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The mediating effects of needs satisfaction on the relationship between teacher support and student engagement with generative artificial intelligence (GenAI) chatbots from a self-determination theory (SDT) perspective

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Abstract
Generative artificial intelligence (GenAI) chatbots, such as ChatGPT and ERNIE Bot, are documented to influence student learning experience and student engagement. However, factors affecting student engagement in GenAI chatbots learning context are less understood. Self-determination theory (SDT) suggests student basic needs satisfaction–autonomy, competence, and relatedness– are associated with student behavioral, cognitive, emotional and agentic engagement. Teacher support–autonomy, structure, and involvement– derived by the three SDT needs. Hence, this study aims to clarify how factors (i.e., teacher support, student needs satisfaction) affect student engagement in this GenAI context in second language (L2) education. It examines the mediating effect of needs satisfaction on the relationship between teacher support and student engagement with a chatbot Data was collected from 364 university students through a questionnaire. The participants learned English as second language with ERNIE Bot under teacher support for four sessions. Our results revealed that needs satisfaction could partially mediate the relationship between teacher support and student behavioral, cognitive, and agentic engagement. They also suggest that needs satisfaction fully mediates the relationship between teacher support and emotional engagement. These suggests that GenAI chatbots better emotionally engage students in language learning than teachers do. One possible explanation for this is that students found learning with chatbots to be enjoyable and stress-free in L2 education. The results suggest teachers should take AI chatbot's affordance and student feeling into account for emotional engagement when using GenAI chatbots. We suggest future studies should include additional factors such as personality and peer support.

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Keywords GenAI chatbots · Student engagement · Language learning · Teacher support · SDT

1 Introduction

Generative artificial intelligence (GenAI) chatbots such as ChatGPT, Bing, and ERNIE Bot, have been increasingly applied in language education, particularly in L2 education (Jeon et al., 2023; Mohamed, 2023; Yan, 2023; Zou & Huang, 2023). L2 learners can have more chances to learn language through environments resembling those of native speakers (Huang et al., 2022; Zou & Huang, 2023). GenAI chatbots can be a good solution to existing challenges in L2 education, for example, limited practice opportunities with native speakers (Hsu et al., 2023; Jeon, 2024; Tai & Chen, 2022).

GenAI chatbots positively influence student engagement by making students more focused and more engaged in language activities (Jeon, 2024; Lee et al., 2023; Tai & Chen, 2023; Yan, 2023), for example, interactive practice for real-time conversations to improve their speaking and listening skills; immediate feedback on grammar, vocabulary, and pronunciation; personalized learning for student proficiency level and learning pace; flexible learning for students to learn anytime, anywhere; and cultural exposure for enhancing students understanding in real-world scenarios. However, most studies on GenAI in language education focused on learning outcomes (Xia et al., 2023), and less attention was paid to student engagement with teacher support in GenAI chatbot contexts (Wang & Xue, 2024). This is supported by a systematic review that a large majority of studies on language learning with AI chatbots (including GenAI chatbots) were more concerned with or only focused on different learning outcomes, like behavioral, emotional, cognitive, and agentic outcomes (Li et al., 2024). However, student engagement in L2 education could be of critical importance as it requires students to be highly involved in a sustained period of learning and practice for automatizing language skills (Mercer & Dörnyei, 2020).

Students benefited from GenAI chatbots for learning languages (Bašić et al., 2023; Escalante et al., 2023; Ghafouri, 2023) while also facing problems and risks. For example, they expressed unclear goals or objectives when using GenAI chatbots (e.g., ChatGPT) for L2 learning, and the lack of structured guidance left them unsure about what and how to learn, thus reducing engagement (Huynh, 2024; Wang & Xue, 2024; Zhai & Wibowo, 2023). These emphasizes the importance of instructions (e.g., teacher support) in language learning with GenAI chatbots (Annamalai et al., 2023; Ho, 2024). However, how teachers interact with AI chatbots (particularly GenAI chatbots) for language acquisition is less understood (Ji et al., 2022).

Self-determination theory (SDT) could study student engagement as a motivational outcome (Ryan & Deci, 2020). SDT suggests satisfaction for three basic psychological needs—autonomy, competence, and relatedness—could foster better engagement and achievement (Ryan & Deci, 2020). SDT has been applied to learning and instructional designs in different learning contexts, such as traditional, online, and blended environments, to satisfy students' basic psychological needs to improve their engagement (Chiu, 2021, 2022, 2023; Conesa et al., 2022; Patall et al., 2024).

Ryan and Deci (2020) proposed the application of SDT in a technology-supported environment would be a focus for future research.

Overall, previous studies have confirmed how teacher support satisfy student SDT needs in non-GenAI contexts for greater engagement. However, very few studies were conducted in GenAI context. This study aims to address this gap to examine how needs satisfaction affects student engagement when learning language with GenAI.

2 Literature review

2.1 Theoretical framework: SDT

SDT is a macro-motivational theory that explains how basic needs satisfaction impacts motivation and wellbeing in a socio-cultural context (Ryan & Deci, 2000, 2020). SDT argues the better satisfaction of the three basic needs, i.e., autonomy (sense of initiative and ownership), competence (feeling of mastery), and relatedness (sense of belonging and connections), the better outcomes (e.g., student engagement) could be yielded (Ryan & Deci, 2020). Therefore, SDT can provide a theoretical framework to examine how student needs satisfaction affects student engagement within social context (e.g., teacher support, GenAI chatbot context).

2.2 GenAI chatbots in language education

GenAI chatbots are gaining popularity in education, particularly in language education, due to their ability to produce creative, high-quality materials and provide human-like interactions (Chiu, 2024). GenAI chatbots have been used in both K-12 and higher education to improve language learning experiences (Wang et al., 2022; Zhang & Huang, 2024). They are capable of giving opportunities for communication in target language, allowing students to interact with native-like speakers and acquire target language without being constrained by their environments (Huang et al., 2022). They were well-documented that they could improve students' academic performance, such as writing skills (Boudouaia et al., 2024), conversational abilities, grammar learning (Kucuk, 2024). Learning with chatbots also benefited language learners emotionally and psychologically, such as improving their language learning motivation (Chiu, Moorhouse, Chai et al., 2024), reducing L2 anxiety and developing grit in language learning (Ghafouri, 2023).

However, there are challenges and risks associated with language learning using GenAI chatbots. The potential issues include (i) irrelevant responses and recognition issues (Bašić et al., 2023; Guo et al., 2023), (ii) misuse or misconduct by language learners, such as plagiarism and academic dishonesty (Bašić et al., 2023; Yan, 2023), and (iii) over-reliance on GenAI chatbots (Cai et al., 2023). These underscore the importance of teacher support in the GenAI chatbot learning context (Chiu, Moorhouse, Chai et al., 2024; Ho, 2024).

2.3 Student engagement and needs satisfaction within SDT in language education

Student engagement, defined as student involvement in educationally purposeful activities, is an important predictor of students' personal development and academic success (Greene et al., 2004; Kahu, 2013; Kuchinski-Donnelly & Krouse, 2020; Reeve et al., 2020). It is a multidimensional construct including distinct yet interrelated four dimensions: behavioral, emotional, cognitive, and agentic engagement (Fredricks, 2011; Reeve, 2013). Behavioral engagement refers to how involved students are in learning activities in terms of attention, participation, effort, intensity, or persistence (Skinner et al., 2009). Emotional engagement refers to the feelings that students have toward teachers, peers, learning activities, and school experience, as well as their sense of belonging (Sinatra et al., 2015). Cognitive engagement refers to how much mental effort students spare in completing learning tasks in terms of thinking-management and using sophisticated rather than superficial learning strategies (Greene et al., 2004; Senko & Miles, 2008). Agentic engagement refers to students' intentional, proactive, and constructive contribution to the flow of the instruction they receive (Reeve, 2013).

Student engagement can be seen as a motivational outcome, thus falling within the domain of SDT (Ryan & Deci, 2020). Many SDT-based research examined the relationship between needs satisfaction and student engagement and confirmed a need-supportive context could enhance student engagement (Chiu, 2021, 2022, 2023; Ryan & Deci, 2020; Xia et al., 2022). However, most SDT-based research was non-discipline focused (Bedenlier, 2020); very limited attention was cast to language education. In addition, a large majority of the research was conducted under the non-GenAI context, resulting in the findings of the relationship between needs satisfaction and student engagement being confined to the non-GenAI context. However, it could be a different picture in the GenAI context considering that powerful GenAI technologies could develop a robust learning environment (Ding & Hong, 2023; Zhi et al., 2023). Hence, due attention should be paid. Although researchers began to make attempts to explore the relationship between needs satisfaction and student engagement in language learning within GenAI chatbots (Wang & Wang, 2024), the attention was far from enough. Moreover, they neglected to consider agentic engagement, despite its significant role in explaining students' academic progress (Reeve et al., 2020).

2.4 Teacher support and student engagement in language education

In line with SDT, teacher support has three dimensions: support for autonomy, structure (competence) and involvement (relatedness) (Lietaert et al., 2015; Vollet et al., 2017). Support for autonomy refers to teachers taking into account students' learning choices, allowing them to learn at their own pace while avoiding the use of controlling language (Alamri et al., 2020; Chiu, 2021). In language education, autonomy-supportive teachers gave students the option of working on language tasks that they were interested in (Tai & Chen, 2023).

Support for structure (competence) involves communication of clear expectations with respect to students' behaviors (Sierens et al., 2009), distribution of desired

materials (Chiu, 2021), and provision of competence-related feedback (Al-Obaydi et al., 2023). In language education, structure-supportive teachers offered appropriate learning materials for vocabulary and reading practice to better students' achievements (Hsu et al., 2023; Lee et al., 2023), encouraged peer-collaboration and organized peer review in writing (Zou & Huang, 2023), provided enough guidance on language tasks (Jeon, 2024), and provided written feedback in EFL writing (Cheng et al., 2024; Zheng & Yu, 2018).

Support for involvement (relatedness) highlights teachers' encouragement for students' independence and initiatives (Yang & Xu, 2019) and inspirations to participate in activities (Reeve, 2013). In language education, involvement-supportive teachers provided emotional support by showing eagerness while listening to students and developed good teacher-student relationships with sharing their feelings and thoughts with students (Ghafouri, 2023), paid attention to students' individual needs, and provided help to make students feel cared for and noticed (Tai & Chen, 2022).

Teacher support has widely been considered as playing a critical role in student engagement (Chiu, 2021; Sadoughi & Hejazi, 2021; Tao et al., 2022; Zhang & Hyland, 2018). Teachers are believed capable of taking significant measures to promote student engagement (Mercer & Dörnyei, 2020). Many studies confirmed the effectiveness of teacher support on different dimensions of student engagement in language learning (Dincer et al., 2019; Sadoughi & Hejazi, 2021, 2023). For example, Vo (2023) found autonomy support from teachers enabled students to feel personal satisfaction and enjoyment with freedom of choices (emotional engagement), perceived utility values of tasks chosen by themselves (cognitive engagement), and spared efforts on the language tasks (behavioral engagement). Cheng et al. (2024) found that structure support from teachers can increase student engagement in L2 learning. When students valued teacher feedback, their emotional engagement increased; their behavioral engagement increased because teacher feedback guided them in revising their writing; and their cognitive engagement increased when they understood teacher feedback.

Digital technologies can have a favorable impact on student engagement (Henrie et al., 2015; Wang & Xue, 2024), but many learners lack expertise and skill in using technological tools, making student participation in technology-supported learning difficult. Jeon (2024) discovered that unskilled use of GenAI technology slowed students' learning processes, irritated their ownership, and negatively influenced their engagement in language learning. Given the widespread belief that teachers can improve student engagement by creating a supportive and encouraging environment (Furrer & Skinner, 2003; Reeve, 2013), it is important to investigate how teachers, in collaboration with GenAI chatbots, can foster a supportive environment to improve student engagement in language learning. However, most studies on AI in education focus on student learning outcomes (Xia et al., 2023) or only on how AI technology influences student engagement in the absence of a teacher (Wang & Xue, 2024), with less emphasis on how teacher support affects student engagement in the AI context.

2.5 Research gap

As previously noted, with GenAI chatbots growing more popular in language education, it is vital to explore how students engage in language learning with them (Amin, 2023; Boudouaia et al., 2024; Law, 2024; Niloy et al., 2023), however, factors affecting student engagement in this GenAI context are less understood. Related studies have confirmed the effectiveness of teacher support and student needs satisfaction in fostering student engagement in non-GenAI contexts, however, limited attention has been paid to such relationships in the GenAI context. In addition, Ryan and Deci (2020), the founder of SDT, suggested future SDT-based research needs to pay attention to the application of SDT to technology-enhanced learning contexts (e.g., GenAI learning context) to better understand how students engage their learning in these contexts.

3 The present study

This study aims to investigate how needs satisfaction mediates the relationship between teacher support and four dimensions of student engagement (behavioral, emotional, cognitive and agentic engagement) in GenAI chatbots language learning environment. The relationship is showed in the proposed research model, see Fig. 1. Accordingly, the three main research questions are:

RQ1: How does teacher support predict student needs satisfaction and student engagement?

RQ2: How does student needs satisfaction predict their engagement?

RQ3: Does student needs satisfaction mediate the relationship between teacher support and student engagement?

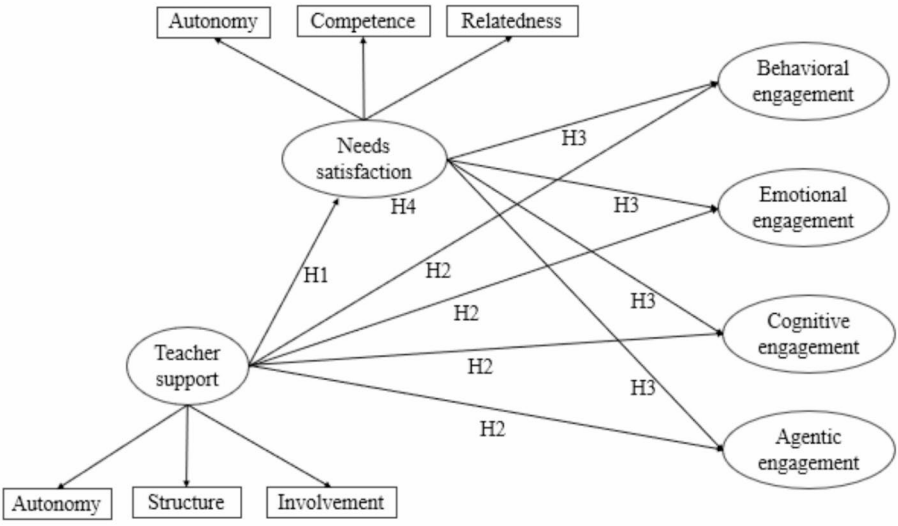

Fig. 1 Research model

The research model is in Fig. 1 and four hypotheses are proposed:

In GenAI chatbots language learning environment,

H1: Teacher support will positively relate to students' needs satisfaction. (RQ1)

H2: Teacher support will positively relate to the four dimensions of student engagement. (RQ1)

H3: Students' needs satisfaction will positively relate to the four dimensions of student engagement (RQ2).

H4: Students' needs satisfaction will mediate the relationship between teacher support and four dimensions of student engagement. (RQ3)

4 Method

4.1 Participants and procedure

Participants were 364 L2 learners from a comprehensive university in eastern China, with 137 male (38%) and 227 female (62%) from different majors (e.g. Education, Physics, Engineering, Math, etc.). They enrolled in College English, an integrated course aiming to develop and enhance language skills (listening, speaking, reading, writing and translating) and improve intercultural awareness for non-English majors. They had average or above average English proficiency based on standardized national English test (College English Test, CET).

The participants and three English teachers in charge of teaching were introduced to the ERNIE Bot. The ERNIE Bot is a sophisticated GenAI chatbot that can recognize speech in real time, enable personalized learning, assist with classroom instruction, provide feedback, and more. The ERNIE Bot has been tested for language learning and shown to be effective in language instruction (Wang & Xue, 2024). The three English teachers have over ten years of teaching experience and got AI training in language instruction. They were advised to introduce ERNIE Bot into their English class using the SDT-based teaching strategies in Table 1 adopted from Li et al., (2024).

We got ethical approval from our institution and consent forms from the participants. After learning English with ERNIE Bot for four sessions (70 min per session) with teacher guidance, the participants were asked to do a questionnaire on teacher support, needs satisfaction, and engagement within 10 min in the class.

4.2 Measurement

A questionnaire was used to measure teacher support (autonomy, structure, involvement), needs satisfaction (autonomy, competence, relatedness) and student engagement (behavioral, emotional, cognitive, agentic engagement) in language learning with ERNIE Bot. All items were rated on a 5-point scale (1 = strongly disagree; 5 = Strongly agree).

Teacher support: The teacher support included three dimensions: autonomy, structure, and involvement. We adapted all items from Standage et al. (2005). Items for autonomy, with an original reliability of $\alpha = 0.92$, were "My English teacher actively

Table 1 Teaching strategies in Language learning with ERNIE bot

Teachers can…	Descriptions	Autonomy	Structure	Involvement
Explain teaching objectives clearly	Teachers explain teaching objectives clearly and allow students to choose their preferred and interesting topic to work on.	**X**	**X**	
Present prior knowledge	Teachers present technological knowledge (TK) and content knowledge (CK) to students to facilitate their learning, and instruct students to interact with ERNIE Bot.	**X**	**X**	
Encourage student-chatbot interactions to generate information and ideas	Teachers encourage students to interact with ERNIE Bot to generate ideas. Students should communicate more with ERNIE Bot if they share the common idea and debate with it if they have different ideas.		**X**	
Provide help when needed	Teachers walk around the classroom, monitor students' participation, provide help when students can not generate useful information from ERNIE Bot, answer their questions, solve technological problems and task performance problems.		**X**	**X**
Lead discussions	Teachers lead discussions with students in a kind and friendly way and comment on their performance after their interactions with ERNIE Bot.		**X**	**X**
Provide feedback	Teachers provide positive feedback during student-chatbot interactions and provide feedback for common problems and questions students encounter after their interactions.		**X**	**X**
Encourage self-reflections	Teachers ask students to rate their performance on lexical and syntactical levels, the use of evidence and overall coherence in their language tasks.		**X**	

Note: X indicates that the teaching strategies fall in the corresponding dimension of teacher support

discussed with me", "My English teacher answered my questions fully and carefully", and "My English teacher made sure I really understood the goals of the lesson". Items for structure, with an original reliability of $\alpha = 0.84$, were "My English teacher made me feel I was good at learning English", "My English teacher made me feel that I was able to do the language activities", and "I felt that my English teacher liked me to do well". Items for involvement, with an original reliability of $\alpha = 0.88$, were "My English teacher supported me", "My English teacher was interested in me", and "My English teacher was friendly to me".

Needs satisfaction. This is to measure student perceived satisfaction of autonomy, competence and relatedness in this AI chatbot-supported learning context. The items were borrowed from the Basic Psychological Needs Scale-Revised (BPNS-R) from Chen and colleagues (2015) with acceptable original reliability of $\alpha > 0.71$. The items also had been used by Chiu and colleagues (2024) in AI context. Items for autonomy were "I felt a sense of choice and freedom in the things I undertook in the learning process", "I felt that my decisions reflect what I really want", and "I felt I did what really interested me". Items for competence were "I felt confident that I can do things well", "I felt competent to achieve my goals", and "I felt capable at what I did". Items for relatedness were "I felt learning in a caring environment", "I felt a warm feeling

in the activity that I was involved in", and "I felt closed and connected to the activity, which was important to me".

Student engagement. This is to measure behavioral, emotional, cognitive and agentic engagement. Items for behavioral and emotional engagement were adapted from Skinner et al. (2009) with acceptable original reliability of $\alpha > 0.79$. Items for behavioral engagement were "I tried to work hard in the English class", "I participated in all the activities in the English class", "I paid attention in English class", and "I worked as hard as I can in the learning process". Items for emotional engagement were "When I worked on something in English class, I felt interested", "I enjoyed learning new things in English class", and "I felt good in English class". Items for cognitive engagement were adapted from Wang et al (2016) with an original reliability of $\alpha > 0.85$, and they were "I went through the work for learning to make sure it was right", "I tried to connect what I was learning to things learned before", "I tried to understand my mistakes when got something wrong", and "I tried to think deeply when I encountered something I did not know". Items for agentic engagement were adapted from Reeve (2013) with acceptable original reliability of $\alpha = 0.84$. Items were "I let my language teacher know what I needed and wanted", "I expressed my preferences and opinions during the language class", and "I adjusted whatever I was learning so I could learn as much as possible".

4.3 Data analysis

We used Mplus 8.3 to conduct structural equation modelling (SEM) to examine the predictive and mediative relationships between variables. The assumption of SEM was firstly assessed by checking normality and multicollinearity (Kline, 2023) followed by conducting measurement model testing and structural model testing (Anderson; & Gerbing, 1988) with considering model fit indices (x^2/df, RMSEA, CFI, TLI, SMR), factor loading and p values, and finally performing mediating analysis with doing bootstrapping analysis (Hayes, 2009). The significance of the mediation analysis was confirmed by 95% confidence intervals (95% CI) generated by bootstrapping with 1000 random samples, which did not include zero (Shrout & Bolger, 2002).

5 Results

5.1 Descriptive statistics

Table 2 shows the descriptive statistics of variables. All the variables were internally reliable with $\alpha > 0.7$. Skewness and kurtosis values fell between acceptable range (Kline, 2023), specifically ranging from −0.21 to 0.36 in skewness values and ranging from −0.06 to 0.84 in Kurtosis values, confirming the data were normally distributed. The correlations between all the variables were positive and significant with all p values < 0.01 (see Table 3). The correlation coefficient was below 0.90, indicating no multicollinearity problems.

Table 2 Descriptive statistics of variables

Variables	Mean	SD	Skewness	Kurtosis	α
Teacher support	3.89	0.57	-0.26	0.13	0.88
Needs satisfaction	3.76	0.49	-0.001	-0.06	0.84
Behavioral engagement	3.85	0.58	-0.17	0.14	0.77
Emotional engagement	3.97	0.55	0.36	0.45	0.80
Cognitive engagement	4.00	0.46	0.06	0.84	0.77
Agentic engagement	3.79	0.61	-0.21	-0.06	0.77

Table 3 Factor loadings and correlation matrix for all variables

Variables	Factor loading	CR	1	2	3	4	5	6
1 Teacher support	0.80 (0.77-0.82)	0.84	**0.80**					
2 Needs satisfaction	0.71 (0.67-0.73)	0.75	0.55**	**0.71**				
3 Behavioral engagement	0.68 (0.59-0.80)	0.78	0.45**	0.46**	**0.68**			
4 Emotional engagement	0.75 (0.73-0.77)	0.80	0.45**	0.56**	0.56**	**0.75**		
5 Cognitive engagement	0.68 (0.64-0.73)	0.77	0.43**	0.43**	0.47**	0.44**	**0.68**	
6 Agentic engagement	0.73 (0.65-0.78)	0.77	0.45**	0.46**	0.60**	0.51**	0.57**	**0.73**

Notes: The bold values on the diagonal are the square root of AVE; **p<.01

5.2 Measurement model analysis

The measurement model was consisted of six latent variables: "teacher support", "needs satisfaction", "behavioral engagement", "emotional engagement" "cognitive engagement" and "agentic engagement". "Teacher support" was the predictor variable and was reflected by "teacher autonomy support", "teacher structure support" and "teacher involvement support"; "needs satisfaction" was the mediating variable and was reflected by "perceived autonomy", "perceived competence" and "perceived relatedness"; the four dimensions of student engagement were the criterion variables.

The measurement model was tested, and the fitness indices indicated a good model fit with x^2/df=293.218/155=1.89 (<3); RMSEA=0.049 (<0.08); SRMR=0.05 (<0.08); CFI=0.94 (>0.90); TLI=0.93 (>0.90). As was shown in Table 3, all the variables had acceptable factor loading and were significantly loaded with p<.01 on each latent variable. The composite reliability (CR) of the variables were higher than 0.7, indicating good level of internal consistency among all subscales. The square root of average variance extracted (AVE) were larger than correlation between latent variables, indicating a good level of convergent validity among all subscale was achieved (Henseler et al., 2014).

5.3 Mediating effect analysis

A structural model was constructed and tested to further examine the relationship between variables. The maximum likelihood (ML) as estimator was used and the SEM indicated the structure model had good model fit indices with x^2/df=367.108/155=2.37 (<3), RMSEA=0.06 (<0.08), SRMR=0.05 (<0.08), CFI=0.93 (>0.9) and TLI=0.92 (>0.9). The path relations and coefficients among the variables are shown in Fig. 2. The standardized direct, indirect and total effects among the variables are presented in Table 4.

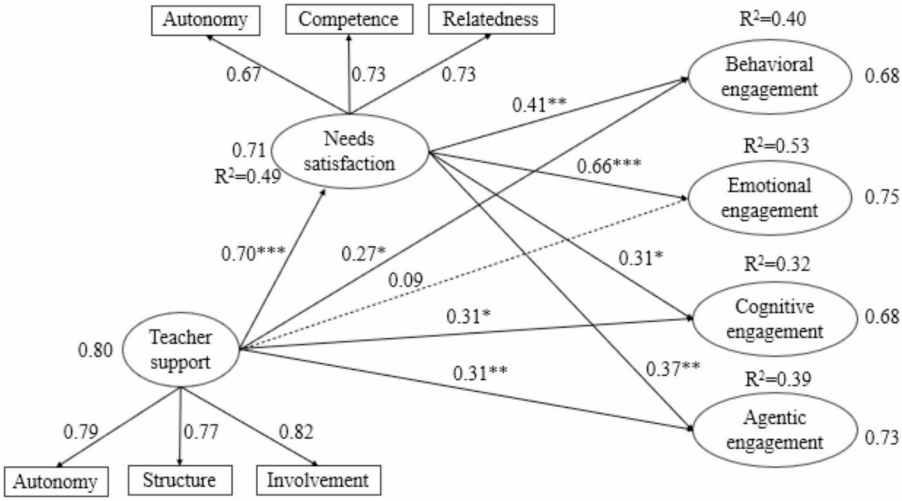

Fig. 2 Path relations and coefficients among variables. Notes: ***$p<.001$, **$p<.01$, *$p<.05$

Table 4 Standardized direct, indirect and total effects among the variables

Predictor	Mediating/criterion variable	Direct effect	Indirect effect	Total effect
Teacher support	Needs satisfaction	0.70 ($p<.001$)	-	0.70
	Behavioral engagement	0.27 ($p=.042$)	0.29	0.56
	Emotional engagement	0.09 ($p=.462$)	0.46	0.55
	Cognitive engagement	0.31 ($p=.012$)	0.21	0.52
	Agentic engagement	0.31 ($p=.016$)	0.26	0.57
Needs satisfaction	Behavioral engagement	0.41 ($p=.002$)	-	0.41
	Emotional engagement	0.66 ($p<.001$)	-	0.66
	Cognitive engagement	0.31 ($p=.014$)	-	0.31
	Agentic engagement	0.37 ($p=.002$)	-	0.37

Table 5 shows the reuslts of the hypotheses. *The relationship between perceived teacher support and needs satisfaction (H1)* Students' perceived three-dimension teacher support (autonomy, structure, involvement) positively and significantly predicted their three-dimension needs satisfaction (autonomy, competence, relatedness) ($\beta=0.70$, $p<.001$).

The relationship between perceived teacher support and student engagement (H2): Students' three-dimension teacher support positively and significantly predicted behavioral engagement ($\beta=0.27$, $p<.05$), cognitive engagement ($\beta=0.31$, $p<.05$)

Table 5 Hypotheses test results

Hypotheses	Test results
H1: Teacher support will positively relate to students' needs satisfaction.	Supported
H2: Teacher support will positively relate to the four dimensions of student engagement.	Supported (except for EE)
H3: Students' needs satisfaction will positively relate to the four dimensions of student engagement.	Supported
H4: Students' needs satisfaction will mediate the relationship between teacher support and the four dimensions of student engagement.	Supported (full and partial mediation)

Note: EE: emotional engagement

and agentic engagement (β=0.31, p<.05), however, the perceived teacher support did not significantly predict emotional engagement (β=0.09, p=.46).

The relationship between needs satisfaction and student engagement (H3): The results indicated that students' needs satisfaction significantly predicted behavioral engagement (β=0.41, p<.01), emotional engagement (β=0.66, p<.001), cognitive engagement (β=0.31, p<.05) and agentic engagement (β=0.37, p<.01).

The mediating role of needs satisfaction (H4): The results in Table 4 indicated direct relationship existed between perceived teacher support and three dimensions of student engagement: behavioral, cognitive and agentic engagement. The results also indicated three-dimension needs satisfaction mediated the relationship between perceived teacher support and four dimensions of student engagement (see Fig. 2). Perceived teacher support indirectly predicted behavioral, emotional, cognitive and agentic engagement via needs satisfaction.

Bootstrapping was used to test the indirect effects as this method could avoid problems of inconsistent results caused by different standard error formulae and produce precise confidence interval (CI), thus being considered as more powerful and valid in conducting mediating effect tests (Hayes, 2009). This study used 95% CIs for the effects of perceived teacher support on four dimensions of student engagement with bootstrapping using 1000 random samples. The coefficient of the indirect effect of perceived teacher support on the behavioral engagement was 0.29 (95% CI = [0.13, 0.52], p=.003), on emotional engagement was 0.46 (95% CI = [0.31, 0.67], p<.001), on cognitive engagement was 0.21 (95% CI = [0.04, 0.41], p=.02) and on agentic engagement was 0.26 (95% CI = [0.11, 0.46], p=.005). The 95% CI should not include 0, thus, perceived teacher support was a significant predictor for four dimensions of student engagement through needs satisfaction. As the direct effect of teacher support on behavioral engagement, cognitive engagement and agentic was also significant and pointed at the same direction, indicating needs satisfaction partially mediate the relationship between teacher support and these three dimensions of student engagement, while the direct effect of teacher support on emotional engagement was non-significant, indicating needs satisfaction fully mediate the relationship between teacher support and emotional engagement. The total effects of teacher support on behavioral, emotional, cognitive and agentic engagement were 0.56. 0.55, 0.52 and 0.56 respectively.

6 Discussions

This study aims to examine the mediating role of SDT needs satisfaction in the relationship between three types of teacher support and four dimensions of student engagement: behavioral, engagement, cognitive and agentic engagement in L2 learning with GenAI chatbots in higher education. The findings provide three empirical implications, two theorical contributions and three practical suggestions for teachers and researchers to better facilitate students' learning with GenAI chatbots.

6.1 Empirical implications

First, teacher support positively and significantly predicted students' needs satisfaction in English language learning with GenAI chatbot in class (H1). This finding is consistent with previous studies (Diaconu-Gherasim et al., 2022; Xu et al., 2024). Teachers' provision of learning choices (Vo, 2023), encouragements (Hsu et al., 2023), delicate instruction designs (Liao et al., 2023), guidance and feedback (Zheng & Yu, 2018) satisfy student needs satisfaction for autonomy, competence and relatedness. However, the relationship between teacher support and needs satisfaction in previous studies were mostly conducted in non-GenAI context, and this study provides evidence of teacher support as a positive and significant predictor for needs satisfaction in GenAI chatbots learning context.

Second, our findings revealed that teacher support had a significant and positive direct relationship with behavioral, cognitive and agentic engagement, but an insignificant relationship with emotional engagement (H2). The positive significant relationships are aligned with previous studies conducted in non-GenAI chatbots context (Chiu, 2021; Liao et al., 2023; Luan et al., 2023; Sadoughi & Hejazi, 2021, 2023). These suggested that the effects of teacher support on behavioral, cognitive and agentic engagement in non-GenAI learning context is as same as that in GenAI learning context. However, our findings suggested teacher support had a significant relationship with student emotional engagement in GenAI learning. One possible explanation is that students found GenAI chatbots learning environment joyful and fun, and exciting, and love to interact with the GenAI chatbot. Teacher may not be important in this emotional engagement as GenAI chatbots provide more human-like conversations.

Third, student needs satisfaction had a significant direct relationship with behavioral, emotional, cognitive and agentic engagement (H3) and acted as a mediator in the relationship between perceived teacher support and four dimensions of student engagement (H4). These findings revealed that needs satisfaction within GenAI context was a predictor for student engagement in language learning. They are aligned with Wang and Wang (2024)'s findings suggesting the positive effects of GenAI chatbots on student engagement in language learning. Moreover, needs satisfaction also acted as a mediator in the relationships between teachers support and student engagement. Xu et al. (2024) shared the same view and emphasized that teachers should provide various supports to students for greater engagement, such as helping students understand the relevance of learning tasks and providing them with com-

prehensive and specific feedback. Our findings further support this view in GenAI learning context.

6.2 Theorical contributions

First, the empirical implications of this study contribute to SDT-based research by examining the relationship between perceived teacher support, needs satisfaction, and four dimensions of student engagement in a new technology-support context, i.e., GenAI context. Our findings echo the SDT founders' call about enriching SDT research in a technological environment Ryan and Deci (2020). In addition, this study specially specified how needs satisfaction affected student engagement and mediated the relationship between teacher support and student engagement in GenAI chatbot language learning. Needs satisfaction in the GenAI context was less understood (Al Shamsi et al., 2022; Xia et al., 2023) and SDT-based research on language education was limited (Xia et al., 2023). Therefore, this study provided more evidence on how needs satisfaction worked under the GenAI context within the L2 education.

Second, this study enriches technological pedagogical content knowledge (TPACK) research by providing teaching strategies in the GenAI chatbots environment. Teachers in this study acted as knowledge presenters, designers, facilitators, assessors, and resource providers. They provided both technology and content knowledge to students and incorporated ERNIE Bot as GenAI chatbots in the teaching process to support the pedagogy, which could contribute to TPACK (Mishra & Koehler, 2006; Rosenberg & Koehler, 2015).

6.3 Practical suggestions

This study provided insights for teachers on how to better facilitate student engagement in GenAI chatbot language learning. First, teachers should try to satisfy students' needs to encourage their engagement in language learning, and teachers should take many factors (e.g., AI chatbot's functions and affordances, students' interest, anxiety, social interaction, and etc.) into account when trying to improve emotional engagement in the GenAI chatbots learning context.

Second, teachers should carefully incorporate GenAI chatbots in their instructional design (i.e., not just let students to use GenAI without guidance). The GenAI technology could improve student engagement (Wang & Xue, 2024); however, students still desired teacher instructions despite recognizing the efficacy of the GenAI chatbot (Ho, 2024). Hence, teachers should enrich their TK in addition to pedagogy knowledge (PK) and CK to better instruct students' learning.

Third, teachers should be more engaged in professional development sessions and receive training on GenAI technology (Chiu, 2022). This technology is emerging, which requires teachers to keep progressing to enhance their AI competency and teacher support in a GenAI learning context.

7 Limitations and future directions

This study has four limitations. First, this study adopted a quantitative approach over a short period, a longitudinal design could be adopted in the future to track the interactions between the variables. Moreover, a qualitative design or a mixed design could be helpful in explaining those that cannot be explained by data. Second, this study relied on a self-report questionnaire, and more methods (e.g. recording, observation, etc.) can be used to make data collected more comprehensive and objective. Third, this study was conducted in a higher education classroom, it could be a different picture for K-12 education or out of class. Future studies are suggested to investigate the mediating effect in different educational contexts. Fourth, student engagement is affected by many factors, although teacher support plays a critical role, other factors, like personality, peer support, and AI support can be influential, which deserves studying in the future.

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Data availability The datasets used for the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval This study got ethical clearance from the author's university.

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