perceived enjoyment, defined as the intrinsic pleasure or affective satisfaction individuals experience while using a technology. When users find the experience enjoyable, their likelihood of sustained engagement and adoption increases (Ateş and Gündüzalp, 2025; Fitzgerald et al., 2022). Another important construct is experience, which in GETAMEL refers specifically to prior exposure to and familiarity with the technology, including the frequency and contexts in which it has been used. It is conceptually distinct from enjoyment or attitude, as it captures the user's accumulated interactions rather than their emotional or evaluative responses (Abdullah and Ward, 2016). The model also includes personal innovativeness, which measures an individual's general willingness to experiment with new technologies. Early adopters are more likely to engage with novel platforms, particularly in dynamic educational environments that demand adaptability (Chong et al., 2016; Cevra et al., 2022). Furthermore, GETAMEL places significant emphasis on technological attributes such as design quality, usability, and user support, recognizing their influence on user satisfaction and engagement. Research suggests that intuitive interfaces and responsive support systems enhance acceptance by creating a positive and accessible user experience (Uppal et al., 2017). Beyond individual and technological factors, contextual elements—including organizational support, training opportunities, and financial incentives—also play a critical role in promoting technology adoption (Al-Maroof et al., 2020; Taroreh et al., 2023). By addressing these diverse dimensions, GETAMEL offers a robust framework for understanding and improving e-learning technology adoption. Its multidimensional structure provides valuable insights for the design of supportive systems and institutional environments that foster sustainable engagement with educational innovations.

Although GETAMEL has been widely applied in e-learning contexts (e.g., Han, 2024; Köroglu, 2024; Tian and Wang, 2024; Zhang and Yang, 2024), its potential for examining teacher-centered adoption of advanced tools such as eye-tracking technology in science education appears to be under-investigated, indicating the need for further empirical inquiry. Eye-tracking systems are increasingly recognized for their ability to capture real-time data on learners' cognitive and behavioral engagement, providing valuable insights for optimizing teaching and learning (Jin et al., 2023; Wolf and Ueda, 2021).

2.2.1 Research hypotheses

Based on the GETAMEL framework and the study's objectives, the following hypotheses are proposed, and the model is presented in Figure 1:

H1: subjective norm positively affects perceived usefulness of eye-tracking technology in science courses.
H2: subjective norm positively affects perceived ease of use of eye-tracking technology in science courses.
H3: experience positively affects perceived usefulness of eye-tracking technology in science courses.
H4: experience positively affects perceived ease of use of eye-tracking technology in science courses.
H5: perceived enjoyment positively affects perceived usefulness of eye-tracking technology in science courses.
H6: perceived enjoyment positively affects perceived ease of use of eye-tracking technology in science courses.
H7: anxiety affects perceived usefulness of eye-tracking technology in science courses.
H8: anxiety affects perceived ease of use of eye-tracking technology in science courses.
H9: self-efficacy positively affects perceived usefulness of eye-tracking technology in science courses.
H10: self-efficacy positively affects perceived ease of use of eye-tracking technology in science courses.

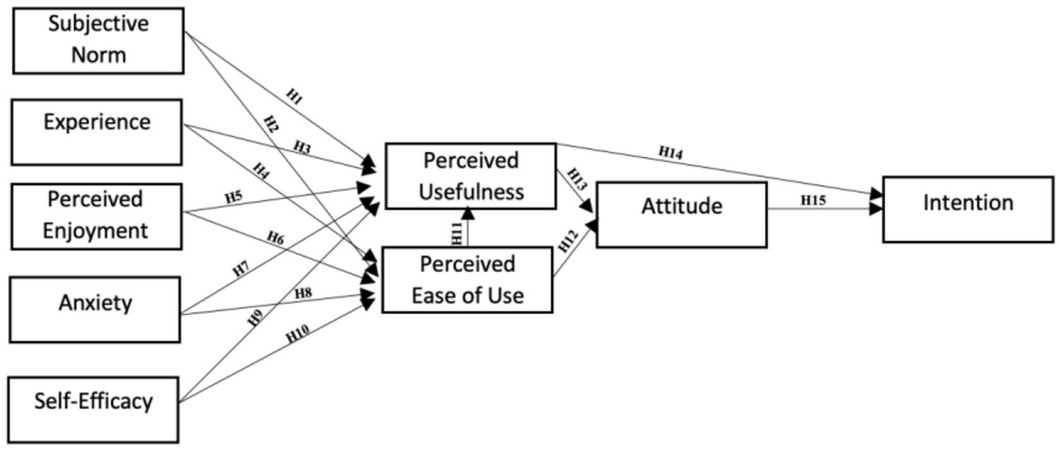

FIGURE 1
Adapted GETAMEL model for eye-tracking in science teaching.

H11: perceived ease of use positively affects perceived usefulness of eye-tracking technology in science courses.
H12: perceived ease of use positively affects attitudes toward eye-tracking technology in science courses.
H13: perceived usefulness positively affects attitudes toward eye-tracking technology in science courses.
H14: perceived usefulness positively affects intentions to use eye-tracking technology in science courses.
H15: attitudes toward eye-tracking technology in science courses positively affect intentions to use it.

3 Material and method

3.1. Data collection process

This study employed a structured data collection process to assess science teachers' readiness to adopt and integrate eye-tracking technology in their teaching practices. Participants were first introduced to eye-tracking technology through a brief overview explaining its purpose, features, and educational benefits, particularly in enhancing student engagement and cognitive learning in science education. Subsequently, participants received technical details, including system requirements, hardware and software specifications, and practical examples of classroom applications. Step-by-step user guides, supplemented with visual aids and brief video tutorials, were provided to facilitate understanding and implementation. Interactive workshops and training sessions offered participants hands-on experience, covering key functionalities and troubleshooting techniques. These sessions aimed to build confidence in using the technology effectively in educational settings. To ensure ongoing support, the study included a feedback mechanism allowing participants to share experiences and challenges via surveys and informal discussions. A dedicated help desk and online forum were also established to address questions and foster collaboration. Case studies showcasing successful applications of eye-tracking technology in science education were shared, providing practical insights and motivation. This streamlined process ensured participants were informed, trained, and supported, enabling effective adoption of eye-tracking technology in their instructional practices.

3.2 Participants

The study employed a convenience sampling method to recruit science teachers as participants. Data collection occurred between September and December 2024, with self-administered questionnaires distributed both online and in-person. Participants were drawn from urban and suburban regions, ensuring representation of diverse teaching environments.

A total of 1,000 questionnaires were distributed, yielding 880 responses (88% response rate). After validation, 800 responses were deemed usable for analysis. The sample consisted entirely of in-service science teachers, with 60% identifying as female and 40% as male. Most participants were aged 30–45, with 85% holding bachelor's degrees and 20% reporting prior experience with educational technologies.

3.3 Instruments

The data collection instrument for this study was meticulously designed to capture comprehensive insights into the factors influencing science teachers' adoption of eye-tracking technology. It was divided into two main sections: demographic information and constructs aligned with the GETAMEL framework.

The demographic section gathered basic participant information, including gender, age, years of teaching experience, frequency of technology use in personal and professional contexts, and familiarity with innovative teaching methods. These questions aimed to contextualize the responses and understand the participant profile.

The GETAMEL-based section included items that measured both the original constructs from the TAM and the external factors unique to GETAMEL. Specifically:

TABLE 1 Research items and sources.

Constructs and statements
Perceived ease of use (Davis, 1989; Nikou and Economides, 2017)
I find eye-tracking technology easy to use for science teaching.
It is easy for me to become skillful at using eye-tracking technology for science teaching.
My interaction with eye-tracking technology during science teaching is clear and understandable.
Perceived usefulness (Davis, 1989; Nikou and Economides, 2017)
Using eye-tracking technology for science teaching is useful for my teaching.
Using eye-tracking technology for science teaching enhances my teaching effectiveness.
Perceived enjoyment (Lu and Zhou, 2009; Moon and Kim, 2001)
Using eye-tracking technology for science teaching is enjoyable to me.
Using eye-tracking technology for science teaching is fun to me.
Using eye-tracking technology for science teaching makes me happy.
Anxiety (Zhai and Ma, 2022)
I feel apprehensive about using eye-tracking technology for science teaching.
It scares me to think that I could make mistakes I cannot correct when using eye-tracking technology for science teaching.
Using eye-tracking technology for science teaching is somewhat intimidating to me.
Experience (Abdullah et al., 2016)
I have used eye-tracking technology in my science teaching before.
I am comfortable using eye-tracking technology for science teaching.
I am comfortable using technology when using eye-tracking technology for science teaching.
Self-Efficacy (Salloum et al., 2019)
I feel confident when utilizing eye-tracking technology for science teaching even when no one is there for assistance.
I have sufficient skills to use eye-tracking technology for science teaching.
I feel confident when using eye-tracking technology for science teaching.
Attitude (Lu and Zhou, 2009; Taylor and Todd, 1995)
Using eye-tracking technology for science teaching is a good idea.
I like using eye-tracking technology for science teaching.
Using eye-tracking technology for science teaching would be pleasant.
Subjective Norm (Ajzen, 2006; Lu and Zhou, 2009; Taylor and Todd, 1995)
People who are important to me think that I should use eye-tracking technology for science teaching.
People who influence my behavior think that I should use eye-tracking technology for science teaching.
Intention (Ajzen, 2006; Davis, 1989; Nikou and Economides, 2017)
I will use eye-tracking technology for science teaching in the future.
I plan to use eye-tracking technology for science teaching in the future.
I will try to use eye-tracking technology for science teaching in the future.

- Core constructs: perceived ease of use (3 items), perceived usefulness (3 items), attitude toward technology (3 items), and behavioral intention to use technology (3 items).
- External factors: perceived enjoyment (3 items), anxiety (3 items), experience with technology (3 items), self-efficacy (3 items), and subjective norm (2 items).

The finalized instrument consisted of a total of 29 items, encompassing 6 demographic questions, 12 items based on the core constructs of TAM, and 14 items addressing the external factors within the GETAMEL framework. All items were assessed on a five-point Likert scale, ranging from *strongly disagree (1)* to *strongly agree (5)*. This approach ensured a nuanced understanding of participants' perceptions and attitudes toward eye-tracking technology integration.

To ensure the content validity of the instrument, the initial version underwent a rigorous review process. A panel comprising university academics specializing in science education and educational technology, experienced science teachers, and postgraduate researchers in related fields critically evaluated the instrument. Their feedback informed revisions to improve item clarity, relevance, and alignment with the study objectives.

Subsequently, a pilot study involving 180 science teachers was conducted to refine the instrument further. Participants provided feedback on item wording and structure, and the responses were analyzed to assess reliability and construct validity. Adjustments were made based on these findings, resulting in the finalized version of the survey instrument.

The final instrument is involved in Table 1.

3.4 Data analysis

The analysis of the survey data was conducted using a two-stage approach, leveraging statistical tools to ensure both the reliability and validity of the constructs. For this purpose, SPSS and AMOS were employed. This dual-software strategy allowed for an in-depth examination of the measurement and structural models, ensuring robust findings aligned with the study's objectives.

In the first phase, the measurement model was assessed to evaluate the reliability and validity of the constructs derived from the GETAMEL framework. Confirmatory Factor Analysis (CFA) was utilized to examine the relationships between observed variables and their underlying latent constructs. Key fit indices were analyzed to determine the adequacy of the model, and the results demonstrated a strong model fit, with indicators meeting or exceeding established thresholds. For example:

- χ^2/df ratio was below 3, indicating an acceptable fit.
- Goodness-of-fit index (GFI), Comparative fit index (CFI), Tucker-Lewis Index (TLI), and Incremental Fit Index (IFI) all exceeded 0.90.
- Root mean square error of approximation (RMSEA) and standardized root mean residual (SRMR) were within acceptable limits, indicating minimal discrepancies between the hypothesized model and the observed data.

TABLE 2 Reliability and validity metrics for eye-tracking adoption constructs.

Constructs and statements	Mean	Standard deviation	Factor loadings	Cronbach Alpha	AVE	CR
Perceived ease of use (PEOU)				0.84	0.71	0.88
PEOU 1	3.32	1.08	0.82			
PEOU 2	3.10	1.12	0.84			
PEOU 3	3.18	1.05	0.86			
Perceived usefulness (PU)				0.83	0.66	0.85
PU 1	3.05	1.09	0.80			
PU 2	3.21	1.02	0.81			
PU 3	3.14	1.04	0.82			
Perceived enjoyment (PE)				0.85	0.73	0.89
PE 1	3.12	1.06	0.87			
PE 2	3.09	1.08	0.86			
PE 3	3.20	1.04	0.84			
Anxiety (ANX)				0.88	0.67	0.86
ANX 1	3.30	1.07	0.81			
ANX 2	3.25	1.09	0.83			
ANX 3	3.15	1.03	0.82			
Experience (EXP)				0.89	0.77	0.91
EXP 1	3.11	1.03	0.88			
EXP 2	3.09	1.07	0.89			
EXP 3	3.17	1.02	0.87			
Self-efficacy (SE)				0.90	0.62	0.83
SE 1	3.20	1.08	0.79			
SE 2	3.15	1.06	0.77			
SE 3	3.23	1.04	0.80			
Attitude (ATT)				0.86	0.61	0.82
ATT 1	3.34	1.08	0.78			
ATT 2	3.29	1.11	0.79			
ATT 3	3.40	1.06	0.77			
Subjective norm (SN)				0.87	0.65	0.79
SN 1	3.14	1.10	0.81			
SN 2	3.08	1.09	0.80			
Intention (INT)				0.91	0.69	0.87
INT 1	3.22	1.08	0.82			
INT 2	3.30	1.05	0.83			
INT 3	3.28	1.04	0.84			

To ensure validity, the average variance extracted (AVE) values were assessed, and all exceeded the recommended threshold of 0.50, indicating sufficient convergent validity. Additionally, the square root of AVE for each construct was higher than its correlations with other constructs, providing evidence of strong discriminant validity. Factor loadings for all items were above 0.40, further affirming the robustness of the measurement items. Reliability was rigorously evaluated using composite reliability (CR) and Cronbach's Alpha. Cronbach's Alpha values ranged from 0.83 to 0.91, while composite reliability scores fell between 0.79 and 0.91, underscoring the high internal consistency of the constructs. Together, these results highlight the strength and reliability of the instrument. A comprehensive summary of the validity and reliability analyses is provided in Tables 2, 3.

Following the validation of the measurement model, the structural model was analyzed to test the relationships between

TABLE 3 Construct correlation matrix and discriminant validity.

Constructs	1	2	3	4	5	6	7	8	9
1. PEOU	-								
2. PU	0.68	-							
3. PE	0.55	0.51	-						
4. ANX	0.50	0.48	0.47	-					
5. EXP	0.31	0.33	0.42	0.48	-				
6. SE	0.35	0.30	0.26	0.25	0.40	-			
7. ATT	0.37	0.39	0.28	0.60	0.25	0.35	-		
8. SN	0.25	0.28	0.31	0.46	0.50	0.41	0.53	-	
9. INT	0.40	0.43	0.38	0.26	0.25	0.48	0.57	0.62	-
$\sqrt{}$AVE	0.84	0.81	0.85	0.82	0.88	0.79	0.78	0.81	0.83

$p < 0.01$.
PEOU, perceived ease of use; PU, perceived usefulness; PE, perceived enjoyment; ANX, anxiety; EXP, experience; SE, self-efficacy; ATT, attitude; SN, subjective norm; INT, intention; $\sqrt{}$AVE, square root of average variance extracted.

constructs within the GETAMEL framework. Maximum likelihood estimation was employed to estimate the path coefficients and evaluate the strength and direction of the relationships.

4 Results

4.1 Structural model analysis

Following the validation of the measurement model through CFA, a path analysis was performed to evaluate the structural model fit of the GETAMEL framework in the context of science teachers' adoption of eye-tracking technology. The analysis revealed that the model fit indices were within acceptable ranges, supporting the adequacy of the structural model. The results indicated $\chi^2/df = 2.78$, GFI = 0.91, IFI = 0.92, TLI = 0.90, CFI = 0.92, RMSEA = 0.04, and SRMR = 0.04, all of which meet established thresholds for acceptable model fit.

The structural model demonstrated moderate explanatory power, with an R^2 value of 0.48, indicating that 48% of the variance in science teachers' behavioral intentions to adopt eye-tracking technology could be explained by the constructs within the GETAMEL framework. These findings highlight the model's effectiveness in capturing the relationships between perceived ease of use, perceived usefulness, and other external factors in this context. The detailed fit indices are presented in Table 4.

TABLE 4 Fit indices of the structural model.

Fit indices	Model fit indices
χ^2	489.12
df	176
χ^2/df	2.78
GFI	0.91
IFI	0.92
TLI	0.90
CFI	0.92
RMSEA	0.04
SRMR	0.04
R^2	0.48

Adapted thresholds based on guidelines from Hair et al. (2018), Hu and Bentler (1999), and Kline (2005).

4.2 Hypothesis testing

The structural model was evaluated using the maximum likelihood estimation method to test the relationships within the GETAMEL framework. The analysis revealed that subjective norm ($\beta = 0.31$, $t = 6.85$), experience ($\beta = 0.27$, $t = 5.20$), perceived enjoyment ($\beta = 0.34$, $t = 6.12$), anxiety ($\beta = 0.40$, $t = 8.75$), and self-efficacy ($\beta = 0.39$, $t = 7.92$) significantly influenced perceived usefulness, collectively explaining 38% of the variance in this construct.

Furthermore, subjective norm ($\beta = 0.47$, $t = 9.32$), experience ($\beta = 0.33$, $t = 6.78$), perceived enjoyment ($\beta = 0.50$, $t = 11.85$), anxiety ($\beta = 0.42$, $t = 8.25$), and self-efficacy ($\beta = 0.43$, $t = 8.64$) were found to have significant effects on perceived ease of use, accounting for 43% of the total variance.

Regarding the constructs within the original TAM, perceived ease of use demonstrated a significant positive impact on perceived usefulness ($\beta = 0.25$, $t = 5.12$) and attitude toward using eye-tracking technology ($\beta = 0.41$, $t = 8.47$).

Additionally, perceived usefulness exhibited strong associations with attitude ($\beta = 0.47$, $t = 10.21$) and intention to use eye-tracking technology ($\beta = 0.46$, $t = 9.14$). Perceived ease of use and perceived usefulness together explained 48% of the variance in attitude. Finally, attitude toward using eye-tracking technology significantly predicted behavioral intention ($\beta = 0.49$, $t = 10.73$). Approximately 52% of the total variance in intention to use eye-tracking technology was explained by attitude and perceived usefulness. The detailed results are summarized in Table 5 and visualized in Figure 2.

TABLE 5 Path analysis results in the context of the GETAMEL framework.

Hypothesis number	Path	Standardized coefficients (β)	t-value	Hypothesis status
H1	SN → PU	0.31*	6.85	Accepted
H2	SN → PEOU	0.47**	9.32	Accepted
H3	EXP → PU	0.27*	5.20	Accepted
H4	EXP → PEOU	0.33*	6.78	Accepted
H5	PE → PU	0.34*	6.12	Accepted
H6	PE → PEOU	0.50**	11.85	Accepted
H7	ANX → PU	0.40**	8.75	Accepted
H8	ANX → PEOU	0.42*	8.25	Accepted
H9	SE → PU	0.39*	7.92	Accepted
H10	SE → PEOU	0.43**	8.64	Accepted
H11	PEOU → PU	0.25*	5.12	Accepted
H12	PEOU → ATT	0.41**	8.47	Accepted
H13	PU → ATT	0.47**	10.21	Accepted
H14	PU → INT	0.46**	9.14	Accepted
H15	ATT → INT	0.49**	10.73	Accepted

*$p < 0.05$.
**$p < 0.01$.
PU, perceived usefulness; PEOU, perceived ease of use; PE, perceived enjoyment; ANX, anxiety; SE, self-efficacy; SN, subjective norm; ATT, attitude; INT, intention.

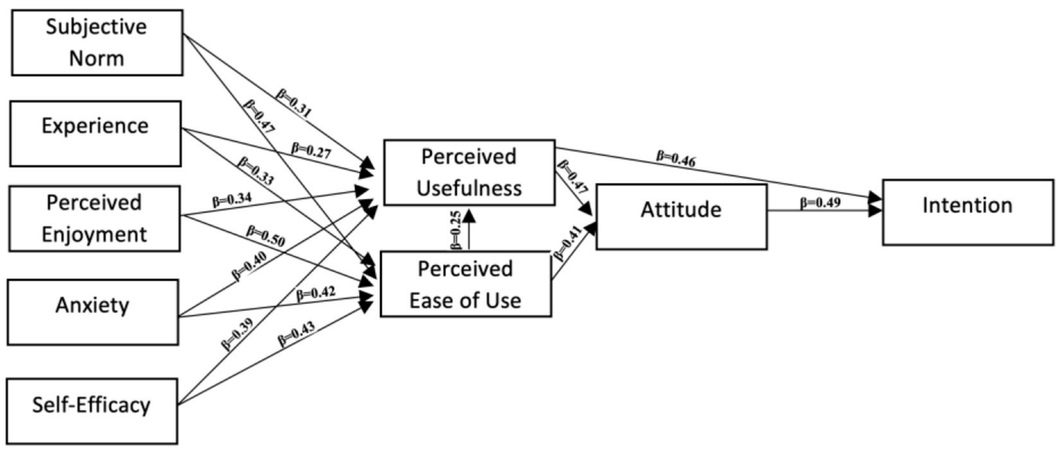

FIGURE 2
Structural model results for adoption of eye-tracking technology using the GETAMEL framework, showing standardized path coefficients and hypothesis testing outcomes.

5 Discussion

5.1 Summary of results

This study examined the factors influencing science teachers' intention to adopt eye-tracking technology through the GETAMEL framework. The findings support the framework's explanatory power, highlighting the roles of subjective norm, perceived enjoyment, experience, self-efficacy, and anxiety in shaping teachers' perceptions of usefulness and ease of use. These perceptions, in turn, influenced attitudes and behavioral intentions. The results emphasize that both emotional and contextual factors are central to understanding how teachers engage with emerging technologies in science education.

5.2 Theoretical implications

The findings of this study contribute significantly to the theoretical understanding of technology adoption in education, particularly in the context of science teachers' use of eye-tracking technology. By applying the GETAMEL framework, this research advances theoretical knowledge in several ways, while also drawing meaningful comparisons to prior studies and existing theories.

This study extends the application of the GETAMEL framework to the adoption of eye-tracking technology, a specialized tool in science education. Consistent with previous research by Ateş et al. (2024), Ateş and Gündüzalp (2025), and Abdullah et al. (2016), the model accounted for significant variance across key constructs, confirming its empirical validity in this educational setting. However, this study differs by emphasizing emotional and psychological factors specific to teachers' contexts, which are less examined in prior applications of GETAMEL. This validates the adaptability of the framework while enriching its theoretical depth.

By incorporating constructs, this study extends the foundational TAM (Davis, 1989) into the educational domain. While previous studies (e.g., Köroglu, 2024) have highlighted the significance of perceived ease of use and perceived usefulness, this research emphasizes the additional influence of social and emotional dynamics. The results align with findings by Ateş and Garzón (2022) and Sakir (2024), which also underscored subjective norms and perceived enjoyment as key drivers of technology adoption among educators. However, this study uniquely contextualizes these influences within science education and emerging tools like eye-tracking technology.

The strong effects of perceived enjoyment and subjective norm resonate with the works of Thompson et al. (2024), who identified these factors as critical for user engagement. In contrast to studies that predominantly focus on technical usability (e.g., Venkatesh et al., 2003), this research shows how positive emotional experiences and peer influence significantly shape attitudes and behavioral intentions among teachers. This suggests that fostering enjoyable, engaging interactions with technology and leveraging social support networks can drive adoption, a finding of both theoretical and practical significance.

Anxiety's negative impact on perceived usefulness and perceived ease of use, as observed in this study, aligns with Zhai and Ma (2022), emphasizing the need to address apprehensions about unfamiliar technologies. Similarly, Bandura's (1978) theory of self-efficacy is supported by findings that confidence in one's abilities positively influences adoption. This study contributes by demonstrating how targeted interventions—such as professional development and hands-on workshops—can enhance self-efficacy, mitigate anxiety, and ultimately facilitate the integration of advanced tools like eye-tracking.

The study highlights its relevance for analyzing how pedagogical and situational variables influence teachers' adoption readiness. Unlike earlier research on traditional e-learning tools (e.g., Sharma et al., 2024), this study emphasizes the complexities of adopting emerging technologies in pedagogical contexts, offering a deeper understanding of teacher-centered adoption processes in science education.

The results of this study align with previous works that validate the predictive power of constructs in shaping behavioral intentions (e.g., Kapoor and Sohi, 2024; Simşek and Ateş, 2022). However, this research advances the literature by highlighting the interplay of external factors, particularly subjective norms and emotional responses, which were not as prominently featured in earlier studies. This research extends GETAMEL to an emerging technological domain—eye-tracking—offering new insight into science teachers' decision-making processes in adopting classroom innovations.

While the GETAMEL framework offered a robust lens for explaining the adoption of eye-tracking technology among science teachers, future studies may benefit from a comparative or integrative approach involving alternative theoretical models. For instance, compared to UTAUT, which emphasizes external enablers, GETAMEL focuses more heavily on emotional and psychological constructs that proved especially relevant in the teaching context. Meanwhile, TPACK offers a pedagogically grounded model that highlights how teachers integrate technological tools into discipline-specific instructional practices. While GETAMEL captures adoption intent, it does not directly account for pedagogical content knowledge, a key dimension in actual classroom integration. Furthermore, the Diffusion of Innovation (DoI) theory introduces valuable system-level constructs—such as relative advantage, compatibility, and observability—that can explain how innovations like eye-tracking spread within educational communities. Incorporating these complementary frameworks may enrich future analyses by revealing how individual beliefs, pedagogical demands, and institutional conditions interact to shape technology adoption. Such a comparative theoretical approach could contribute to a more comprehensive and nuanced understanding of how emerging tools are evaluated, accepted, and implemented by educators.

5.3 Practical implications

The findings of this study offer valuable insights for educators, administrators, policymakers, and technology developers aiming to facilitate the integration of eye-tracking technology into science education. The significant role of perceived ease of use and self-efficacy highlights the need for targeted teacher training and professional development programs. Workshops and hands-on practice sessions can help build confidence and familiarity with the technology, while guided practice can reduce apprehensions and enhance perceived ease of use. Training should also emphasize the practical applications of eye-tracking technology to demonstrate its utility in science education.

Given that teacher anxiety was a significant negative predictor of adoption, professional development programs should not only focus on technical skill-building but also address ethical concerns associated with the use of eye-tracking technology in educational contexts. Teachers may be apprehensive about data privacy, especially when working with minors in K—12 settings. Therefore, training should include clear guidelines on obtaining informed consent, managing data confidentiality, and understanding institutional policies on ethical technology use. Equipping teachers with knowledge of legal frameworks (e.g., GDPR or national student privacy laws) and best practices for ethical implementation may reduce anxiety and foster confidence. These safeguards are especially critical for sensitive technologies like eye-tracking, which collect fine-grained behavioral data that may be perceived as intrusive. Embedding ethical awareness into training not only supports teacher readiness but also promotes responsible integration of emerging technologies in educational environments.

Creating collaborative environments where teachers can share experiences and learn from peers is equally important. Peer mentorship and professional learning communities can normalize the use of innovative tools and promote broader adoption. To address emotional barriers, resources like clear instructional guides and troubleshooting support should be made available. Encouraging a culture of experimentation and removing the stigma of failure can further motivate teachers to explore the potential of eye-tracking technology.

The study underscores the importance of designing engaging and interactive interfaces for eye-tracking tools. Enjoyable user experiences can foster positive attitudes and enhance adoption. Technology developers should consider incorporating features that make the tools not only functional but also enjoyable to use. Sharing case studies and success stories can provide evidence of the tangible benefits of eye-tracking technology, helping align teachers' perceived usefulness of the tool with its practical impact on teaching effectiveness and student outcomes.

Tailored interventions are essential to address the diverse needs of science teachers. Differentiated training can cater to both novice and experienced users, ensuring that all educators feel equipped to adopt the technology. Policymakers and administrators should also ensure the availability of necessary infrastructure and support systems. Investments in affordable and scalable devices can help address resource disparities, and incentives such as funding and recognition can encourage technology adoption.

To ensure relevance, the integration of eye-tracking technology should align with curriculum goals in science education. Collaboration between educators, curriculum designers, and technology developers can help create tools that meet specific instructional needs, such as enhancing student engagement and understanding of complex concepts. These efforts collectively provide a roadmap for the successful implementation of eye-tracking technology in science education, supporting teachers in adopting innovative tools and improving teaching practices and student outcomes.

6 Conclusions

This study provides a consolidated perspective on the psychological and contextual factors influencing science teachers' adoption of eye-tracking technology. By applying the GETAMEL framework, it confirms the central role of usability perceptions and social-emotional constructs in shaping attitudes and intentions. The findings reinforce the importance of fostering teachers' confidence and reducing anxiety through targeted training and support. GETAMEL's applicability to an emerging instructional tool such as eye-tracking further enriches our understanding of technology adoption in education. These insights underscore the value of designing both pedagogically relevant and emotionally supportive implementation strategies to ensure successful classroom integration.

6.1 Limitations and future lines of research

While this study provides valuable insights, several limitations offer opportunities for future research. The sample, though diverse in geographic and demographic representation, primarily included participants from urban and suburban settings, potentially limiting its generalizability to rural areas. Expanding the scope of future studies to include educators from rural schools could reveal contextual differences in technology adoption.

This study employed a cross-sectional design, which restricts the ability to assess causal relationships over time. Longitudinal studies are recommended to track changes in teachers' attitudes, intentions, and actual usage of eye-tracking technology. Such studies could provide richer insights into the long-term effects of interventions aimed at promoting technology integration.

The research focused on teacher-related factors influencing the adoption of eye-tracking technology. However, successful classroom integration also depends on student engagement, institutional support, and technological infrastructure. Future studies could take a holistic approach by including these dimensions to gain a more comprehensive understanding of the adoption process.

The reliance on self-reported data may have introduced social desirability bias or inaccuracies. Future research could incorporate observational methods, classroom experiments, or data from eye-tracking systems to validate and complement self-reported findings. While this study centered on science education, eye-tracking technology has potential applications in other disciplines, such as mathematics, language learning, and special education. Examining adoption patterns across different domains could identify discipline-specific factors that influence technology acceptance.

Although the GETAMEL framework proved effective in capturing psychological, emotional, and contextual determinants of science teachers' adoption of eye-tracking technology, future research would benefit from a comparative theoretical perspective to enhance interpretive depth. For instance, compared to UTAUT, which emphasizes external, system-related factors, GETAMEL places greater emphasis on individual cognitive and emotional variables. This distinction suggests that combining the two could provide a fuller picture encompassing both internal motivation and external constraints. Likewise, while GETAMEL effectively explains behavioral intention, it lacks the pedagogical specificity of frameworks like TPACK, which could help investigate how teachers integrate eye-tracking tools within subject-specific instructional practices. In contrast, diffusion of innovation (DoI) theory offers a broader sociological lens focused on how innovations spread within networks, potentially complementing GETAMEL's focus on individual-level determinants with insights into organizational and cultural adoption dynamics. Additionally, models such as Protection Motivation Theory (PMT) may enrich the framework by incorporating constructs like perceived risk and coping efficacy, which are particularly relevant when investigating novel or technically complex technologies. A comparative or integrative approach using these frameworks may help future researchers account for both individual readiness and systemic influences, ultimately supporting more robust explanatory models of technology adoption. Furthermore, emerging technological advancements—such as real-time analytics or immersive feedback systems—warrant future investigation, as they may interact differently with the constructs emphasized by each theoretical model.

Finally, as this study was conducted within the cultural, institutional, and policy context of Türkiye, the findings may reflect specific characteristics of the Turkish education system—such as centralized curriculum structures, examination-driven instructional environments, and the role of governmental technology initiatives. These factors may influence science teachers' perceptions and adoption behaviors differently compared to those in more decentralized or autonomy-oriented educational systems. For instance, teacher autonomy, institutional innovation culture, and national-level digital infrastructure may vary across countries, shaping the relevance and transferability of our findings. Future studies are encouraged to examine the adoption of eye-tracking technology in diverse international contexts to explore how cultural values, professional norms, institutional governance, and policy frameworks interact with technology acceptance. Such comparative research could yield deeper insights into both universal and context-specific dynamics of educational technology integration.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving humans were approved by Nevşehir Haci Bektaş Veli University Scientific Research and Publication Ethics Committee. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

AÖ: Validation, Data curation, Conceptualization, Methodology, Project administration, Supervision, Investigation, Writing – original draft, Resources, Funding acquisition, Writing – review & editing, Visualization, Software, Formal analysis.

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The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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The author(s) declare that no Gen AI was used in the creation of this manuscript.

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