



# The impact of mobile-based language learning on speaking and learning anxiety, engagement and achievement in Chinese language learning: The mediating role of cognitive load

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## ABSTRACT

This study examines the impact of mobile-based language learning (MBLL) on speaking and learning anxiety, learning engagement, and language achievement among international students learning Chinese with a specific focus on cognitive load as a mediator. A cross-sectional survey of 175 international students enrolled in universities in Anhui province, China was conducted. Regression and mediation analyses indicated that MBLL was significantly associated with lower speaking and learning anxiety, higher learning engagement, and higher language achievement. Results indicated that cognitive load partially mediates these associations; MBLL significantly lessened cognitive load, which in return was related to lower speaking and learning anxiety and higher engagement and achievement. The results reinforce the importance of choosing or designing mobile learning tools that do not overload learners cognitively, thereby addressing international students' emotional and academic needs.

## 1. Introduction

Digital technologies have revolutionized language education by introducing innovative ways to improve learner engagement and outcomes (Zhu et al., 2023). In the context of foreign languages such as Chinese, mobile based language learning (MBLL) technologies have transformed language acquisition and teaching by integrating these tools into educational setting. MBLL refers to use of mobile devices such as smartphones, tablets and other portable technology to support language learning outside of the traditional classroom (Melchor-Couto, 2016). With the rapid growth of mobile technologies, more educators and students are using mobile applications and platforms as a means of language acquisition, overcoming learning barriers and enriching the learning experience (Bai, 2024; Zhou, 2024).

Speaking anxiety is a common issue among language learners, referring to the fear of speaking a foreign language (Suleimenova, 2013). Learning anxiety, on the other hand, is caused by a fear of failure or inability to understand the language and it can get worse when tasks are complex and difficult. For international students, acquiring a foreign language such as Chinese is very challenging as cognitively demanding

as well as emotionally and psychologically taxing (Andrea, 2021). Mobile learning, due to its flexibility and accessibility, offers valuable tools for the language learners, especially those learning Chinese, which presents extra unique challenges such as the complex writing system, the tonal pronunciation and the grammatical structures (Liu & Xiangming, 2019; Luo, 2015).

Popular mobile based language learning tools include Duolingo, Hello-Chinese and Memrise which offers interactive lessons, voice recognition and spaced repetition techniques. Many students feel anxious about speaking, fearing mistakes, embarrassment in front of peers, or high expectations in a non-native language environment. According to Abdurahman and Rizqi (2020) speaking is considered necessary and positive personal characteristic in the educational world (Abdurahman & Rizqi, 2020). However, the acquisition of the target foreign language is a source of stress, nervousness, or anxiety for many foreign language learners. Language anxiety has been found to be 'alarming' among university students and up to one half of all language students are estimated to experience speaking anxiety at debilitating levels (Wu et al., 2022). MBLL platforms as they provide a safe environment to practice (Grant et al., 2017), and features like voice

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recognition and repeating of exercises help learners speak without the fear of being judged by others (Martin & Alvarez Valdivia, 2017).

Academic/Learning engagement is referred to the level of involvement and motivation that students display in the learning process. A high level of engagement is associated with better learning outcomes because the engaged learner devote more time, effort and attention into their learning (Muir et al., 2019). In the context of language learning, learning achievement refers to language proficiency, including the learner's ability to understand, produce and use the target language. The mobile learning has the potential for meaningful engagement in the learning process (Wang et al., 2018). According to previous research, the use of smartphones motivates university students to actively participate in online classes even if they are shy to ask questions in face to face classes due to social stigma (Salhab & Daher, 2023a). Besides, students with smartphones can communicate with their peers online as they can easily ask their friends or lecturers about educational issues through the online platforms that support social interaction (Mushtaque et al., 2022).

Cognitive load is a key concept in cognitive psychology that refers to the mental effort required to process information and perform tasks (Sweller et al., 2019). In language learning, it is particularly important because learners must manage multiple skills simultaneously (speaking, listening, reading, and writing), while also acquiring new vocabulary and grammar rules. Cognitive Load Theory (CLT) posits that there are three types of cognitive load: includes intrinsic load (related to the complexity of the content itself), extraneous load (due to how the information is presented), and germane load (supporting the process of learning and the construction of knowledge structures, or schemas) (Sweller, 2010). When cognitive load exceed the learner's capacity, it can impair the learning outcomes, leading to anxiety, disengagement and poor academic performance (Langerock et al., 2025). In the context of MBLL, cognitive load is influenced by both the design of the platform and the nature of the tasks. Excessive extraneous cognitive load may result from overly complex tasks, poor design, or insufficient scaffolding; while task are too difficult or too easy can increase intrinsic load (Faber et al., 2024). Therefore, MBLL should be designed to optimize cognitive load to promote germane load which supports understanding and long-term retention of language concepts (Van Nooijen et al., 2024).

In this study, studying speaking and learning anxiety, learning engagement and language achievement was strategically and thoughtfully chosen. Each variable reflects a key affective (anxiety), behavioral/cognitive (engagement) and performance (achievement) area of language learning. Theoretically, by studying all three variables, this study will highlight how MBLL could affect not only learner outcomes, but the psychological and motivational processes that act as the underpinnings of successful language acquisition. Ultimately, this framework is especially useful when considering how emotional, cognitive, and performance challenges manifest in the process of Chinese language learning for international students.

In addition to the above, it is necessary to understand the effectiveness of MBLL through the cost-benefit model of learning. This model highlights that the cognitive benefits of an instructional method should be greater than the mental effort put forth to support the learning goal. Therefore, a type of Learning using Mobile Technologies (i.e., MBLL) requires a high level of mental effort with little cognitive benefit (for example, if there is too much complexity in navigation or sequencing of tasks, or if the multimedia content is overwhelming), it could further support cognitive overload and diminish learning. In this case, MBLL could reinforce anxiety and minimize learning and/or engagement. This is congruent with the cost-benefit perspective that suggests instructional methods only have value when the mental effort required to learn with them is the same as or less than the cognitive gain they deliver (Lyu &

Deng, 2024; Sweller et al., 2019).

This relationship also parallels the mirrored in research that we explored in understanding embodied learning. For example, embodied learning approaches (that use any form of haptic feedback or gesture-based interface) have been shown to reduce cognitive load and enhance spatial or language acquisition through multi-sensory experiences. However, the method is deemed effective only when it aligns with the stated learning objectives. Existing research suggests that tangible user interfaces improve learning when the interface assists learners in conceiving abstract forms of content in a more concrete fashion, and not when extra load is added (Zou et al., 2023). In either instance, the degree of cognitive cost of the mobile tool or embodied interface warrants consideration in relation to learning gains to assure outcomes are not hindered. A recent meta-analysis by Lyu and Deng (2024) (Lyu & Deng, 2024) found that embodied learning is more effective when it reduces extraneous load and improves germane load. Thus, this study provides a potential fit of MBLL within the cognitive load model and cost benefit models of learning, as it determines the effectiveness of MBLLs will be most effective when the cognitive demands are being managed well, and support the learner in reducing anxiety, generation of engagement and increased achievement.

## 2. Purpose of study

The purpose of this study is to examine the impact of mobile-based language learning on speaking and learning anxiety, academic engagement and achievement in the context of learning the Chinese language. Chinese is considered one of the most difficult language for speaker of non-tonal, alphabets based language to learn. The study specifically examines the role of cognitive load to further understand the use of mobile learning tools interacts with cognitive load, a mental effort involved in processing information, to affect various psychological and academic outcomes in language learners (Fig. 1).

## 3. Literature review and hypothesis development

### 3.1. Mobile based language learning and speaking and learning anxiety

Mobile based language learning (MBLL) is the use of technology to deliver language instruction through portable devices (Lei et al., 2022). These technologies are prized for their flexibility and convenience for learning language material any time and in nearly any location. Mobile applications by adding interactive elements enhance the opportunity for learners to practice and immerse in the language, thus expanding the teaching beyond the standard methods (Ekinci, 2017). Several researches examined the effectiveness of mobile applications have been demonstrated to increase learner motivation, facilitate vocabulary development and enhance a more meaningful and focused language learning experience (Fathi & Rahimi, 2022; Klimova & Zamborova, 2020). Many students frequently encounter different challenges in language acquisition especially Chinese language (Bao & Du, 2015). Traditional method of teaching language such as memorization of grammar rules leads to low motivation and detachment to learning new language. Integration of mobile based learning technologies into language education helped to reduce speaking anxiety by providing learners with a low pressure, flexible environment in which to practice speaking at their own pace. For this reason, a few mobile applications that have speech recognition and interactive voice based activities have emerged to become safe spaces for learners' practice of pronunciation, fluency, and conversational skills (Zhou, 2024). Moreover, a recent study even showed that mobile based language learning had huge improvements in listening, speaking and reduced anxiety than the group

only with classroom instruction (Bai, 2024). Based on the literature thus following hypothesis is formulated:

**H1.** Mobile based language learning has the negative association with speaking and learning anxiety among international students learning Chinese.

### 3.2. Mobile based learning and learning engagement

Increasing research on mobile based learning (MBL) has been directed towards investigating the role of mobile technologies on learner engagement, with studies that the learners' engagement with mobile based learning has been significantly increased (Zhao et al., 2022). Because mobile learning applications have interactivity is commonly combined with quizzes, gamified features and multimedia content that increase learner engagement (Hellín et al., 2023). With these features, the learning is more dynamic and personal which makes it more fun and its outcome more rewarding. In particular, games and interactive features of mobile learning apps have been proven to raise learners' intrinsic motivation and improve retention of learning material (Salhab & Daher, 2023b). For example, mobile apps like Duolingo that resort to gamification to motivate people to learn because gamification rewards progress, stimulates friendly competition, exhorts people rather positively to achieve (Huynh et al., 2016). Based on the literature thus following hypothesis is formulated:

**H2.** Mobile based language learning has the positive association with learning engagement among international students learning Chinese.

### 3.3. Mobile based learning and language achievement

Mobile learning tools used in technology enhanced learning environments create immersive language practice and greater exposure that contribute to successful language acquisition and achievement (Cho et al., 2018). Language achievement is concerned with language skills (listening, speaking, reading, writing, grammar), and language achievement also depends on the motivation to learn, the way student practice and the methods of learning. A systematic review of published empirical studies (2015–2024) yielded a sample of 50 articles. It was found that in majority of studies reviewed, the use of mobile learning (m-learning) tools has potential to facilitate students learning outcomes and foster critical thinking skills (Pedraja-Rejas et al., 2024). As mobile-based language learning and achievement explore an ongoing interest in education research, not an abundance of research exists regarding the combined role of cognitive load and affective and behavioral factors, particularly with respect to international students learning Chinese a situation that carries unique linguistic and psychological challenges. This study begins to help fill that gap, providing a unique and potential new contribution to understanding MBLL within this context. The following hypothesis is formulated:

**H3.** Mobile based language learning has the positive association with language learning achievement among international students learning Chinese.

### 3.4. Cognitive load

Studies have reported that mobile learning tools both relieve or amplify cognitive load depending upon how the tools are designed and used. As researchers showed that the flexibility and accessibility in the mobile learning environment lead to extraneous cognitive load if most of the apps used in these environments are not properly designed or too complex (Hwang et al., 2013). Yet well designed apps with multimedia, gamification and scaffolding can be used to manage the cognitive load and improve the learning experience (Hasumi & Chiu, 2024). Moreover, mobile based language learning tools such as spaced repetition, interactive practice, and visual cues help reduce this load by giving learners

ways to cope with cognitive load more effectively (Chen & Lin, 2014). It is also important to consider that the effectiveness of MBLL is not necessarily universal, as it is likely contingent on the design of the application and the integration of the learning process. Some studies found that bad design of mobile applications can actually create more cognitive load, resulting in learner frustration and in some cases even higher levels of learner anxiety (Hwang et al., 2013; Sweller, 2010; Wang et al., 2018). For example, when navigation is challenging or the tasks are too complex, MBLL can unintentionally overload students rather than support those (Fredericks et al., 2021). The preceding findings suggest a careful implementation is necessary and align with the current study's focus on cognitive load as a mediating aspect. So the following hypothesis is formulated:

**H4.** Mobile based language learning has the association with cognitive load among international students learning Chinese.

The research indicates that cognitive load, in particular if too high, has the possibility to increase learning anxiety, such as speaking anxiety (Fredericks et al., 2021). But various apps built on mobile that can minimize cognitive load of the learner, will help reduce this anxiety and make the learning a more comfortable one. The AI speaking evaluation program's study results revealed that the majority of the participants thought that they improved their speaking skills with the feedback provided by the AI speaking evaluation program. The mean scores of their speaking skills in pre and posttests also showed there were significant improvements (Zou et al., 2023). So the following hypothesis is formulated:

**H5.** Cognitive load has the association with speaking and learning anxiety among international students learning Chinese.

**H6.** Cognitive load mediate the relationship between mobile based learning and speaking and learning anxiety.

Studies have shown that engaging behavior is obtained at an optimal level of cognitive load. The well designed, interactive content used in mobile based learning can take advantage of apps that balance cognitive load. Freeman et al. (2023), reported that the mobile apps with minimal extraneous load and encouraging tasks (games or rewards) increased students' engagement in language learning greatly (Freeman et al., 2023). A more recent study results that confirm this effect on learner engagement also showed significant gains in the affective, cognitive and behavioral domains, indicating that Duolingo has a positive effect on engagement in general. In addition, the large effect sizes identified support Duolingo's contribution to improving language attitudes, engagement and communicative confidence (Ouyang et al., 2024). In the experimental group, overall willingness to speak, read, write, comprehend, and communicate generally increased in the manner of a statistically significant difference when compared to the control group (Ouyang et al., 2024). Thus the following hypothesis is formulated:

**H7.** Cognitive load has the association with language engagement.

**H8.** Cognitive load mediate the relationship between mobile based learning and learning engagement.

**H9.** Cognitive load has the association with the language achievement.

**H10.** Cognitive load mediate the relationship between mobile based learning and language learning achievement.

### 3.5. Conceptual framework

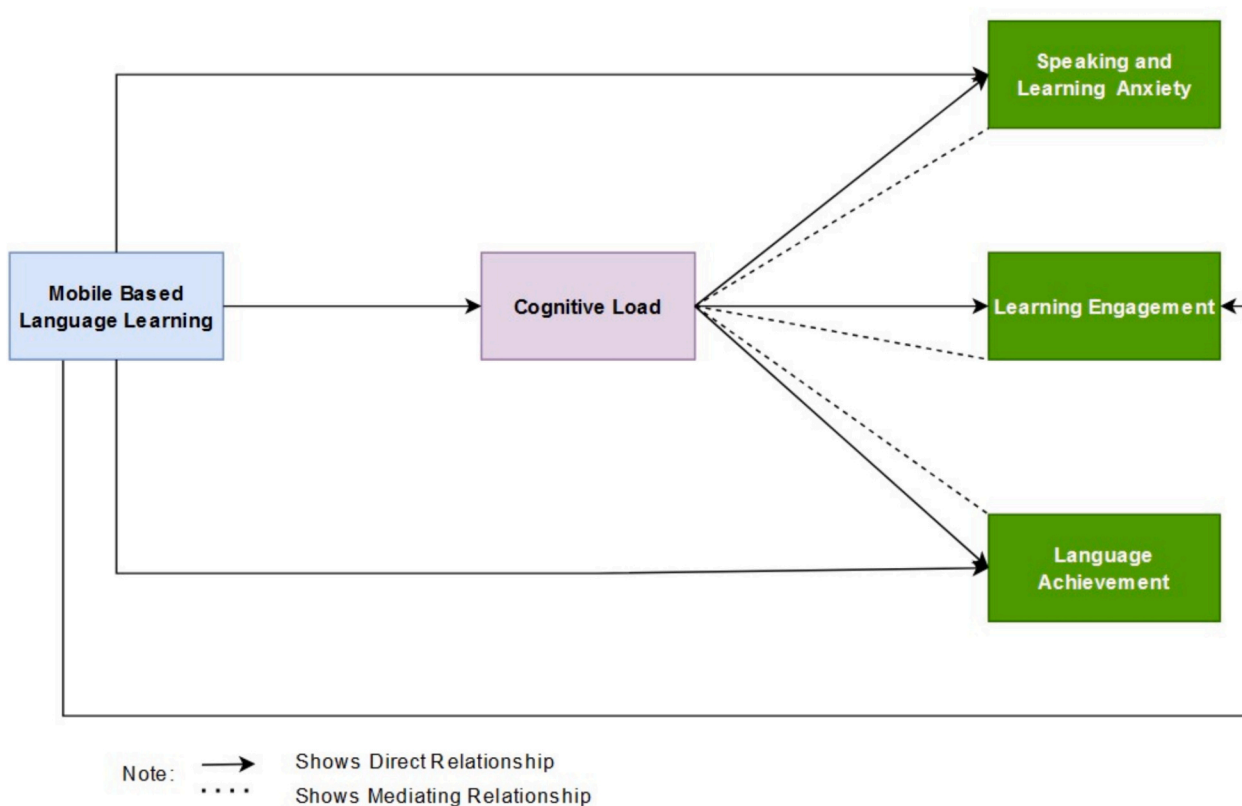


Fig. 1. Conceptual Framework of current Study.

## 4. Methods

### 4.1. Research design

The current study adopted the cross-sectional design. To examine the impact of mobile based language learning (MBLL) on speaking and learning anxiety of Chinese language, learning engagement and achievement.

### 4.2. Participants

This study includes the international students as Chinese language learners from Universities in Anhui, China, including undergraduate and postgraduate students. Participants were recruited using purposive sampling with the aid of Chinese language program coordinators from a few universities in Anhui Province. The invitation to the study was sent via WeChat groups that were used by international students for academic correspondence. The invitation contained a brief explanation of the study, the inclusion criteria, and a secure link to the consent form and questionnaire. Participation in the study was voluntary, only students who completed the required informed consent were able to access the survey.

Prior to beginning this investigation, a priori power analysis was completed to determine an appropriate sample size using G\*Power 3.1 software to ensure adequate sample size. A priori power analyses would adhere to the statistical test of linear regression (fixed model,  $R^2$  deviation from zero). The input parameters were a medium effect size ( $f^2 = 0.15$ ) based on Cohen's recommendations,  $\alpha = 0.05$ , a statistical power of 0.95, and five predictors in the model (MBLL, cognitive load, anxiety, engagement and achievement). Based on the parameters selected, the required minimum sample size was calculated to be 138. All sample sizes should allow for unusable responses or incomplete data, so the target sample size was increased to 200. In the end, there were 175 complete responses available for the analysis. Purposive sampling

technique is used to recruit these participants who were enrolled in learning Chinese as a foreign language and in using mobile applications for learning language. Participants had to be university students aged 18–30 years, enrolled in beginner or intermediate level Chinese language courses, and regular mobile device users (smartphones or tablets) as the criteria for inclusion. Exclusions were students with a native or near native level of Chinese or students who had substantial exposure to mobile Chinese language learning platforms.

### 4.3. Measures

In this study, six validated instruments were used to measure the construct of interest. All scales were originally developed in English and administered in English language, as all international student participants had sufficient English proficiency for academic communication.

#### 4.3.1. Mobile based language learning

The 15-item questionnaire via a 5-point Likert scale was derived from questions to assess various aspects of mobile learning (Aliakbari & Mardani, 2022), such as whether mobile learning had impact on students learning experience; student satisfaction through mobile learning classes; effectiveness of mobile tools for language acquisition; and if and how student participation was affected due to mobile learning. All the items scored in same direction and higher score indicating higher positive perception; the score range was 15 to 75. In the current study the scale reliability was  $\alpha = 0.99$ ; which shows the high reliability on the study sample.

#### 4.3.2. Foreign Language Speaking Anxiety Scale (FLSAS)

The scale designed as a 13-item questionnaire based on the 5-point Likert scale, was used to assess students' foreign language speaking anxiety (FLSA) in the present study (He, 2013). It is a single-factor measure of speaking anxiety. The score range is 13–65; higher score indicate higher levels of foreign language speaking anxiety. Students are

measured by the scale in terms of the reasons behind their FLSA, for example, “I avoid speaking Chinese due to embarrassment,” “I am nervous when asked to speak Chinese,” and “I am afraid of making mistakes because of speaking Chinese.” The FLSAS was found to have good reliability of internal consistency in measuring FLSA in this context with Cronbach's alpha coefficient of 0.99.

4.3.3. Learning chinese language anxiety

Was measured in the current study using a 4-item and a 5-point Likert-scale adapted from previous research (Luo, 2011). The items of this scale were designed to measure students' anxiety towards learning Chinese by believing that “I feel stressed when learning Chinese grammar rules” and “it is overwhelming learning Chinese vocabulary for me.” The total item score range is 4–20; high score revealed high level of anxiety. In the current study the scale reliability was  $\alpha = 0.97$ ; which shows high reliability on the study sample.

4.3.4. Learning engagement scale

The Assessment Engagement Scale (AES), containing nine items selected to assess the level of engagement for learning Chinese language, was used in the current study to assess student engagement (Evans & Zhu, 2023). Example items include statements as ‘I participate actively in class activities related to Chinese learning’ and ‘I do the assignments on time about Chinese language course’. The sum of all items score range is 9–45. High score indicates the stronger engagement. A Cronbach's alpha coefficient of 0.98 was shown suggesting good reliability and strong internal consistency in measuring students' engagement in the learning process.

4.3.5. Language achievement scale

In the current study, two methods of measuring language achievement are examined. We used a 4-item with 5 point Likert scale to assess students' self-reported perceptions about their language achievement (Marian et al., 2007), e.g. “I am satisfied with my performance in Chinese language courses” and “My grades in the Chinese language courses reflect my exertion.” The scale score range is 4–20 and the scale reliability was 0.96. In addition to this, to verify the results objectively, we also measured students' actual grades in their Chinese language course. This two pronged assessment enabled us to look at perceived and actual achievement in learning Chinese language.

4.3.6. Cognitive load scale

In this study, the Cognitive Load Scale (CLS), a ten item inventory is used (Leppink et al., 2013). The scale has three dimensions (intrinsic, extraneous and self-perceived learning). In particular, items 1, 2, and 3 measure intrinsic cognitive loads, items 4, 5, and 6 capture extraneous cognitive load, and 7, 8, 9, and 10 items measure students' self-perceived learning. With this scale we were able to assess these students not only according to what they were required to do cognitively during their learning process, but also according to their perceptions of their own learning outcomes.

In current study cognitive load scale used as a unidimensional scale and for this purpose we examined the scale validity and reliability on the current sample data via using confirmatory factor analysis, specifying a single latent “Cognitive Load” factor onto which all ten items load. The results strongly support a unidimensional representation in our data set: standardized factor loadings are all very high (ranging from 0.924 to 0.958), indicating that each item shares substantial common variance with the general factor. Model fit is good to excellent for the one-factor model: CFI = 0.994, TLI = 0.992, RMSEA = 0.053 (90 % CI: 0.017–0.082, PCLOSE = 0.403), and RMR = 0.006). The reliability of the scale is 0.98 which is considered that the scale is highly reliable. These indices collectively indicate that the single factor structure provides an adequate approximation of the covariance structure in our data.

**Table 1**  
Demographic Information of Participants (N = 175).

Variables	F (%)
Gender	
Male	120 (68.6)
Female	55 (31.4)
Age of Students	
18-22 years	12 (6.9)
23-26 years	104 (59.4)
27-30 years	59 (33.7)
Education Level	
Learning Language Program	43 (24.6)
Bachelors	45 (25.7)
Master	55 (31.4)
Ph.D.	32 (18.3)
Mobile Device usage for Language Learning	
Daily	127 (72.6)
Weekly	26 (14.9)
Occasionally	18 (10.3)
Never	4 (2.2)
Chinese's learning Mobile Application	
Hello Chinese	49 (28.0)
Duolingo	73 (41.7)
Chinese Skill	25 (14.3)
Any other App	28 (16.0)

5. Data collection

The final questionnaire was made up of 55 items, 6 scales. The approximate time to complete the survey was 15–20 min. The survey was administered online and structured with a progress indicator and basic instructions. Respondents were encouraged to complete the survey in one sitting and environment free of distractions in order to reduce the possibility of questionnaire fatigue. All scales were reliable considering the length of the survey and that the respondents showed high internal consistency.

6. Data analysis

The data were then analyzed. All survey measures were computed using descriptive statistics, regression and mediation analysis (PROCESS).

7. Ethical consideration

Ethical guidelines were followed very carefully throughout the data collection process. The written informed consent was taken from the participants and identities of participants were kept anonymous and the data were stored in a secured format. The study followed the university's ethical standards for research among human participants, and an approval was obtained from the Institutional Review Board (IRB) before the start of the study.

**Table 2**  
Psychometric Properties of the Scale (N = 175).

Scales	Items	$\alpha$	M	(SD)	Skewness	Kurtosis
MBLL	15	0.99	62.9	12.5	-0.967	0.279
FLSA	13	0.99	23.4	12.2	1.08	0.393
LCLA	4	0.97	7.4	3.5	0.809	-0.207
LE	9	0.98	37.9	7.4	-0.741	-0.520
LA	4	0.96	16.8	3.2	-1.09	1.03
CL	10	0.98	18.2	7.8	0.747	-0.059

Note: MBLL = Mobile Based Language Learning, FLSA = Foreign Language Speaking Anxiety, LCLA = Learning Chinese language anxiety, CL = Cognitive Load, LE = Language Engagement, LA = Language Achievement.

8. Results

Table 1 provides the demographic characteristics of the participants in the sample (N = 175). The sample was composed of 175 participants, of whom, 68.6 % (n = 120) were men and 31.4 % (n = 55) were women. Most of the students' ages were between 23 and 26 years (59.4 %), 27 and 30 years (33.7 %), and an even smaller group 18 and 22 years (6.9 %). In level of education, 24.6 % of the participants reported a level of education in language learning, 25.7 % had a bachelor, 31.4 % either a master's or in process of the degree, and 18.3 % were at a doctorate level. In what situations/tasks will the participants use their mobile devices to language learning, most stated (72.6 %) they will use their mobile devices daily compared with being (14.9 %) once a week, (10.3 %) occasionally, and (2.2 %) stated they will never use a mobile device to language learning. Of the applications for Chinese language learning, (41.7 %) of participants reported to use Duolingo, (28.0 %) used Hello Chinese, (14.3 %) used Chinese Skill, and (16.0 %) used other applications.

Table 2 shows the psychometric properties of the measures used in the current study with a sample size of 175 participants. The Mobile-Based Language Learning (MBLL) measure had 15 items and excellent internal consistency ( $\alpha = 0.99$ ), M = 62.9, SD = 12.5, skewness = -0.967, kurtosis = 0.279. The Foreign Language Speaking Anxiety (FLSA) measure, which had 13 items, also had excellent reliability ( $\alpha = 0.99$ ), M = 23.4, SD = 12.2, skewness = 1.08, kurtosis = 0.393. The Chinese Language Learning Anxiety (LCLA) measure had 4 items, had a reliability of  $\alpha = 0.97$ , and the M = 7.4, SD = 3.5, skewness = 0.809, kurtosis = -0.207. The Learning Engagement (LE) measure had 9 items, and reported a reliability of  $\alpha = 0.98$  (M = 37.9, SD = 7.4, skewness = -0.741, kurtosis = -0.520). Additionally, the 4-item Language Achievement (LA) measure had a reliability of  $\alpha = 0.96$  and the mean score was 16.8 (SD = 3.2) with skewness = -1.09 and kurtosis = 1.03. Finally, the Cognitive Load (CL) measure had a total of 10 items and evidenced strong internal consistency ( $\alpha = 0.98$ ) and the means were 18.2 (SD = 7.8), with skewness = 0.747 and kurtosis = -0.059. The values shown in Table 2 indicate reliability and normality across all measurements.

Language achievement (LA) data for participants is presented in Table 3. Mean self-reported language achievement score was 3.75 (SD = 0.92). Course scores ranged from 0 to 100 and had a mean of 80.5 (SD = 11.4).

Table 4 shows the direct path analysis of Mobile-Based Language Learning (MBLL), Cognitive Load (CL), and three language learning outcomes. As seen in the second column of Table 4, MBLL negatively and significantly predicts Foreign Language Speaking Anxiety (FLSA) ( $\beta = -0.61, p < .001, R^2 = 0.37$ ), and Learning Chinese Language Anxiety (LCLA) ( $\beta = -0.62, p < .001, R^2 = 0.38$ ), which indicates that the more you utilize mobile-based learning approaches, the less language anxiety you experience. In terms of CL, MBLL negatively and significantly predicts CL ( $\beta = -0.38, p < .001, R^2 = 0.14$ ), which indicates that mobile learning reduced cognitive load while learning the languages. Also, MBLL significantly positively predicts Learning Engagement (LE) ( $\beta = 0.71, p < .001, R^2 = 0.50$ ) and Language Achievement (LA) ( $\beta = 0.63, p < .001, R^2 = 0.40$ ) meaning, in other words, using mobile-based language tools and approaches helped facilitate active participation, but also demonstrated improvements in students' academic performance. Finally, Table 4 also indicates that CL positively predicts FLSA ( $\beta = 0.47, p < .001, R^2 = 0.22$ ) and LCLA ( $\beta = 0.36, p < .001, R^2 = 0.13$ ) which indicates that as the cognitive load becomes lighter and decreases, the

Table 3  
Language Achievement (LA).

Variable	M (SD)	Range
Self-Reported LA	3.75 (0.92)	1-5
Course Grade	80.5 (11.4)	0-100

Table 4  
Direct path analysis regression result.

Direct Path	B	SE	$\beta$	t-value	p	R <sup>2</sup>
MBLL → FLSA	-0.59	0.05	-0.61	-10.1	0.001	0.37
MBLL → LCLA	-0.17	0.017	-0.62	-10.4	0.001	0.38
MBLL → CL	-0.23	0.044	-0.38	-5.37	0.001	0.14
MBLL → LE	0.42	0.032	0.71	13.3	0.001	0.50
MBLL → LA	0.16	0.015	0.63	10.8	0.001	0.40
CL → FLSA	0.73	0.10	0.47	7.09	0.001	0.22
CL → LCLA	0.16	0.032	0.36	5.10	0.001	0.13
CL → LE	-0.41	0.065	-0.440	-6.44	0.001	0.19
CL → LA	-0.21	0.027	-0.520	-8.015	0.000	0.27

Note: MBLL = Mobile Based Language Learning, FLSA = Foreign Language Speaking Anxiety, LCLA = Learning Chinese language anxiety, CL = Cognitive Load, LE = Language Engagement, LA = Language Achievement.

Table 5  
Mediating role of cognitive load between mobile base language learning and foreign language speaking anxiety (N = 175).

Mediation Path	$\beta$	SE	95 % CI LL UL	t	p-value
a (MBLL → Cognitive)	-0.237	0.044	-0.325 -0.150	-5.37	<0.001
b (Cognitive → FLSA)	0.440	0.095	0.252 0.628	4.62	<0.001
c (Total effect)	-0.597	0.059	-0.712 -0.481	-10.20	<0.001
c' (Direct effect)	-0.492	0.060	-0.610 -0.374	-8.24	<0.001
ab (Indirect effect)*	-0.104	0.029	-0.166 -0.053	-	-

Table 6  
Mediating role of cognitive load between mobile base language learning and Learning Chinese language anxiety (N = 175).

Mediation Path	$\beta$	SE	95 % CI LL UL	t	p-value
a (MBLL → Cognitive)	-0.237	0.044	-0.325 -0.150	-5.37	<0.001
b (Cognitive → LCLA)	0.067	0.029	0.010 0.123	2.33	0.021
c (Total effect)	-0.176	0.017	-0.209 -0.142	-10.43	<0.001
c' (Direct effect)	-0.160	0.018	-0.195 -0.124	-8.89	<0.001
ab (Indirect effect)*	-0.016	0.007	-0.032 -0.003	-	-

learners are less anxious about speaking in a foreign language. Additionally, CL also negatively predicts Learning Engagement ( $\beta = -0.44, p < .001, R^2 = 0.19$ ) and Language Achievement ( $\beta = -0.52, p < .001; R^2 = 0.27$ ). Overall, the data from the direct path analysis presents the relevant data that demonstrate the importance of mobile-based language learning to impact educational outcomes by lowering anxiety and cognitive load, but also increasing students learning engagement as well as their levels of achievement.

Table 5 shows the results of the mediation analysis to test if cognitive load mediates the relationship between mobile-based language learning (MBLL) and foreign-language speaking anxiety (FLSA) among 175 participants. The mediation analysis revealed that MBLL significantly predicted cognitive load (a path:  $\beta = -0.237, SE = 0.044, 95\% CI [-0.325, -0.150], t = -5.37, p < .001$ ), which shows that more MBLL was related to less cognitive load. Cognitive load also significantly predicted FLSA (b path:  $\beta = 0.440, SE = 0.095, 95\% CI [0.252, 0.628], t = 4.62, p < .001$ ),

Table 7  
Mediating role of cognitive load between mobile base language learning and Learning Engagement (N = 175).

Mediation Path	$\beta$	SE	95 % CI LL UL	t	p-value
a (MBLL → Cognitive)	-0.237	0.044	-0.325 -0.150	-5.37	<0.001
b (Cognitive → LES)	-0.189	0.053	-0.294 -0.085	-3.57	0.001
c (Total effect)	0.427	0.032	0.364 0.489	13.37	<0.001
c' (Direct effect)	0.382	0.033	0.316 0.447	11.44	<0.001
ab (Indirect effect)*	0.045	0.016	0.017 0.078	-	-

meaning that as cognitive load decreased, language speaking anxiety decreased. The total effect of the MBLL→FLSA relationship was significant and negative (c path:  $\beta = -0.597$ , SE = 0.059, 95 % CI [-0.712, -0.481],  $t = -10.20$ ,  $p < .001$ ). The direct effect remained significant after controlling for cognitive load (c' path:  $\beta = -0.492$ , SE = 0.060, 95 % CI [-0.610, -0.374],  $t = -8.24$ ,  $p < .001$ ) showed that after accounting for cognitive load, MBLL was significantly related to FLSA, even though this effect was reduced from the total effect, indicating some reduction in effect due to cognitive load. The indirect effect (through cognitive load;  $ab = -0.104$ , SE = 0.029, 95 % CI [-0.166, -0.053]) was also significant, because the confidence interval did not include zero. Overall, cognitive load partially mediated the relationship between MBLL and FLSA, and suggests the need for reducing cognitive load in order to reduce language anxiety for learners.

Table 6 summarizes the mediation analysis; cognitive load's role between mobile-based language learning (MBLL) and Learning Chinese Language Anxiety (LCLA) from 175 participants. The b path indicated that MBLL was a significant predictor of cognitive load (a path:  $\beta = -0.237$ , SE = 0.044, 95 % CI [-0.325, -0.150],  $t = -5.37$ ,  $p < .001$ ), with higher MBLL activity being associated with lower cognitive load. The cognitive load variable was a significant predictor of LCLA (b path:  $\beta = 0.067$ , SE = 0.029, 95 % CI [0.010, 0.123],  $t = 2.33$ ,  $p = .021$ ). This suggests that having a lower cognitive load positively relates to lower language anxiety when learning Chinese. The total effect of MBLL on LCLA was significant and negative (c path:  $\beta = -0.176$ , SE = 0.017, 95 % CI [-0.209, -0.142],  $t = -10.43$ ,  $p < .001$ ), and the c' path indicated that the direct effect of MBLL was still significant even after accounting for cognitive load (c' path:  $\beta = -0.160$ , SE = 0.0187, 95 % CI [-0.195, -0.124],  $t = -8.89$ ,  $p < .001$ ). The model also indicates there was an indirect effect of MBLL on LCLA through cognitive load ( $ab = -0.016$ , SE = 0.007, 95 % CI [-0.032, -0.003]), as the confidence interval did not cross zero. This means cognitive load did partially mediate the relationship between mobile-based language learning and learning Chinese language anxiety, indicating that managing cognitive demands may help learners to reduce language anxiety.

Table 7 presents the mediation analysis results examining the role of cognitive load in the relation between mobile-based language learning (MBLL) and learning engagement (LES) for 175 of the 181 participants. The analysis showed that MBLL significantly predicted cognitive load (a path:  $\beta = -0.237$ , SE = 0.044, 95 % CI [-0.325, -0.150],  $t = -5.37$ ,  $p < .001$ ), which suggested greater engagement with mobile-based language learning was associated with lower cognitive load. Cognitive load also significantly predicted learning engagement (b path:  $\beta = -0.189$ , SE = 0.053, 95 % CI [-0.294, -0.085],  $t = -3.57$ ,  $p = .001$ ), which suggested greater cognitive load was associated with lower learning engagement. The total effect of MBLL on LES was significant and positive (c path:  $\beta = 0.427$ , SE = 0.032, 95 % CI [0.364, 0.489],  $t = 13.37$ ,  $p < .001$ ) and the direct effect was still significant when cognitive load was included (c' path:  $\beta = 0.382$ , SE = 0.033, 95 % CI [0.316, 0.447],  $t = 11.44$ ,  $p < .001$ ). The indirect effect of MBLL on LES through cognitive load was also significant ( $ab = 0.045$ , SE = 0.016, 95 % CI [0.017, 0.078]) as the confidence interval did not include zero. Overall, the results demonstrate that cognitive load partially mediates the positive relationship between mobile-based language learning and learning engagement and highlights the significance of reducing cognitive load to promote

**Table 8**  
Mediating role of cognitive load between mobile base language learning and Language Achievement (N = 175).

Mediation Path	$\beta$	SE	95 % CI LL UL	t	p-value
a (MBLL → Cognitive)	-0.237	0.044	-0.325 -0.150	-5.37	<0.001
b (Cognitive → LA)	-0.137	0.025	-0.185 -0.089	-5.59	<0.001
c (Total effect)	0.167	0.015	0.137 0.197	10.82	<0.001
c' (Direct effect)	0.135	0.015	0.104 0.165	8.74	<0.001
ab (Indirect effect)*	0.033	0.009	0.017 0.050	-	-

engagement with mobile-based language learning.

The mediation analysis presented in Table 8 examined the effect of cognitive load in the relationship between mobile-based language learning (MBLL) and language achievement (LA) in 175 respondents. The results indicate that MBLL predicts cognitive load (a path:  $\beta = -0.237$ , SE = 0.044, 95 % CI [-0.325, -0.150],  $t = -5.37$ ,  $p < .001$ ) and higher levels of MBLL is associated with lower levels of cognitive load. Furthermore, cognitive load significantly predicts language achievement (b path:  $\beta = -0.137$ , SE = 0.025, 95 % CI [-0.185, -0.089],  $t = -5.59$ ,  $p < .001$ ), indicating that higher cognitive load associates with lower levels of LAS. The total effect of MBLL on LA was significant and positive (c path:  $\beta = 0.167$ , SE = 0.015, 95 % CI [0.137, 0.197],  $t = 10.82$ ,  $p < .001$ ) and after controlling for cognitive load, the direct effect remained significant (c' path:  $\beta = 0.135$ , SE = 0.015, 95 % CI [0.104, 0.165],  $t = 8.74$ ,  $p < .001$ ). Further, the effect of MBLL on LA through cognitive load was significant ( $ab = 0.033$ , SE = 0.009, 95 % CI [0.017, 0.050],) since the confidence interval did not include zero. Overall, the significant mediation indicates that cognitive load partially mediated the positive relationship between mobile-based language learning and language achievement and as cognitive demand diminishes it is more likely to improve language achievement among learners.

## 9. Discussion

This study aimed to investigate the influence of Mobile-Based Language Learning (MBLL) on speaking and learning anxiety, engagement and achievement of international students learning Chinese, with a specific emphasis on cognitive load as a mediating variable. The discussion provides new ways of thinking about mobile technology can be used to counter cognitive and affective challenges in learning a language with high linguistic and cultural complexity such as Chinese.

The results show that MBLL has a significant impact on the reduction of both foreign language speaking anxiety (FLSA) and Chinese language learning anxiety (LCLA) in international students. The effect is even more remarkable for the complexities of the Chinese language given the specific features: tonal system of Chinese, character-based writing system, and relatively complex syntactic structures (Bao & Du, 2015; Luo, 2015). All three of these features have been shown to increase anxiety and inhibit oral proficiency performance in learners from non-tonal alphabetic languages (Liu & Xiangming, 2019). This research reinforces previous research suggesting that anxiety presents a major obstacle in both communicative competence and engagement in foreign language learning (Suleimenova, 2013; Wu et al., 2022). The reduction of anxiety provided in this study can be attributed to several aspects of MBLL environments. First, mobile applications allow for self-paced, privately, and with repetition; students can practice and develop skills without the pressure of peer judgment or judgment by their teacher (Bai, 2024; Melchor-Couto, 2016). Many MBLL applications are gamified with a level of simulated stress relief and often have automatic feedback with features like voice recognition; both can create a sense of accomplishment and opportunities for students to make mistakes and correct them in a comfortable environment (Zhou, 2024). This tension is consistent with models of language anxiety that define the importance of perceived control and safe, judgment-free spaces for learning (Martin & Alvarez Valdivia, 2017).

An important finding from this research is that the anxiety-reducing effects of MBLL are mediated, in part, by a reduction in cognitive load. Research on cognitive load (Sweller, 2010; Sweller et al., 2019) demonstrates that language learning, particularly for a complex language, such as Chinese, can place strain on the learner's working memory which can lead to a sense of overwhelmed working memory load when cognitive demands made by the instructional design data exceeds the working memory capacity of the learner and [degrades performance and affective outcome]. The current findings in this study demonstrate that MBLL not only reduce extraneous cognitive load (e.g., through intuitive interfaces and bundled or segmented content) but also enable the

support of germane cognitive load to support core learning tasks (Faber et al., 2024; Wang et al., 2018). As cognitive load reduced, so did anxiety and learners could focus and devote their mental resources to authentic language use and practice.

The investigation also determined that the benefits to language engagement and language achievement were very significant according to self-report data and final course grades. The increase in engagement could be a by-product of MBLL's ability to incorporate interactive content, gamified tasks, and instant feedback - all of which would increase students' intrinsic motivation and persistence (Freeman et al., 2023; Hellín et al., 2023). MBLL allows students to practice language as often and flexibly as they wish, and when they practice language freely and independently, MBLL provides these students with many opportunities to remain continuously engaged with the target language. In this way, MBLL connects the language learning environment, through formal study, and to independent study (Muir et al., 2019). For international students, who must adjust to new language and cultural norms, the capacity to practice anytime and anywhere has a potentially unique value (Salhab & Daher, 2023a).

The language achievement enhancements seen in the current study are in line with other meta-analyses reporting that mobile learning technologies can increase vocabulary, pronunciation, and language proficiency (Cho et al., 2018; Pedraja-Rejas et al., 2024). The mediation analyses indicate that the improvements in cognitive load partially explained the impact of MBLL on both engagement and achievement. Given these results, mobile learning benefits may not only stem from novelty or convenience, but also to the relative advantage of mobile learning as it aligns task demands with learner capacity (Sweller, 2020).

While previous research has demonstrated the positive influence of MBLL on language outcomes (Bai, 2024; Zhou, 2024), only a limited number of studies have investigated cognitive load, as a mediating mechanism in MBLL, especially in the context of Chinese as a foreign language. Results from the present study add to the body of literature relating to cognitive load theory in that it provides a basis for understanding reductions in extraneous cognitive load relate not subsequently to performance benefits, but to affective benefits (e.g., less anxiety, increased engagement). A comprehensive understanding of cognitive load effects is particularly relevant to language learning arenas that can be high stakes and high difficulty. Furthermore, through the inclusion of both self-reported and objective (course grade) indicators of achievement, this study provides a better reflection of the impact of MBLL, responding to critics in the literature about an over-reliance of self-reported outcomes (Marian et al., 2007).

## 10. Implications for Language Learner

The results provide valuable implications for language teachers and curriculum developers. Including MBLL tools within Chinese language programs can lead to more scaffold, motivating and cognitively efficient learning experiences. However, it is important to select or develop mobile applications that have easy to follow navigation, adaptive scaffolding, and opportunities for repetitive independent practice. Reducing cognitive load should be a specific part of teaching, especially for learners experiencing complex levels of language or anxiety.

## 11. Limitations and Future Suggestion

The study has few limitations. As 175 participants are the samples which are not generalize the wider population of language learners or cultural background perspective. The study also used self-report measure, more objective measures of language proficiency, like standardized tests or performance based assessment (HSK and IELTS), could be used for future research. Moreover, the investigations are built on a particular language (i.e., Chinese), which to an extent limits the generalizability to learners of different languages. Future research should explore the effects of MBLL separately on the three forms of cognitive load, intrinsic,

extraneous, and germane, rather than only on a cumulative score. If the instrument permits, the exploration of these sub-dimensions separately will provide a more accurate understanding of how MBLL interventions can limit cynical loads (extraneous) and enhance learning experience (intrinsic and germane) for better language-learning outcomes.

## 12. Conclusion

This study investigated the impact of mobile-based language learning (MBLL) on language anxiety, speaking anxiety, engagement, and achievement for international students learning Chinese as a foreign language, and cognitive load mediated this relationship. The study results showed that MBLL reduces language speaking anxiety and learning anxiety in learners of Chinese, which is significant due to Chinese being noted as a language with unique language issues. Additionally, MBLL result showed the increased learning engagement and language achievement through self-reported and objectively measured course performance. The study results also revealed that engagement and language achievement are partially mediated through a reduction in cognitive load whereby less cognitive overload resulted in less anxiety, higher engagement, and a likely higher level of achievement.

## Abbreviations

MBLL	Mobile-Based Language Learning
FLSA	Foreign Language Speaking Anxiety
LCLA	Learning Chinese language anxiety
CL	Cognitive Load
LE	Language Engagement
LA	Language Achievement

## CRediT authorship contribution statement

**Barsha Puri:** Validation, Software, Resources, Formal analysis, Data curation. **Iqra Mushtaque:** Writing – original draft, Project administration. **Shuanghu Fang:** Writing – review & editing, Supervision, Conceptualization. **Guo Chenhe:** Software, Resources, Investigation, Data curation. **Ammar Younas:** Resources, Investigation, Data curation.

## Consent for publication

Not applicable.

## Ethical approval

All the methods were performed in accordance with the Declaration of Helsinki. The study was approved by the Research Ethics Board (TSUL/RB-199-21). All the participants provided informed consent.

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## Declaration of competing interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest. The authors declare no conflict of interest.

## Data availability

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

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