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Acceptance and Engagement in Artificial Intelligence–Supported Reading Among Primary School Learners of English as a Foreign Language

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ABSTRACT

Artificial intelligence (AI) is increasingly used to support language learning, yet little is known about how younger learners accept and engage with AI-assisted reading. This study investigates primary school students' acceptance of and engagement with an AI-supported adaptive reading application for English as a Foreign Language (EFL). Guided by the Motivational Technology Acceptance and Engagement Model (MTAEM), which integrates the Technology Acceptance Model and Self-Determination Theory, the study examines how psychological needs shape technology acceptance and learner engagement. Data were collected from 631 pupils in China through structured questionnaires after using an AI reading app that provides personalised text recommendations and automated feedback during reading activities. Structural equation modelling showed that autonomy, competence, and relatedness support predicted psychological needs satisfaction, which in turn influenced perceived ease of use, perceived usefulness, and behavioural intention. Acceptance constructs also contributed to behavioural, emotional, cognitive, and agentic engagement. The findings highlight the importance of motivationally supportive AI design for fostering young learners' engagement in EFL reading.

1 | Introduction

Artificial intelligence (AI) is increasingly being used in education and is creating new possibilities for personalised and adaptive language learning (Adiguzel et al. 2023; Zou et al. 2024). In English as a Foreign Language (EFL) contexts, AI-supported tools can offer responsive support and interactive learning experiences (J. Jeon 2024; Al-kfairy 2024). However, their educational value depends not only on what they can do technically, but also on how learners accept and engage with them.

This issue is particularly important in reading. Reading is central to language development and academic success, especially for younger learners who are still building foundational literacy skills (E. H. Jeon and Yamashita 2014). In primary education, effective use of AI for reading may depend on whether pupils feel supported, capable, and willing to continue using the technology (Dignath et al. 2008; Sankalaite et al. 2021).

To address this issue, this study examines Chinese primary school pupils' acceptance of and engagement with an AI-supported reading application for EFL learning. Drawing on the Technology Acceptance Model (TAM) and Self-Determination Theory (SDT), it proposes the Motivational Technology Acceptance and Engagement Model (MTAEM) to explain how support, psychological needs, acceptance and engagement are related in AI-assisted reading (Davis and Granić 2024; Deci and Ryan 2000; Ryan and Deci 2018). The study addresses the following research questions:

1. How do autonomy, competence, and relatedness support shape pupils' psychological needs in AI-assisted reading?
2. How do psychological needs influence acceptance of AI reading tools, including perceived ease of use, perceived usefulness, and behavioural intention?
3. In what ways do psychological needs and acceptance contribute to behavioural, emotional, cognitive, and agentic engagement?
4. Does acceptance serve as a pathway through which psychological needs translate into sustained engagement with AI for reading?

2 | Literature Review and Hypothesis Development

2.1 | AI for EFL Reading Practice

Artificial intelligence (AI) has become an important force in education, particularly in language learning (Adiguzel et al. 2023; C. Du et al. 2025). AI systems support reading practice through adaptive platforms, intelligent tutoring systems, and conversational agents (J. Du and Daniel 2024; Zou et al. 2024). These systems personalise instruction by adjusting text difficulty, offering vocabulary and comprehension scaffolds, and providing immediate feedback (J. Jeon 2024; Wang et al. 2025). They also sustain motivation through interactive features, such as gamification and personalised recommendations (Al-kfairy 2024). Such affordances make AI especially relevant for reading, where learners often struggle with comprehension and sustained engagement.

Although research on AI in language education has expanded, most studies emphasise speaking (e.g., Wang et al. 2024; Zou et al. 2023, Zou et al. 2024), writing (e.g., Barrot 2023; Guo and Wang 2024; Koltovskaia et al. 2024) or vocabulary (e.g., Bashori et al. 2021; Yang 2025) rather than reading. This gap is notable given the well-established importance of reading comprehension for second language development and academic success (E. H. Jeon and Yamashita 2014). Moreover, much of the existing research on AI-assisted language learning has focused on university students, who typically possess greater digital literacy and learning autonomy (J. Du and Daniel 2024). By contrast, relatively little attention has been given to primary school learners, even though this stage is critical for the development of reading habits and foundational literacy skills. Investigating younger learners is therefore important for understanding how AI systems can support early reading development in EFL contexts (Dignath et al. 2008; Sankalaite et al. 2021). Finally, most prior studies treat acceptance and engagement as separate concerns (e.g., Cai et al. 2024; X. Wu et al. 2025). Few have examined how learners' acceptance of AI contributes to meaningful and sustained engagement in reading practice. This is particularly important for younger learners, for whom motivation and support are critical to maintaining participation and building reading skills (Taylor et al. 2006).

Taken together, these observations point to the need for research that examines how primary school students accept and engage with AI for reading, within a framework that highlights the role of support in shaping both technology acceptance and learner engagement.

2.2 | The Conceptual Model

This study proposes the MTAEM (see Figure 1), which integrates insights from the TAM (Davis and Granić 2024) and SDT (Deci and Ryan 2000) to explain how learners adopt and engage with AI-assisted reading.

The model begins with support, which strengthens learners' psychological needs for autonomy, competence, and relatedness. In line with SDT (Deci and Ryan 2000), supportive learning environments foster the satisfaction of these needs, which in turn influence learners' motivation and learning behaviours. When these needs are satisfied, they influence both acceptance and engagement. In terms of acceptance, perceived autonomy, competence and relatedness shape learners' perceptions of AI's ease of use and usefulness, which subsequently affect their behavioural intention to use the technology. In terms of engagement, psychological needs are also expected to predict behavioural, cognitive, emotional and agentic involvement in learning activities.

Acceptance itself further contributes to engagement. Drawing on the TAM (Davis and Granić 2024), perceived ease of use and perceived usefulness, together with behavioural intention, are expected to influence the depth and quality of students' participation. Thus, acceptance is not only an outcome of psychological needs but also a pathway through which engagement is sustained.

By linking support, psychological needs, acceptance and engagement, the MTAEM provides a comprehensive framework for examining how primary school students interact with AI in EFL reading tasks.

2.3 | Support and Psychological Needs

SDT argues that the satisfaction of autonomy, competence and relatedness is central to sustaining motivation and high-quality learning (Deci and Ryan 1996). In AI-assisted EFL reading, these needs are shaped by the extent to which learners perceive support from the system or learning environment.

Autonomy support refers to experiences of choice and volition (Adams et al. 2017). Studies show that autonomy-supportive environments enhance intrinsic motivation and persistence (Ma 2021). In AI reading tools, options such as text selection or pacing can nurture learners' sense of agency, which is especially important for primary students who often experience limited choice in traditional classrooms (Reeve et al. 2004; Shen et al. 2009).

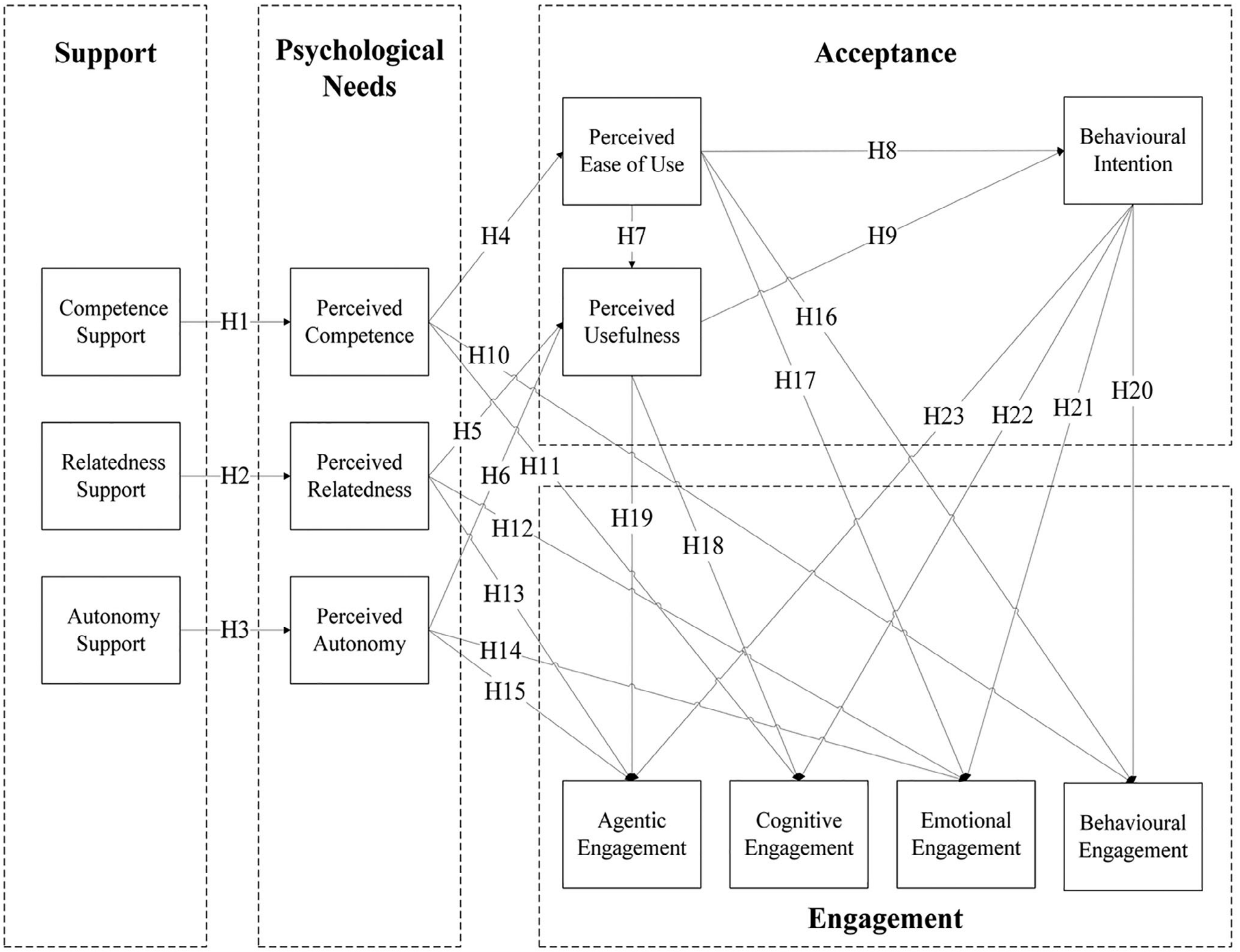

FIGURE 1 | The conceptual model.

Competence support concerns scaffolding and feedback that help learners feel capable of success (Ryan and Deci 2018). Prior research demonstrates that competence support enhances motivation and persistence by preventing feelings of failure (Kiemer et al. 2018). AI systems are well placed to provide this support through adaptive feedback and tailored tasks that match developing reading skills (Li et al. 2025).

Relatedness support reflects learners' sense of connection with others (Deci and Ryan 2000). Evidence suggests that relatedness strengthens positive emotions and motivation to participate (Klassen et al. 2012; Sparks et al. 2016). In AI contexts, conversational agents or collaborative features can simulate social presence and foster belonging (Li et al. 2025). Accordingly, this study hypothesises that:

Hypothesis 1. *Autonomy support positively predicts perceived autonomy.*

Hypothesis 2. *Relatedness support positively predicts perceived relatedness.*

Hypothesis 3. *Competence support positively predicts perceived competence.*

2.4 | Psychological Needs and Technology Acceptance Variables

While the TAM highlights perceived usefulness, ease of use, and behavioural intention as key determinants of adoption (Davis and Granić 2024), SDT suggests that these perceptions are shaped by the satisfaction of autonomy, competence, and relatedness (Adams et al. 2017). Learners who feel competent, autonomous and connected are more likely to evaluate technologies positively and intend to continue using them (Chiu 2021).

Perceived competence has been consistently linked to perceived ease of use. Learners who feel capable of managing learning tasks tend to find technology less burdensome (Xia et al. 2025). Empirical studies confirm this relationship, showing that higher competence perceptions reduce technology-related anxiety and increase perceived ease of use (Fathali and Okada 2018; Racero et al. 2020).

Perceived relatedness supports positive evaluations of usefulness. When learners feel connected and supported, they are more likely to value technology as a tool that enhances collaboration and communication (Linares et al. 2021). Evidence from online and blended learning shows that social presence and relatedness support strengthen perceptions of usefulness and satisfaction (Chiu 2021).

Perceived autonomy has also been linked to perceived usefulness. When students experience meaningful choice and control, they are more likely to see technology as beneficial and relevant to their learning (Xia et al. 2025). Research in language learning confirms that autonomy-supportive features, such as personalised pathways, improve students' perceptions of usefulness (Linares et al. 2021).

Finally, according to the TAM (Davis and Granić 2024), when a system is perceived as easy to use, users are more likely to see it as useful and to develop stronger intentions to use it. Likewise, perceived usefulness directly enhances behavioural intention, as individuals are more inclined to adopt a system they believe improves their performance.

Hypothesis 4. *Perceived competence positively predicts perceived ease of use.*

Hypothesis 5. *Perceived relatedness positively predicts perceived usefulness.*

Hypothesis 6. *Perceived autonomy positively predicts perceived usefulness.*

Hypothesis 7. *Perceived ease of use positively predicts perceived usefulness.*

Hypothesis 8. *Perceived ease of use positively predicts behavioural intention.*

Hypothesis 9. *Perceived usefulness positively predicts behavioural intention.*

2.5 | Psychological Needs and Engagement

SDT positions the satisfaction of autonomy, competence and relatedness as central to sustaining learners' engagement (Reeve 2012; Ryan and Deci 2018). Engagement itself is multidimensional, encompassing behavioural, cognitive, emotional and agentic involvement (Reeve 2012). When learners' psychological needs are met, they are more likely to participate actively, think deeply, experience positive emotions, and contribute proactively to learning.

Perceived competence supports both behavioural and cognitive engagement. Learners who feel capable of success are more persistent and willing to invest effort, and they employ deeper strategies for comprehension and retention (X. Wu et al. 2025). In AI-assisted reading, adaptive scaffolding and immediate feedback can strengthen competence and promote active, thoughtful engagement.

Perceived relatedness is associated with emotional and agentic engagement. A sense of belonging fosters enjoyment and reduces anxiety, while also empowering learners to voice opinions, ask questions, and shape the learning process (Chiu 2021). Features such as conversational agents or collaborative reading activities can help generate this connection.

Perceived autonomy also predicts emotional and agentic engagement. When learners feel they have meaningful choice and control, they experience greater enjoyment and satisfaction, which enhances emotional involvement, and they are more likely to take initiative in their learning (Lan and Hew 2020). Personalised or self-paced features in AI systems are well placed to foster such autonomy (An et al. 2023). Accordingly, the model hypothesises that:

Hypothesis 10. *Perceived competence positively predicts behavioural engagement.*

Hypothesis 11. *Perceived competence positively predicts cognitive engagement.*

Hypothesis 12. *Perceived relatedness positively predicts emotional engagement.*

Hypothesis 13. *Perceived relatedness positively predicts agentic engagement.*

Hypothesis 14. *Perceived autonomy positively predicts emotional engagement.*

Hypothesis 15. *Perceived autonomy positively predicts agentic engagement.*

2.6 | Technology Acceptance Variables and Engagement

Technology acceptance research traditionally examines whether learners adopt and intend to continue using a system, while engagement research explores how learners invest effort, emotion, and agency in the learning process. Studies suggest these constructs are interconnected: acceptance may shape not only adoption but also the quality of engagement (Davis and Granić 2024).

Perceived ease of use is expected to influence behavioural and emotional engagement. When learners find an AI system manageable, they are more likely to participate actively and experience enjoyment rather than frustration (Teo et al. 2018). Prior research confirms that user-friendly designs enhance both participation and positive emotions, particularly among younger learners (Teo 2011).

Perceived usefulness contributes to deeper engagement. When students see clear value in technology, they are more inclined to engage cognitively, by applying strategies and concentrating on tasks, and agentically, by taking initiative and shaping their learning (Lai et al. 2023; Zhao et al. 2024).

Behavioural intention reflects not only willingness to adopt but also commitment to continued use. Learners who intend to persist with AI-assisted reading are more likely to sustain behavioural participation, experience positive emotions, think more deeply, and act as active contributors (Davis and Granić

2024). Evidence from e-learning contexts confirms that intention to use predicts both persistence and meaningful involvement (Venkatesh et al. 2016).

Although behavioural intention and behavioural engagement are closely related, they represent distinct aspects of learners' interaction with technology. Behavioural intention refers to learners' willingness to continue using the AI system in the future (Davis and Granić 2024), whereas behavioural engagement reflects the effort and participation displayed during learning activities (Reeve 2012). Distinguishing them enables the model to capture both motivation to use the technology and actual involvement in reading tasks. Based on this reasoning, the model hypothesises that:

Hypothesis 16. *Perceived ease of use positively predicts behavioural engagement.*

Hypothesis 17. *Perceived ease of use positively predicts emotional engagement.*

Hypothesis 18. *Perceived usefulness positively predicts cognitive engagement.*

Hypothesis 19. *Perceived usefulness positively predicts agentic engagement.*

Hypothesis 20. *Behavioural intention positively predicts behavioural engagement.*

Hypothesis 21. *Behavioural intention positively predicts emotional engagement.*

Hypothesis 22. *Behavioural intention positively predicts cognitive engagement.*

Hypothesis 23. *Behavioural intention positively predicts agentic engagement.*

3 | Methods

3.1 | Participants

A total of 631 pupils from Grades 3 to 6 at a private primary school in Shenzhen, China, participated in the study. The sample consisted of 326 boys (51.7%) and 305 girls (48.3%). Participants ranged in age from 8 to 12 years, with a mean age of 9.9 years (SD = 1.2). By grade level, 150 pupils were in Grade 3 (23.8%), 160 in Grade 4 (25.4%), 162 in Grade 5 (25.7%), and 159 in Grade 6 (25.2%). All participants had prior exposure to English learning as part of the school curriculum.

Prior to data collection, pupils had been using the AI reading application as part of their regular English learning activities for a period of time during the school term. The application was used primarily in classroom settings, particularly during scheduled IT or English-related lessons, although some pupils may also have accessed it outside class. Learning with the application was largely teacher-guided, as teachers assigned reading tasks, monitored progress, and provided support when needed. This instructional context is important for interpreting pupils' perceptions of support, autonomy, and engagement.

To describe pupils' general use of the AI application, self-reported frequency and duration of use were measured on a five-point Likert scale (1 = very low, 5 = very high). The mean score for frequency of use was 3.3 (*SD* = 1.0), and the mean score for duration of use was 2.9 (SD = 0.8). These scores indicate that, on average, pupils reported a moderate level of use. As these measures were based on ordinal self-report ratings, they should be interpreted as broad indicators of perceived usage rather than precise behavioural records of actual time spent or frequency of use.

The final sample of 631 participants was considered adequate for structural equation modelling. With 48 observed indicators, the study achieved a cases-to-indicator ratio of approximately 13:1, exceeding the commonly recommended minimum of 10:1 (Kline 2016). In addition, the sample size substantially exceeds the minimum of 200 cases typically recommended for SEM and is appropriate for models with multiple latent constructs and structural paths (Hair 2019), supporting stable estimation and reliable hypothesis testing.

Ethical approval was obtained from the authors' institution. Approval to conduct the study was also granted by the school, and informed consent was obtained from both pupils and their parents or guardians. Participation was voluntary, anonymity and confidentiality were assured, and pupils were free to withdraw at any stage without consequence.

3.2 | Instruments

3.2.1 | The AI App for EFL Reading Practice

The AI reading application provided pupils with English learning resources and activities tailored to their levels and interests (Figure 2). Using AI-driven recommendations and adaptive design, the app offered a range of texts, including lower-level passages, bridge books, chapter books, fairy tales, holiday-themed picture books and magazines. Interactive features such as video animation and video dubbing provided AI-supported content delivery and feedback, aiming to increase engagement while ensuring materials were developmentally appropriate.

Teachers accessed the system through a dedicated interface that combined classroom management with AI-supported monitoring (Figure 3). Functions included managing classes, assigning tasks, tracking class hours, and reviewing individual or group performance through a data centre. AI-generated progress reports helped identify pupils' strengths and areas for improvement, while event and competition modules encouraged participation. The platform therefore, served both as a self-learning tool for pupils and a classroom management resource for teachers.

Several AI-driven functions supported personalised reading practice. Recommendation algorithms suggested materials based on pupils' proficiency and learning progress, using interaction data such as reading completion, task performance and activity preferences to adjust text difficulty and recommend appropriate

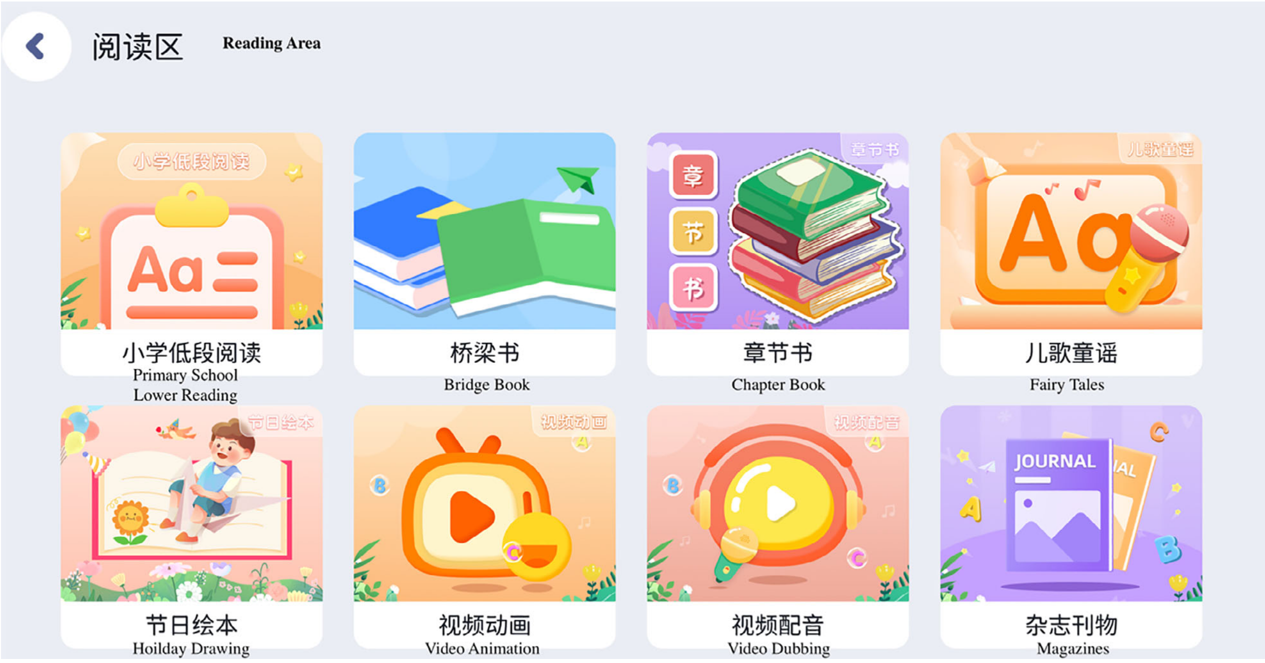

FIGURE 2 | Example student interface of the AI reading application with selected reading activities.

FIGURE 3 | Example teacher interface of the AI reading application with management and monitoring functions.

resources. The system also provided automated feedback during activities such as video dubbing and comprehension tasks, enabling immediate responses to performance. In addition, learning analytics and progress reports allowed teachers to monitor progress and identify areas needing support. These functions operated alongside conventional digital features such as multimedia content and task management to create an interactive reading environment.

Within this environment, teachers could assign reading tasks and monitor progress through the management interface. Such instructional support may shape students' experiences with the AI application. In this study, these influences were conceptualised as contextual support in the proposed model, examining how autonomy, competence, and relatedness support contribute to learners' psychological needs and subsequent acceptance and engagement with the AI reading tool.

3.2.2 | Questionnaires

A structured questionnaire was designed to assess pupils' perceptions of the AI reading application, the satisfaction of their psychological needs, and their acceptance and engagement with the tool (see Appendix A). The items were adapted from well-established scales in the fields of technology acceptance and

SDT (Cai et al. 2024; Ebadi and Raygan 2023; Sparks et al. 2016; Vansteenkiste et al. 2012; J. Wu et al. 2024; X. Wu et al. 2025), and were tailored to the context of primary school English reading practice (Y. Du 2024).

The questionnaire covered four sets of constructs. Acceptance was measured by perceived ease of use, perceived usefulness and behavioural intention, each assessed by four items. Psychological needs were measured through perceived autonomy, competence, and relatedness, each with four items. Support was captured by autonomy support, competence support and relatedness support, each represented by three items. Finally, engagement was measured across four dimensions, behavioural, emotional, cognitive and agentic, each assessed by three items.

All items were initially adapted in English and subsequently translated into Chinese. A back-translation procedure (Brislin 1970) was employed to ensure equivalence between the two versions. Only the Chinese items were presented to the pupils to guarantee clarity and age appropriateness. Because the youngest participants were eight years old, particular attention was given to simplifying the wording of questionnaire items to ensure that they were easily understood by primary school learners. A pilot test with a small group of pupils ($N = 30$) confirmed that the items were understandable and suitable for the target age group. Responses were recorded on a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree).

To reduce the potential influence of common method bias associated with self-report data, several procedural steps were implemented. The questionnaire items were adapted from established scales and simplified to ensure clarity and age appropriateness. Participation was anonymous, and pupils were informed that there were no right or wrong answers, which was intended to reduce social desirability bias. In addition, items measuring different constructs were presented in an integrated format rather than grouped by construct, thereby reducing response patterning. A Harman's single-factor test was also conducted. The results showed that the first unrotated factor accounted for 36.4% of the total variance, which is below the commonly used threshold of 50%, suggesting that common method bias was unlikely to pose a serious threat in this study.

3.3 | Procedure

The study was conducted in the spring semester of 2025 at a private primary school in Shenzhen, China. Ethical approval was obtained from the authors' institution and the school. Parents received information sheets and consent forms, and only pupils with parental consent and their own assent participated.

Data were collected during scheduled IT classes. Teachers explained the study, emphasising voluntary participation and confidentiality. To ensure consistency, the four English teachers followed standardised instructions prepared by the research team when introducing the questionnaire. Pupils completed the survey individually on classroom computers, with research assistants and teachers present only to clarify instructions. Each session lasted about 20 min.

Responses were securely stored and exported for coding and analysis. Data quality was checked following Ward and Meade (2023). Questionnaires showing inattention, such as straight-lining or unusually short completion times, were removed. Forty cases were excluded, leaving 631 valid responses (see Section 3.1 for demographics). The procedure was applied consistently across all grades to ensure reliability and comparability.

3.4 | Data Analysis

Data analysis was conducted using R (Version 4.3.3) within a structural equation modelling (SEM) framework. The analysis proceeded in two stages. First, the measurement model was evaluated by examining reliability and validity using Cronbach's alpha, composite reliability (CR), average variance extracted (AVE), the Fornell–Larcker criterion, and the heterotrait–monotrait ratio (HTMT). Model fit was assessed using χ^2/df, CFI, TLI, RMSEA and SRMR. Second, the structural model was tested to examine the hypothesised relationships among support, psychological needs, technology acceptance variables, and engagement. In the SEM analyses, latent constructs were estimated directly from their observed indicators rather than from mean or total scores. Prior to model testing, the data were screened for statistical assumptions, including normality and multicollinearity. The results of these checks are reported in Section 4.1.

4 | Results

4.1 | Assumption Check

Before conducting the SEM analysis, the data were examined for key assumptions. Normality was assessed through skewness and kurtosis values. The skewness values ranged from −0.71 to 1.02, and kurtosis values ranged from −1.35 to 1.89, all of which were within the acceptable range of ±2, indicating no serious departure from normality (Kline 2016). Multicollinearity was checked through the variance inflation factor (VIF) and tolerance values. The VIF values ranged from 1.27 to 2.84, and tolerance values ranged from 0.35 to 0.79, all within recommended thresholds, confirming that multicollinearity was not a concern (Tabachnick and Fidell 2013).

4.2 | The Measurement Model

The measurement model demonstrated strong reliability and validity. As shown in Appendix B, all standardised factor loadings were above 0.70, Cronbach's alpha and composite reliability values ranged from 0.83 to 0.92 and 0.87 to 0.95, respectively, exceeding the recommended threshold of 0.70, and average variance extracted (AVE) values ranged from 0.64 to 0.84, surpassing the 0.50 criterion, thereby confirming convergent validity (Nunnally and Bernstein 1994). Discriminant validity was established using the Fornell–Larcker criterion (see Appendix C), as the square roots of AVEs were consistently greater than their correlations with other constructs (Fornell and Larcker 1981). In addition, the heterotrait–monotrait ratio (HTMT) was examined, and the results indicated that the HTMT values were within acceptable

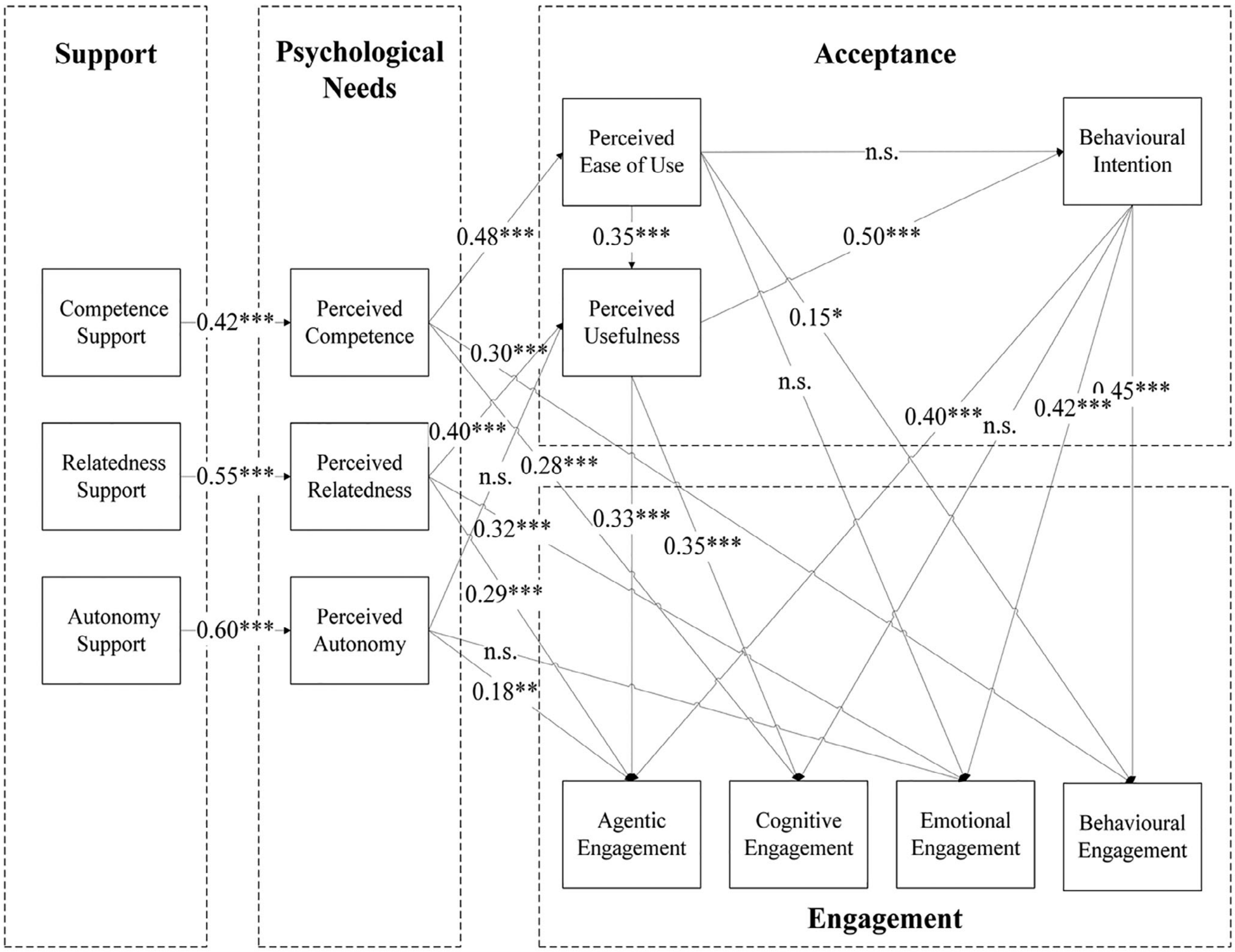

FIGURE 4 | Hypothesis testing results. *Note:* Statistical significance is denoted as *** for $p < 0.001$, ** for $p < 0.01$, * for $p < 0.05$, and n.s. for not significant.

ranges (< 0.90), further supporting discriminant validity among the constructs (see Appendix E). Model fit indices also indicated excellent fit, with chi-square divided by degrees of freedom (χ^2/df) = 2.15 (< 3), comparative fit index (CFI) = 0.94 (> 0.90), Tucker–Lewis index (TLI) = 0.93 (> 0.90), root mean square error of approximation (RMSEA) = 0.05 (≤ 0.06), and standardised root mean square residual (SRMR) = 0.04 (< 0.08), confirming that the measurement model achieved both reliability and validity (Hair 2019; Hair et al. 2019).

4.3 | The Structural Model

The structural model was tested to examine the hypothesised relationships among support, psychological needs, technology acceptance variables, and engagement. Model fit was satisfactory, χ^2/df = 2.58, CFI = 0.92, TLI = 0.94, RMSEA = 0.05, and SRMR = 0.04.

As shown in Appendix D and Figure 4, Hypotheses 1–3 were supported: autonomy support positively predicted perceived autonomy ($\beta = 0.42$, $p < 0.001$), relatedness support positively predicted perceived relatedness ($\beta = 0.55$, $p < 0.001$) and competence support positively predicted perceived competence ($\beta = 0.60$, $p < 0.001$).

For the technology acceptance variables, Hypotheses 4, 5, 7, and 9 were supported. Perceived competence positively predicted perceived ease of use ($\beta = 0.48$, $p < 0.001$). Perceived relatedness ($\beta = 0.40$, $p < 0.001$) and perceived ease of use ($\beta = 0.35$, $p < 0.001$) positively predicted perceived usefulness. Perceived usefulness also positively predicted behavioural intention ($\beta = 0.50$, $p < 0.001$). However, Hypotheses 6 and 8 were not supported, as perceived autonomy did not significantly predict perceived usefulness ($\beta = 0.08$, $p = 0.263$), and perceived ease of use did not significantly predict behavioural intention ($\beta = 0.10$, $p = 0.101$).

For engagement, Hypotheses 10–13 and 15 were supported. Perceived competence positively predicted behavioural engagement ($\beta = 0.30$, $p < 0.001$) and cognitive engagement ($\beta = 0.28$, $p < 0.001$). Perceived relatedness positively predicted emotional engagement ($\beta = 0.32$, $p < 0.001$) and agentic engagement ($\beta = 0.29$, $p < 0.001$). Perceived autonomy positively predicted agentic engagement ($\beta = 0.18$, $p = 0.011$), supporting Hypothesis 15, but did not significantly predict emotional engagement ($\beta = 0.09$, $p = 0.190$); thus, Hypothesis 14 was not supported.

Among the technology acceptance variables, Hypotheses 16, 18 and 19 were supported. Perceived ease of use positively predicted behavioural engagement ($\beta = 0.15$, $p = 0.014$), while perceived usefulness positively predicted cognitive engagement ($\beta = 0.35$, $p < 0.001$) and agentic engagement ($\beta = 0.33$, $p < 0.001$). Hypothesis 17 was not supported, as perceived ease of use did not significantly predict emotional engagement ($\beta = 0.05$, $p = 0.384$).

Finally, behavioural intention positively predicted behavioural engagement ($\beta = 0.45$, $p < 0.001$), emotional engagement ($\beta = 0.42$, $p < 0.001$), and agentic engagement ($\beta = 0.40$, $p < 0.001$), supporting Hypotheses 20, 21 and 23. Hypothesis 22 was not supported, as behavioural intention did not significantly predict cognitive engagement ($\beta = 0.12$, $p = 0.093$).

5 | Discussion

5.1 | Support and the Satisfaction of Psychological Needs

The study shows that support plays a central role in nurturing learners' psychological needs, consistent with the core claims of SDT (Deci and Ryan 1996, 2000). Autonomy, competence and relatedness support each strengthened the corresponding psychological needs, confirming that supportive environments are fundamental to motivation and learning (Adams et al. 2017; Ryan and Deci 2018).

Competence support was particularly important for primary school learners. As children are still developing literacy skills, they can easily become discouraged by difficulty. Research shows that scaffolding and constructive feedback reduce feelings of failure and sustain motivation (Dignath et al. 2008; Kiemer et al. 2018). By adapting tasks and providing encouragement, AI reading tools can foster capability and resilience, strengthening engagement.

Relatedness support also contributed strongly, highlighting the importance of social presence in AI-assisted learning. When learners feel connected and supported, they experience more positive emotions and participate more actively (Klassen et al. 2012; Sparks et al. 2016; Chiu 2021). Conversational agents or collaborative activities can help create this sense of connection in digital reading environments.

Autonomy support showed a more modest but still significant influence by enabling learners to experience choice and agency. Autonomy-supportive contexts are known to enhance intrinsic motivation and persistence (Reeve et al. 2004; Ma 2021). As primary classrooms often offer limited decision-making opportunities (Shen et al. 2009), AI reading applications that allow pupils to select texts or control pacing may help cultivate autonomy.

5.2 | Psychological Needs and Technology Acceptance

The results show that fulfilment of psychological needs is closely linked to students' acceptance of AI-assisted reading. This extends the TAM (Davis and Granić 2024) by indicating that perceptions of ease of use, usefulness, and behavioural intention are shaped not only by technological features but also by whether learners feel competent, autonomous, and socially connected. This is consistent with SDT, which emphasises that motivation and technology-related behaviours depend on the satisfaction of basic psychological needs (Deci and Ryan 2000; Adams et al. 2017).

Perceived competence significantly influenced perceptions of ease of use. When pupils feel capable of completing reading tasks, they are less likely to see the technology as difficult. Prior research likewise shows that stronger competence beliefs reduce technology-related anxiety and lead learners to evaluate digital tools as easier to use (Fathali and Okada 2018; Xia et al. 2025). Adaptive scaffolding, immediate feedback, and levelled reading materials may therefore help younger learners form positive evaluations of AI reading systems.

Perceived relatedness also strengthened perceptions of usefulness. When students feel supported and connected, they are more likely to view digital tools as valuable for learning. Studies similarly show that social presence and supportive environments enhance learners' evaluations of educational technologies (Chiu 2021; Linares et al. 2021). In AI-assisted reading, features, such as interactive activities, conversational agents, or teacher mediation may reinforce this sense of connection.

However, some hypothesised relationships were not supported. Perceived autonomy did not significantly predict perceived usefulness, and perceived ease of use did not significantly predict behavioural intention. These results may reflect the developmental context of primary learners, whose technology use is often guided by teachers and structured classroom activities rather than independent evaluation (Dignath et al. 2008; Sankalaite et al. 2021). Consequently, autonomy may play a weaker role in usefulness judgments at this stage, unlike in studies of older learners (Linares et al. 2021; Xia et al. 2025). Similarly, when systems are already intuitive, ease of use may become less decisive in shaping continued intention to use (Davis and Granić 2024).

5.3 | Psychological Needs and Multidimensional Engagement

The study shows that satisfaction of psychological needs is central to fostering engagement in AI-assisted reading. This aligns with SDT, which proposes that autonomy, competence, and relatedness underpin learners' willingness to invest effort, emotion, and agency in learning (Reeve 2012; Ryan and Deci 2018). Examining behavioural, cognitive, emotional, and agentic engagement reveals that each need contributes differently to sustained participation.

Competence was particularly influential for behavioural and cognitive engagement. Learners who feel capable are more persistent and more likely to apply strategies that support deep comprehension. The results confirm that perceived competence predicted both behavioural and cognitive engagement. Prior research similarly shows that adaptive scaffolding and timely feedback enhance effort and strategy use, helping learners overcome difficulties and build confidence (X. Wu et al. 2025).

Relatedness was strongly linked to emotional and agentic engagement. When learners feel supported and connected, they experience more enjoyment and are more willing to ask questions, express opinions, and take initiative. This supports evidence that social presence promotes positive affect and active participation in technology-enhanced learning (Klassen et al. 2012; Chiu 2021). For primary students, who rely heavily on teacher and peer encouragement, this relational dimension is particularly important.

Autonomy also contributed to engagement by fostering initiative and ownership of learning. Opportunities for choice and flexible pacing encourage enjoyment and proactive participation. Previous studies show that autonomy-supportive features such as personalisation and flexible pathways strengthen emotional and agentic engagement (Lan and Hew 2020; An et al. 2023).

5.4 | Acceptance as a Potential Pathway to Engagement

The findings suggest that technology acceptance is associated not only with learners' willingness to adopt AI-assisted reading but also with the quality and depth of their engagement. This extends the traditional scope of the TAM (Davis and Granić 2024), which has often focused on behavioural intention, by indicating that technology acceptance variables may also relate to behavioural, emotional, cognitive, and agentic engagement.

Perceived ease of use was positively associated with behavioural engagement. When children experience a system as intuitive and manageable, they may be more willing to participate actively in reading tasks. Previous studies have similarly suggested that user-friendly design is linked to greater participation and lower frustration, particularly among younger learners with limited digital literacy (Teo 2011; Teo et al. 2018).

Perceived usefulness was positively associated with cognitive and agentic engagement. When pupils recognise value in the AI reading application, they may be more likely to concentrate on reading tasks, apply learning strategies, and contribute more actively to the learning process. This interpretation is consistent with prior research indicating that technologies perceived as useful are often associated with deeper investment in learning activities (Lai et al. 2023; Zhao et al. 2024).

Behavioural intention was also positively related to behavioural, emotional, and agentic engagement. Pupils who reported stronger intentions to continue using the application also tended to report higher levels of participation, enjoyment, and proactive involvement. This pattern is consistent with previous research showing that intention to use is linked to continued participation in technology-supported learning contexts (Venkatesh et al. 2016).

5.5 | Theoretical Implications

This study advances theory by proposing the MTAEM, which integrates the TAM (Davis and Granić 2024) with SDT (Deci and Ryan 2000). The model suggests that perceptions of ease of use, usefulness, and intention to use are shaped by autonomy, competence, and relatedness, extending prior work that has combined TAM and SDT (Fathali and Okada 2018; Xia et al. 2025). It also shows that acceptance not only predicts adoption but drives behavioural, emotional, cognitive, and agentic engagement, addressing a gap in studies that have examined these constructs separately (Cai et al. 2024; X. Wu et al. 2025). By focusing on primary school learners, the study further extends technology acceptance research to a younger population that relies heavily on support for literacy development (Dignath et al. 2008; Sankalaite et al. 2021).

Most research on AI-assisted language learning has examined university or adult learners and focused on skills such as speaking, writing, or vocabulary (Barrot 2023; Wang et al. 2024; Yang 2025; Zou et al. 2023). These studies highlight how AI tools enhance participation and skill development through personalised feedback and interactive practice. The present findings extend this literature by showing that similar motivational and acceptance mechanisms operate among younger learners engaged in reading. However, primary pupils appear to rely more strongly on competence and relatedness support to sustain engagement, reflecting their developmental needs and dependence on external guidance. The MTAEM therefore provides a framework explaining how support, psychological needs, and acceptance interact to sustain engagement with AI in EFL reading, with implications for broader educational contexts.

5.6 | Practical Implications

The findings highlight several implications for the design and use of AI in primary EFL reading. First, AI systems should provide strong competence support through adaptive feedback and scaffolding, ensuring that learners feel capable and motivated to persist. Second, relatedness support is vital; features such as conversational agents or opportunities for teacher mediation can help sustain emotional and agentic engagement by fostering a sense of connection (Chiu 2021; Sparks et al. 2016). Third, autonomy support can be enhanced by allowing pupils to choose texts, set goals, or control pacing, thereby nurturing agency in contexts where classroom choice is often limited (Reeve et al. 2004; Ma 2021). For teachers, the results suggest that effective integration of AI tools requires combining technological support with pedagogical guidance. Teachers can use AI as a complement rather than a replacement, reinforcing social and motivational elements that AI alone may not fully provide. In this way, AI-assisted reading can become both engaging and developmentally appropriate for young learners.

5.7 | Limitations and Directions for Future Research

The study has three main limitations. First, its context was narrow: data were collected from one private primary school in Shenzhen, China, where pupils may have better technological access, school support, and parental involvement than those in public or rural schools. This may have contributed to more positive views of AI-assisted reading and higher engagement, so the model should be tested in more diverse educational and cultural settings.

Second, the study relied on self-report questionnaires. Although the measures were adapted for younger learners, primary pupils may still find it difficult to assess abstract constructs accurately, and their responses may be influenced by temporary impressions or social desirability. Future research could use additional data sources such as observations, learning analytics, teacher reports, and interviews.

Third, the cross-sectional design limits causal interpretation. While the model proposes directional relationships, data were collected at one time point, so the findings show associations rather than causal effects. Longitudinal or experimental studies are needed to test how acceptance of and engagement with AI-assisted reading develop over time.

6 | Conclusion

This study examined primary school learners' acceptance of and engagement with an AI-supported reading application for EFL. The findings suggest that autonomy, competence, and relatedness support are important for satisfying learners' psychological needs, which are, in turn, associated with technology acceptance variables and multidimensional engagement. Competence and relatedness appeared particularly important in shaping younger learners' experiences. Overall, the study highlights the value of combining adaptive AI functions with motivationally supportive design. AI-supported reading tools may be more effective when they not only personalise learning but also help young learners feel capable, supported, and involved in the reading process.

Author Contributions

Mi Tang led the study design, coordinated data collection, conducted the main analyses, and drafted the initial manuscript. Kunjie Jia carried out the primary data analysis and prepared the figures. Huimin He contributed to the literature review, data interpretation, and manuscript refinement. Chenghao Wang supported methodological decisions, contributed to data analysis, and assisted in revising the manuscript. Bin Zou provided guidance on the research design, contributed to the theoretical framing, and offered critical revisions. Yiran Du supervised the overall project, contributed to conceptualisation and methodological planning, and provided substantial revisions throughout the writing process. All authors approved the final manuscript.

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Conflicts of Interest

The authors declare no conflicts of interest.

Ethics Statement

This study was conducted in accordance with the principles of the Declaration of Helsinki. Ethical approval was obtained from the institutional ethics committee of Xi'an Jiaotong-Liverpool University prior to data collection.

Peer Review

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Appendix A: Construct and Measurement Items

Construct (Reference)	English items	Chinese items
Perceived ease of use (PEOU) (Ebadi and Raygan 2023)	PEOU1: I find the AI reading app easy to use.	我觉得这个AI阅读应用很好用。
	PEOU2: Learning how to use the AI reading app is simple for me.	学会使用这个AI阅读应用对我来说很简单。
	PEOU3: I can use the AI reading app without much help.	我可以自己使用这个AI阅读应用, 不需要很多帮助。
	PEOU4: It is easy for me to understand how the AI reading app works.	我很容易理解这个AI阅读应用是怎么用的。
Perceived usefulness (PU) (Ebadi and Raygan 2023)	PU1: The AI reading app helps me improve my English reading.	这个AI阅读应用能帮助我提高英语阅读。
	PU2: Using the AI reading app makes my reading practice more effective.	用这个AI阅读应用让我练习阅读更有效。
	PU3: The AI reading app is useful for practising English reading.	这个AI阅读应用对练习英语阅读很有用。
	PU4: The AI reading app helps me read better than without it.	有了这个AI阅读应用, 我的阅读比没有它时更好。
Behavioural intention (BI) (Cai et al. 2024)	BI1: I want to keep using the AI reading app.	我想一直用这个AI阅读应用。
	BI2: I will use the AI reading app often in the future.	将来我会经常使用这个AI阅读应用。
	BI3: I plan to continue using the AI reading app regularly.	我打算继续经常使用这个AI阅读应用。
	BI4: I will use the AI reading app whenever I study English reading.	每次学习英语阅读时, 我都会用这个AI阅读应用。
Perceived autonomy (PA) (X. Wu et al. 2025)	PA1: I feel I can make choices when using the AI reading app.	我觉得用这个AI阅读应用时我可以自己做选择。
	PA2: I can decide how I want to use the AI reading app.	我能决定自己怎样使用这个AI阅读应用。
	PA3: I feel free to learn in my own way with the AI reading app.	我觉得用这个AI阅读应用时能按照自己的方式学习。
	PA4: The AI reading app lets me take charge of my English reading.	这个AI阅读应用让我能自己掌握学习英语阅读的方式。
Perceived competence (PC) (X. Wu et al. 2025)	PC1: I feel confident when using the AI reading app.	我在用这个AI阅读应用时很有信心。
	PC2: I am good at using the AI reading app.	我觉得自己很会用这个AI阅读应用。
	PC3: The AI reading app makes me feel I can learn to read English well.	这个AI阅读应用让我觉得自己有能力学好英语阅读。
	PC4: With the AI reading app, I can do well in reading English.	有了这个AI阅读应用, 我能在英语阅读中表现得很好。
Perceived relatedness (PR) (X. Wu et al. 2025)	PR1: I feel connected to my teacher when using the AI reading app.	我用这个AI阅读应用时觉得和老师有联系。
	PR2: The AI reading app makes me feel supported in reading English.	这个AI阅读应用让我觉得在学英语阅读时得到了支持。
	PR3: I feel encouraged by my teacher when using the AI reading app.	我用这个AI阅读应用时觉得老师鼓励我。
	PR4: The AI reading app makes me feel I am reading together with others.	这个AI阅读应用让我觉得我是在和别人一起阅读。

(Continues)

Construct (Reference)	English items	Chinese items
Autonomy support (AS) (Vansteenkiste et al. 2012)	AS1: I can choose how to use the AI reading app.	我可以选择怎样使用这个AI阅读应用。
	AS2: My ideas are respected when I use the AI reading app.	我在用这个AI阅读应用时, 我的想法会被尊重。
	AS3: I feel free when learning with the AI reading app.	我在用这个AI阅读应用学习时感到很自由。
Relatedness support (RS) (Sparks et al. 2016)	RS1: I feel cared about when I use the AI reading app.	我用这个AI阅读应用时觉得有人关心我。
	RS2: Someone listens to me when I share my thoughts about the AI reading app.	当我分享对AI阅读应用的想法时, 有人会认真听。
	RS3: I feel important when I learn with the AI reading app.	我用这个AI阅读应用学习时觉得自己很重要。
Competence support (CS) (J. Wu et al. 2024)	CS1: I am given clear explanations on how to use the AI reading app.	我会得到清楚的讲解, 知道如何使用这个AI阅读应用。
	CS2: I get help when I have trouble using the AI reading app.	我在使用AI阅读应用时遇到问题时会得到帮助。
	CS3: I feel encouraged when I use the AI reading app.	我在使用AI阅读应用时会得到鼓励。
Behavioural engagement (BE) (X. Wu et al. 2025)	BE1: I work hard when using the AI reading app.	我用这个AI阅读应用学习英语阅读时很努力。
	BE2: I try to finish all reading tasks in the AI app.	我会尽量完成AI阅读应用里的所有阅读任务。
	BE3: I pay attention when practising English reading with the AI app.	我用这个AI阅读应用学习英语阅读时很专心。
Emotional engagement (EE) (X. Wu et al. 2025)	EE1: I enjoy practising English reading with the AI app.	我喜欢用这个AI阅读应用学习英语阅读。
	EE2: I feel excited when I use the AI reading app.	我用这个AI阅读应用时很兴奋。
	EE3: I am interested in the English reading activities in the AI app.	我对AI阅读应用里的英语阅读活动很感兴趣。
Cognitive engagement (CE) (X. Wu et al. 2025)	CE1: I think carefully about what I read in the AI app.	我会认真思考AI阅读应用里学到的内容。
	CE2: I try to understand difficult parts in the AI app.	我会努力理解AI阅读应用里的难点。
	CE3: I put effort into solving reading problems in the AI app.	我会花心思解决AI阅读应用里的问题。
Agentic engagement (AE) (X. Wu et al. 2025)	AE1: I ask questions when I want to know more about the AI app.	我想知道更多时, 会主动问关于AI阅读应用的问题。
	AE2: I share my ideas about using the AI reading app.	我会分享自己对AI阅读应用使用的想法。
	AE3: I suggest new ways of learning English reading with the AI app.	我会提出新的建议来用AI阅读应用学习英语阅读。

Appendix B: Reliability and Validity Results

Construct	Indicator	Loading	Cronbach's α	CR	AVE
Perceived ease of use (PEOU)	PEOU1	0.80	0.83	0.87	0.65
	PEOU2	0.77			
	PEOU3	0.85			
	PEOU4	0.81			
Perceived usefulness (PU)	PU1	0.92	0.90	0.95	0.82
	PU2	0.91			
	PU3	0.89			
	PU4	0.88			
Behavioural intention (BI)	BI1	0.86	0.91	0.94	0.81
	BI2	0.89			
	BI3	0.93			
	BI4	0.92			
Perceived autonomy (PA)	PA1	0.72	0.82	0.87	0.64
	PA2	0.90			
	PA3	0.85			
	PA4	0.78			
Perceived competence (PC)	PC1	0.74	0.84	0.88	0.65
	PC2	0.77			
	PC3	0.86			
	PC4	0.88			
Perceived relatedness (PR)	PR1	0.88	0.90	0.92	0.76
	PR2	0.91			
	PR3	0.87			
	PR4	0.83			
Autonomy support (AS)	AS1	0.78	0.87	0.90	0.71
	AS2	0.85			
	AS3	0.89			
Relatedness support (RS)	RS1	0.87	0.90	0.93	0.80
	RS2	0.89			
	RS3	0.91			
Competence support (CS)	CS1	0.84	0.84	0.87	0.72
	CS2	0.87			
	CS3	0.83			
Behavioural engagement (BE)	BE1	0.88	0.88	0.90	0.77
	BE2	0.87			
	BE3	0.90			
Emotional engagement (EE)	EE1	0.91	0.91	0.93	0.84
	EE2	0.93			
	EE3	0.92			
Cognitive engagement (CE)	CE1	0.89	0.89	0.91	0.79

(Continues)

Construct	Indicator	Loading	Cronbach's α	CR	AVE
	CE2	0.91			
	CE3	0.87			
Agentic engagement (AE)	AE1	0.89	0.89	0.91	0.78
	AE2	0.91			
	AE3	0.86			

Appendix C: Fornell–Larcker Criterion Table

	PEOU	PU	BI	PA	PC	PR	AS	RS	CS	BE	EE	CE	AE
PEOU	**0.81**												
PU	0.67	**0.91**											
BI	0.55	0.82	**0.90**										
PA	0.66	0.70	0.63	**0.82**									
PC	0.74	0.78	0.79	0.71	**0.81**								
PR	0.50	0.77	0.82	0.64	0.78	**0.88**							
AS	0.54	0.68	0.71	0.59	0.76	0.74	**0.84**						
RS	0.59	0.73	0.70	0.60	0.79	0.77	0.83	**0.89**					
CS	0.64	0.72	0.69	0.64	0.78	0.71	0.82	0.84	**0.86**				
BE	0.62	0.80	0.79	0.63	0.79	0.83	0.76	0.75	0.82	**0.89**			
EE	0.55	0.77	0.81	0.61	0.79	0.85	0.66	0.72	0.72	0.84	**0.92**		
CE	0.58	0.82	0.81	0.64	0.79	0.85	0.71	0.76	0.78	0.81	0.88	**0.90**	
AE	0.54	0.78	0.85	0.63	0.79	0.86	0.72	0.73	0.75	0.80	0.85	0.88	**0.89**

Note: The square roots of the AVEs are highlighted in bold along the diagonal.

Appendix D: Hypothesis Testing Results

H	Path	β	SE	z (Sig)	Result
H1	Autonomy support → Perceived autonomy	0.42	0.06	7.13***	Supported
H2	Relatedness support → Perceived relatedness	0.55	0.05	11.27***	Supported
H3	Competence support → Perceived competence	0.60	0.05	12.04***	Supported
H4	Perceived competence → Perceived ease of use	0.48	0.07	6.82***	Supported
H5	Perceived relatedness → Perceived usefulness	0.40	0.06	6.61***	Supported
H6	Perceived autonomy → Perceived usefulness	0.08	0.07	1.12	Unsupported

(Continues)

H	Path	*β*	SE	*z* (Sig)	Result
H7	Perceived ease of use → Perceived usefulness	0.35	0.05	6.89***	Supported
H8	Perceived ease of use → Behavioural intention	0.10	0.06	1.64	Unsupported
H9	Perceived usefulness → Behavioural intention	0.50	0.05	9.87***	Supported
H10	Perceived competence → Behavioural engagement	0.30	0.07	4.23***	Supported
H11	Perceived competence → Cognitive engagement	0.28	0.07	3.94***	Supported
H12	Perceived relatedness → Emotional engagement	0.32	0.06	5.29***	Supported
H13	Perceived relatedness → Agentic engagement	0.29	0.06	4.76***	Supported
H14	Perceived autonomy → Emotional engagement	0.09	0.07	1.31	Unsupported
H15	Perceived autonomy → Agentic engagement	0.18	0.07	2.54**	Supported
H16	Perceived ease of use → Behavioural engagement	0.15	0.06	2.46*	Supported
H17	Perceived ease of use → Emotional engagement	0.05	0.06	0.87	Unsupported
H18	Perceived usefulness → Cognitive engagement	0.35	0.05	6.93***	Supported
H19	Perceived usefulness → Agentic engagement	0.33	0.05	6.57***	Supported
H20	Behavioural intention → Behavioural engagement	0.45	0.05	8.92***	Supported
H21	Behavioural intention → Emotional engagement	0.42	0.05	8.37***	Supported
H22	Behavioural intention → Cognitive engagement	0.12	0.07	1.68	Unsupported
H23	Behavioural intention → Agentic engagement	0.40	0.05	7.94***	Supported

Note: Statistical significance is denoted as ***$p < 0.001$, **$p < 0.01$, and **$p < 0.05$.

Appendix E: HTMT Ratio of Correlations

Construct	PEOU	PU	BI	PA	PC	PR	AS	RS	CS	BE	EE	CE	AE
PEOU	—												
PU	0.73	—											
BI	0.61	0.86	—										
PA	0.70	0.74	0.67	—									
PC	0.78	0.82	0.84	0.75	—								
PR	0.57	0.83	0.85	0.68	0.83	—							
AS	0.60	0.73	0.76	0.63	0.80	0.78	—						
RS	0.64	0.79	0.75	0.65	0.84	0.82	0.86	—					
CS	0.69	0.77	0.74	0.67	0.82	0.76	0.84	0.86	—				
BE	0.67	0.83	0.85	0.67	0.84	0.86	0.79	0.77	0.85	—			
EE	0.60	0.80	0.84	0.64	0.84	0.87	0.72	0.78	0.76	0.88	—		
CE	0.63	0.86	0.85	0.68	0.84	0.87	0.76	0.81	0.81	0.83	0.88	—	
AE	0.58	0.82	0.87	0.65	0.84	0.88	0.77	0.76	0.79	0.81	0.86	0.88	—