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Journal of Advanced Research in Social and Behavioural Sciences

Journal homepage:
https://karyailham.com.my/index.php/jarsbs/index
ISSN: 2462-1951


# Constructing and Validating the Google Meet Mandarin Learning Scale (GMLS) for Malaysian Public Local University Students: Exploratory and Confirmatory Factor Analysis Approaches

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**ARTICLE INFO**

***Article history:***
Received 29 March 2026
Received in revised form 18 May 2026
Accepted 20 July 2026
Available online 26 August 2026

***Keywords:***
Confirmatory factor analysis; google meet; Exploratory Factor Analysis; local university; Technology Acceptance Model

**ABSTRACT**

The widespread adoption of digital learning platforms during the COVID-19 pandemic has emphasized the need for proficiency in using tools like Google Meet (GM) for education. In Malaysia, the enforcement of the Movement Control Order (MCO) further accelerated the shift to online learning, particularly for language courses. However, research suggests that tertiary students' acceptance and effective use of Google Meet for Mandarin language learning remain suboptimal or unsatisfactory level. This study aims to address this issue by developing and validating the Google Meet Mandarin Learning Scale (GMLS) to assess key factors influencing learners' adoption of GM for Mandarin learning. Grounded in the Technology Acceptance Model (TAM) and the Unified Theory of Acceptance and Use of Technology (UTAUT), the study employed a cross-sectional research design. A pilot study with 139 responses underwent Exploratory Factor Analysis (EFA) using SPSS to refine the instrument, followed by Confirmatory Factor Analysis (CFA) on 366 responses using AMOS, ensuring the scale's validity and reliability. The GMLS provides critical insights into the facilitators and barriers affecting students' acceptance of Google Meet in Mandarin learning. The findings contribute to optimizing digital learning environments by offering a validated instrument for educators and policymakers to enhance students' engagement and learning outcomes. This study underscores the importance of technology integration in language education, supporting a more interactive and effective Mandarin learning experience.

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https://doi.org/10.37934/arsbs.45.1.352373

## 1. Introduction

The importance of e-learning has been highlighted, particularly since the implementation of the Movement Control Order (MCO) in Malaysia several years ago. During this period, the country's education system underwent a significant shift from traditional classroom teaching to online platforms, with Google Meet (GM) emerging as a crucial tool [6,29,31]. Consequently, Google Meet has become a vital platform for learning across all levels, from primary school to tertiary education, marking a transition from traditional teaching methods to e-learning-based approaches in Malaysia (1,12,36,74]. In essence, the COVID-19 pandemic has completely transformed the educational method from face-to-face to online learning. Looking ahead, e-learning is poised to dominate the educational industry [22,66,76,132].

According to recent research, the Google Meet application has been recognized as a highly interactive, engaging, accessible, and adaptable learning tool. The use of Google Meet allows learners to engage in real-time interactions with instructors and peers, effectively overcoming the traditional barriers of physical distance and rigid scheduling [73,110.]. This platform supports a range of multimedia content and collaborative tools such as breakout rooms, polls, and screen sharing, enhancing the learning experience [30, 66,95]. Consequently, proficiency in utilizing the Google Meet application is increasingly viewed as a critical skill for learners, equipping them to participate effectively in modern educational environments [21,64,69].

The Google Meet application plays a significant role in modern educational settings; however, several studies have identified key obstacles that hinder its effective utilization, particularly in the context of language learning. These challenges include a lack of technical skills among learners, insufficient knowledge of the platform's features, low confidence in using the application, the absence of appropriate instructional strategies, and a lack of clear directions or guidelines [40, 41,88,71,135]. Collectively, these factors create barriers that impede the optimal use of Google Meet, especially in enhancing language skills where active interaction is crucial. Moreover, while numerous studies have documented the problems associated with learning via Google Meet, there is a notable lack of research proposing effective solutions or models to address these issues. This research gap is particularly significant in areas requiring soft skills development, such as foreign language acquisition, especially Mandarin, which is considered one of the most difficult languages in the world [56]. The nuances of communication and cultural expressions are best learned through interactive and engaging methods. Therefore, this situation underscores the urgent need for more targeted research focused on developing practical, evidence-based strategies and models specifically designed to overcome these barriers.

To address this challenge, this study aims to develop a practical model that enhances the use of the Google Meet application for language learning. This model seeks to overcome barriers such as technical skill deficits, insufficient platform knowledge, and low user confidence by providing clear guidance and tailored instructional strategies. By equipping learners with necessary skills and engaging them with dynamic, culturally relevant content, the model is designed to create a more immersive and effective learning environment. This approach aims to make virtual language learning as impactful as traditional classroom experiences.

## 2. Literature Review

Central to the discipline of new technology acceptance in learning, the Technology Acceptance Model (TAM) serves as a critical framework for understanding how learners adopt and engage with educational technologies [18,78]. Developed by Fred Davis in 1989, TAM explains how users come to

accept and use technology, positing that two main factors: perceived usefulness (the belief that using a particular technology will enhance learning performance) and perceived ease of use (the extent to which a user finds the technology easy to use), are key determinants of technology adoption [18,38, 78,117,101].

While TAM has been widely applied in educational research to explore how students and educators adopt digital tools, some scholars critique it for oversimplifying the complexities of today's rapidly evolving technological landscape (14,16,44,111). They argue that TAM may not fully capture the nuanced and dynamic factors influencing technology adoption in real-world educational settings, where technological advancements occur at an unprecedented pace [48,49,60,124]. To address these limitations, extensions of TAM, such as the Unified Theory of Acceptance and Use of Technology (UTAUT), have been developed. UTAUT expands on TAM by incorporating additional factors like social influence, facilitating conditions, effort expectancy, and performance expectancy, providing a more comprehensive framework for understanding technology acceptance across various contexts [38,116,123,128]. While these extensions offer a broader perspective, they also present challenges, primarily in identifying and integrating relevant variables that reflect the specific factors influencing technology adoption in unique settings. In educational contexts, especially Mandarin learning, there is a need to incorporate additional constructs like learning motivation and technology self-efficacy. These factors can help create a more robust model that better predicts technology adoption, addressing the complexities of the educational environment and the specific needs of language learners (16,30,58,69,71,104,117,126,129).

According to Gardner's socio-educational model, highly motivated learners are more likely to invest effort, persist in the face of challenges, and seek out additional resources to enhance their learning, which can include adopting new technologies. While Gardner did not specifically address technology, his broader insights into the role of motivation in learning suggest that motivated learners are more likely to adapt to new methods and tools, such as digital platforms, to support their educational goals. This assertion is supported by studies highlighting the positive correlation between motivation and the adoption of new technologies in educational settings [6,27,43,75). For example, Liu and Li [77] found that students with high intrinsic motivation were more inclined to use technology as a supplementary tool for their studies, demonstrating greater engagement and persistence in digital learning environments. Similarly, Teo [117] emphasized that motivation significantly influences students' attitudes towards adopting new technologies, such as e-learning platforms, where motivated students are more likely to explore and utilize these resources effectively. In the context of language learning, Warschauer [127] noted that students motivated to learn a language are more proactive in using available technological resources, including language apps and online communication tools, to enhance their learning experiences. Dörnyei [37] also suggested that motivated language learners are more adaptable and willing to experiment with new learning methods, including technology-based solutions, to achieve their educational objectives. Collectively, these findings prove that motivation plays a crucial role in the willingness and ability of learners to adapt to new educational technologies, supporting Gardner's broader claims about the impact of motivation on learning behavior [34,74,106,84,133].

Apart from learning motivation, technology self-efficacy is another significant factor influencing technology adoption in educational settings. Numerous studies have demonstrated that incorporating technology self-efficacy provides a better understanding and creates a more comprehensive model for predicting technology acceptance [2,30,55,85,91,108,118,121,126]. Research has suggested that technology self-efficacy should act as a mediator within TAM, as it directly impacts users' perceptions of ease of use and usefulness, thereby influencing their intention to adopt the technology [57,61,92,119,121]. Venkatesh and Bala [121] highlighted that technology

self-efficacy mediates the relationship between external factors, perceived ease of use, and perceived usefulness in their TAM3 model, enhancing TAM's explanatory power. Lee *et al*., [70] found that self-efficacy mediates the effects of external variables on user perceptions in e-learning contexts, reinforcing its critical role in technology adoption. Similarly, Ong and Lai [89] demonstrated that self-efficacy serves as a mediator between system accessibility and perceived usefulness, suggesting that users' confidence in their ability to use technology is pivotal in adoption decisions. Ng and Abbott [86] affirmed that self-efficacy mediates the impact of perceived ease of use on the intention to use learning management systems, underscoring its significance in educational technology settings. Thus, technology self-efficacy as a mediator enriches the understanding of technology acceptance and provides valuable insights into designing interventions that can effectively boost user adoption in various educational contexts [5,14,18,42,45,46,102,109]. Based on the evidence and recommendations from previous studies, it is strongly supported that self-efficacy should play a pivotal role as a mediator in the TAM model, enhancing the predictive power of the model by accounting for users' confidence in their ability to use the technology. This mediator role of self-efficacy not only bridges the gap between perceived ease of use and perceived usefulness but also influences the overall intention to adopt and effectively utilize the technology. In this study, the researcher established a framework that integrates perceived usefulness, perceived ease of use, and learning motivation as independent variables, with technology self-efficacy acting as a mediator (exogenous variable). The Google Meet Application Mandarin Learning (GMLS) serves as the dependent variable (endogenous variable). The relationships among these variables are visually represented in Figure 1 below:

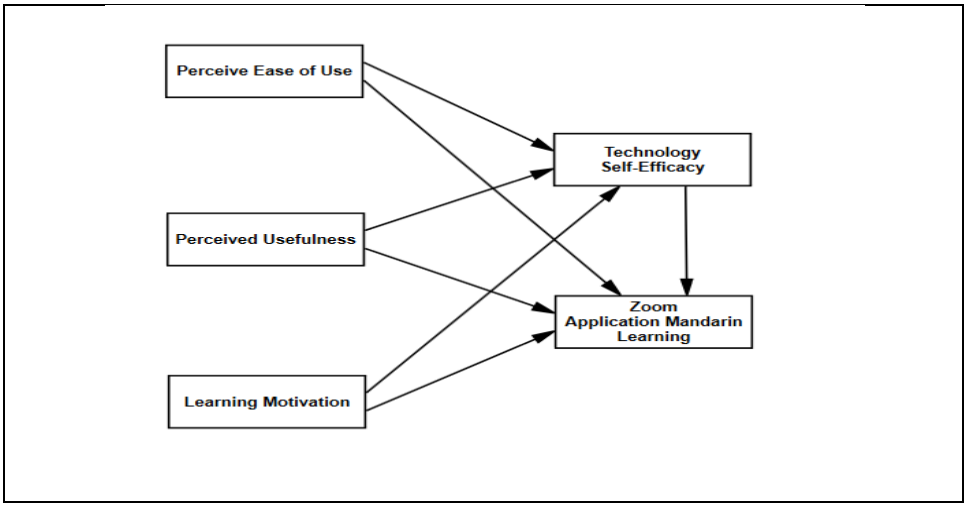


**Fig. 1.** Theoretical framework

This study extends the TAM model and UTAUT by incorporating learning motivation and technology self-efficacy as mediators to develop a more reliable instrument for measuring the influence of the Google Meet Application Mandarin Learning Scale. Perceived usefulness, perceived ease of use, and learning motivation will serve as independent variables, with technology self-efficacy acting as a mediator (exogenous), while the Google Meet Application Mandarin Learning Scale functions as the dependent variable (endogenous). In other words, this extended model aims to provide a comprehensive understanding the influences of these factors collectively affect Mandarin learners' adoption and effective use of Google Meet in their learning process. By positioning technology self-efficacy as a mediator, the study seeks to investigate the impact of confidence in

using technology enhances the perceived usefulness and ease of use, thereby positively impacting learning motivation and, ultimately, the adoption of Google Meet as a learning tool.

Therefore, the current study aims to develop and validate the Google Meet Application Mandarin Learning Scale (GMLS). This model is expected to provide a better understanding of the interplay between psychological factors and technology acceptance. Ultimately, it can offer a clear perspective on the development of targeted strategies to support learners in overcoming barriers to technology adoption, fostering a more engaging and effective learning environment. Additionally, the insights gained from this study will be valuable for educators and policymakers striving to enhance digital learning experiences for Mandarin learners, guiding them in implementing more effective and supportive educational practices

## 3. Methodology

This study employed a cross-sectional research design, collecting data at a single point in time [105]. Data for both the pilot and actual studies were gathered from eight language faculties at Malaysian universities, including the University of Malaya (UM), University Putra Malaysia (UPM), University Utara Malaysia (UUM), University Teknologi Malaysia (UTM), University Sains Malaysia (USM), University Malaysia Perlis (UNIMAP), University Perguruan Sultan Idris (UPSI), and University Malaysia Kelantan (UMK). Cluster sampling was used to select respondents among Mandarin Level-3 learners. The questionnaire was constructed by adapting instruments from previous research. For instance, items measuring perceived ease of use were adapted from Davis [32] and Teo [117]. The instrument for perceived usefulness was based on Davis [32], Venkatesh and Davis [122], and Venkatesh *et al*., [123]. Learning motivation items were adapted from Deci and Ryan [34], Fryer and Bovee [43], and Lin *et al*., [75]. Additionally, items for assessing the use of the Google Meet application for Mandarin learning were developed based on an elicitation survey, as recommended by Francis *et al*., [40]. This survey included responses from 26 participants, exceeding the recommended minimum of 25 [40].

A pre-test was conducted to ensure content, face, and criterion validity of the GMLS before the actual fieldwork. Content validity was assessed by five experts who were experienced academicians teaching Mandarin courses for over 15 years. Criterion validity was evaluated by a statistical expert to ensure the scale appropriately measured the intended constructs. To establish face validity, the GMLS was translated from English to Malay (Bahasa Malaysia) using back-translation by a certified translator. This process is crucial for enhancing clarity, cultural relevance, and comprehension of survey instruments, particularly when targeting specific linguistic groups. Best practices in translation and validation emphasize back-translation and the involvement of native speakers to achieve accurate and culturally appropriate adaptations [24,79]. These practices are especially important when respondents are more comfortable with their native language, as they help maintain the instrument's validity and reliability across different cultural settings [15,70]. Following the validation procedure, the GMLS was pre-tested on 15 randomly selected respondents to evaluate the consistency of their responses and gather feedback on ambiguous terms, question clarity, and overall questionnaire design. Identified issues were resolved before conducting the pilot study and the main survey [85]. After revisions based on expert feedback and pre-test results, a pilot study was conducted, yielding 106 valid responses, which met the required minimum sample size of 100 [7,11]. The pilot data were subjected to exploratory factor analysis (EFA) before the main survey.

The finalized Google Meet Application Mandarin Learning Scale (GMLS) consisted of 28 items, excluding demographic questions. It employed a 10-point interval scale ranging from 1 (strongly disagree) to 10 (strongly agree), following recommendations from Awang [10-12], Cummins and

Gullone [31], Dawes [33] and Preston and Colman [94] to ensure more detailed insights, reduce skewness in data distribution, and enhance the psychometric properties of the survey instruments. The survey was distributed to 400 respondents, with 389 providing feedback, resulting in an excellent response rate of 97.25% [20]; 366 of these were valid. Data analysis was conducted using the Statistical Package for Social Science (SPSS) for data screening and exploratory factor analysis (EFA), while the Analysis of Moment Structures (AMOS) was used to validate the measurement model for unidimensionality, validity, and reliability through confirmatory factor analysis (CFA) [1,7,8,96].

## 4.Results

### *4.1 Exploratory Factor Analysis (EFA)*

The core objective of Exploratory Factor Analysis (EFA) is to identify and summarize the underlying structure within a set of variables by grouping those that are highly correlated, thereby reducing data complexity and aiding in the identification of latent constructs [85]. In this study, EFA was conducted using pilot study data to uncover the key dimensions of perceived usefulness, perceived ease of use, learning motivation, technology self-efficacy, and the Google Meet Application Mandarin Learning. When performing EFA, several critical criteria must be met to ensure the validity of the results. First, the Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy should be above 0.50, indicating that the sample is adequate for factor analysis. Second, Bartlett's test of sphericity must be significant at $p < 0.001$, confirming that correlations among the variables are sufficiently large for EFA, as recommended by Hair *et al*., [50], Awang [11,12], and Bahkia *et al*., [11]. These tests ensure that the factor structure identified is robust and suitable for further analysis.

Table 1 outlines the results of the KMO and Bartlett's test of sphericity for perceived usefulness, perceived ease of use, learning motivation, technology self-efficacy, and the Google Meet Application Mandarin Learning. The values of KMO for all constructs exceeded 0.5. The Bartlett's test of sphericity results for all constructs were significant ($p < 0.001$) as recommended by Hair *et al*., [48,49,50], Bahkia *et al*., [11], Rahlin *et al*., [96], and Shkeer and Awang [10].

**Table 1**
Results of KMO and Bartlett's Test of Sphericity

| Construct | KMO (>0.50) | Bartlett's Test of Sphericity (p<0.001) |
|---|---|---|
| Perceived Usefulness | 0.765 | 0.00 |
| Perceived Ease of Use | 0.820 | 0.00 |
| Learning Motivation | 0.767 | 0.00 |
| Technology Self-Efficacy | 0.806 | 0.00 |
| Google Meet Application Mandarin Learning | 0.818 | 0.00 |

During the exploratory factor analysis (EFA), the principal component analysis (PCA) method was employed to extract and evaluate factors, guiding the decision on which factors to retain or eliminate. To improve the clarity and interpretability of the analysis, varimax rotation, an orthogonal rotation technique commonly used in factor analysis was applied [29]. Factors with loadings below the threshold of 0.5 were considered insignificant and subsequently removed from further analysis, while those with loadings above 0.5 were deemed significant and retained for inclusion in the measurement model [29]. The results of the rotated component matrix are presented in Table 2 below.

**Table 2**
Rotated component matrix for all constructs

| No | Sub-Construct | Item Label | Rotated Component Matrix Item Statement | Component 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|---|---|
| 1 | | Pu1 | Google Meet enhances my understanding of Mandarin. | .591 | | | | |
| 2 | | Pu2 | Google Meet helps me improve my Mandarin skills. | .692 | | | | |
| 3 | Perceived Usefulness | Pu3 | Google Meet is valuable for practicing Mandarin conversation. | .735 | | | | |
| 4 | | Pu4 | Google Meet significantly contributes to my overall Mandarin learning experience. | .666 | | | | |
| 5 | | Pu5 | Google Meet enhances my ability to learn Mandarin effectively. | .655 | | | | |
| | | Pu6 | Google Meet is beneficial for my Mandarin proficiency. | .721 | | | | |
| | | Pu7 | Google Meet provides useful resources to improve my Mandarin skills. | **.493*** | | | | |
| 1 | | Pe1 | Google Meet is efficient for Mandarin classes. | | .686 | | | |
| 2 | | Pe2 | Google Meet ’s features make Mandarin learning easy. | | .669 | | | |
| 3 | Perceived Ease of Use | Pe3 | Google Meet is straightforward for Mandarin learning. | | .569 | | | |
| 4 | | Pe4 | Google Meet boosts my confidence in Mandarin learning. | | .610 | | | |
| 5 | | Pe5 | Google Meet ’s interface helps me understand Mandarin better. | | .585 | | | |
| 6 | | Pe6 | Google Meet requires minimal effort for Mandarin learning. | | **.427*** | | | |
| 7 | | Pe7 | I can easily access Google Meet ’s tools for Mandarin learning. | | .572 | | | |
| 1 | | Lm1 | I am eager to learn Mandarin through Google Meet. | | | .666 | | |
| 2 | | Lm2 | Learning Mandarin on Google Meet aligns with my academic goals. | | | **.394*** | | |
| 3 | Learning Motivation | Lm3 | I am willing to put extra effort into Mandarin lessons on Google Meet. | | | .660 | | |
| 4 | | Lm4 | I stay motivated to learn Mandarin on Google Meet, even when it's challenging. | | | .679 | | |
| 5 | | Lm5 | I am confident in improving my Mandarin skills with Google Meet. | | | .605 | | |
| | | Lm6 | I enjoy Mandarin classes on Google Meet. | | | .726 | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | Lm7 | I am motivated to excel in Mandarin learning through Google Meet. | .801 | | |
| 1 | | Ts1 | I feel confident using Google Meet for Mandarin learning. | | .556 | |
| 2 | | Ts2 | I can easily navigate Google Meet features. | | .685 | |
| 3 | | Ts3 | Using Google Meet for Mandarin learning comes naturally to me. | | ***.466*** | |
| 4 | | Ts4 | I can handle technical issues on Google Meet for Mandarin classes. | | .689 | |
| 5 | Technology Self-Efficacy | Ts5 | I adapt quickly to Google Meet updates and new features. | | .630 | |
| 6 | | Ts6 | Overall, I am confident in using Google Meet for my Mandarin studies. | | .773 | |
| 1 | | Za1 | Google Meet has improved my Mandarin skills. | | | .820 |
| 2 | Google Meet Application Mandarin Learning | Za2 | I am more engaged learning Mandarin on Google Meet than with traditional methods. | | | .795 |
| 3 | | Za3 | Google Meet provides valuable interaction with peers and instructors. | | | ***.456** |
| 4 | | Za4 | I am satisfied with learning Mandarin on Google Meet. | | | .691 |
| 5 | | Za5 | Google Meet has greatly enhanced my Mandarin knowledge. | | | .796 |
| 6 | | Za6 | I plan to continue using Google Meet for Mandarin learning. | | | .769 |
| 7 | | Za7 | Learning Mandarin on Google Meet has been rewarding. | | | **.326*** |

Based on the results in Table 2, the rotated component matrix indicated that all 34 items were appropriately sorted into five components. The final EFA results for all constructs revealed five distinct components, with 28 items having factor loadings above 0.5, making them valid. Items with factor loadings below 0.5 were eliminated [29]. Since the items for each component remained distinct and did not overlap across the five components, the labels for the components were retained as follows: perceived ease of use, perceived usefulness, learning motivation, technology self-efficacy, and Google Meet application for learning Mandarin.

Subsequently, the researcher summarized the EFA results, indicating the number of items for each construct before and after the analysis. The results are presented in Table 3 below:

**Table 3**
Item retention result after EFA

| No | Construct | Items before EFA | Number of Items Dropped | Number of Items Retained after EFA |
|---|---|---|---|---|
| 1 | Perceived Usefulness (PUS) | 7 | 1 | 6 |
| 2 | Perceived Ease of Use (PEU) | 7 | 1 | 6 |
| 3 | Learning Motivation (LS) | 7 | 1 | 6 |
| 4 | Technology Self-Efficacy (TsSE) | 6 | 1 | 5 |
| 5 | Google Meet Application Mandarin Learning (MZL) | 7 | 2 | 5 |

| | | | |
|---|---|---|---|
| **Total** | **34** | **6** | **28** |

Table 3 presents the EFA results, showing the number of items for each construct before and after the analysis. The table indicates that one item was eliminated from each of the perceived usefulness, perceived ease of use, and learning motivation constructs due to factor loadings below 0.5. Similarly, two items were removed from the Google Meet Application Mandarin Learning construct because they failed to achieve the required factor loading of 0.5. Consequently, the initial 34 items in the GMLS were revised to 28 items.

### *4.2 Confirmatory Factor Analysis (Pooled-CFA)*

The study aimed to validate all measurement models of latent constructs by assessing (1) unidimensionality, (2) validity, and (3) reliability, following the guidelines set by Afthanorhan *et al*., [2], Aimran *et al*., [4] Awang [10,11,12], Hair *et al*., [50], Kashif et al. [62], and Mohamad *et al*., [82]. This validation process, known as Confirmatory Factor Analysis (CFA), involves evaluating the measurement model against three key types of validity: convergent validity, construct validity, and discriminant validity [10,29,131]. Convergent validity was assessed by calculating the Average Variance Extracted (AVE), which measures the extent to which items on a construct are correlated. Construct validity was determined by examining the fitness indices of the measurement model, ensuring that the model adequately represents the constructs being measured. Discriminant validity was established through the development of a Discriminant Validity Index Summary, which ensures that the constructs are distinct from one another. Additionally, Composite Reliability (CR) was used to evaluate the reliability of the constructs, as it provides a more robust alternative to the traditional Cronbach's Alpha method [7,13,29,87,131] CR assesses the internal consistency of the items within each construct, offering a comprehensive measure of the reliability of the scales used in the study. This thorough validation process ensures that the measurement models are both reliable and valid, supporting the overall credibility of the research findings. The results of this study are displayed in Figure 2 below:

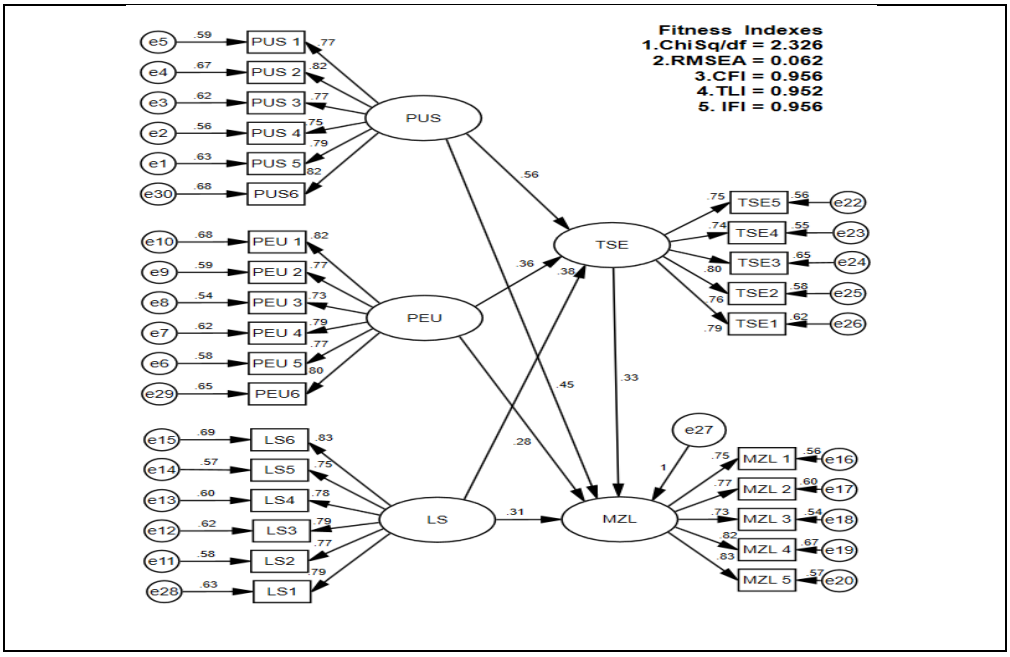


**Fig. 2.** Result from pooled CFA procedure

Figure 2 demonstrates that all constructs in this model were validated simultaneously using Pooled Confirmatory Factor Analysis (Pooled-CFA). As noted by Awang [10] and Awang *et al*., [10-12], model identification is typically not an issue with Pooled-CFA; however, attention should be given to the number of items within each construct, which should be at least four or more. Including additional items can increase the model's degree of freedom, enhancing its robustness. Therefore, in this study, the researcher ensured that each construct contained at least four items. Furthermore, Pooled-CFA was employed in the current study because it is more efficient than conducting separate CFA for each measurement model.

### *4.3 Unidimensionality*

Unidimensionality is the idea that a set of observed variables or items can be represented by a single underlying factor or construct, indicating that the items measure the same concept [29]. Achieving unidimensionality ensures that each construct in a model is distinct and reliably measured by its items. According to Awang [10-12], unidimensionality is confirmed when all the items associated with a particular construct have acceptable factor loadings, typically exceeding a threshold of 0.50 or higher, indicating a strong relationship between the items and the underlying construct.

In the context of CFA, assessing unidimensionality is critical for validating the measurement model. If any items exhibit low factor loadings, generally below the acceptable threshold (0.5) they should be systematically removed to improve the construct's measurement accuracy and the overall model fit. This iterative process continues until the model achieves satisfactory fit indices, which include measures like the Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), and Root Mean Square Error of Approximation (RMSEA). Ensuring unidimensionality is not only a step towards achieving construct validity but also enhances the clarity and reliability of the data interpretation [3, 9,10,29,62]. By refining the measurement model through unidimensionality checks, researchers can ensure that each construct is accurately represented by its indicators, thus enhancing the overall robustness and reliability of the analytical framework. This careful validation process helps to confirm that the constructs are distinct and measured effectively, providing a solid foundation for further analysis [10]. The results of this study are displayed in Table 4 below:

**Table 4**
Factor loading of all items

| No | Construct/Item | Factor Loading |
|---|---|---|
| | **Perceived Usefulness (PUS)** | |
| 1 | Google Meet enhances my understanding of Mandarin. | 0.77 |
| 2 | Google Meet helps me improve my Mandarin skills. | 0.82 |
| 3 | Google Meet is valuable for practicing Mandarin conversation. | 0.77 |
| 4 | Google Meet significantly contributes to my overall Mandarin learning experience. | 0.75 |
| 5 | Google Meet enhances my ability to learn Mandarin effectively. | 0.79 |
| 6 | Google Meet is beneficial for my Mandarin proficiency. | 0.82 |
| | **Perceived Ease of Use (PUE)** | |
| 1 | Google Meet is efficient for Mandarin classes. | 0.82 |
| 2 | Google Meet 's features make Mandarin learning easy. | 0.77 |
| 3 | Google Meet is straightforward for Mandarin learning. | 0.73 |
| 4 | Google Meet boosts my confidence in Mandarin learning. | 0.79 |
| 5 | Google Meet 's interface helps me understand Mandarin better. | 0.77 |
| 6 | I can easily access Google Meet 's tools for Mandarin learning. | 0.80 |
| | **Learning Motivation (LS)** | |
| 1 | I am eager to learn Mandarin through Google Meet. | 0.83 |

| | | |
|---|---|---|
| 2 | I am willing to put extra effort into Mandarin lessons on Google Meet. | 0.75 |
| 3 | I stay motivated to learn Mandarin on Google Meet, even when it's challenging. | 0.78 |
| 4 | I am confident in improving my Mandarin skills with Google Meet. | 0.79 |
| 5 | I enjoy Mandarin classes on Google Meet. | 0.77 |
| 6 | I am motivated to excel in Mandarin learning through Google Meet. | 0.79 |
| | **Technology Self-Efficacy (TSE)** | |
| 1 | I feel confident using Google Meet for Mandarin learning. | 0.79 |
| 2 | I can easily navigate Google Meet features. | 0.76 |
| 3 | I can handle technical issues on Google Meet for Mandarin classes. | 0.80 |
| 4 | I adapt quickly to Google Meet updates and new features. | 0.74 |
| 5 | Overall, I am confident in using Google Meet for my Mandarin studies. | 0.75 |
| | **Google Meet Application Mandarin Learning (MZL)** | |
| 1 | Google Meet has improved my Mandarin skills. | 0.75 |
| 2 | I am more engaged learning Mandarin on Google Meet than with traditional methods. | 0.77 |
| 3 | I am satisfied with learning Mandarin on Google Meet. | 0.73 |
| 4 | Google Meet has greatly enhanced my Mandarin knowledge. | 0.82 |
| 5 | I plan to continue using Google Meet for Mandarin learning. | 0.83 |

Factor loading (>.50)

Table 4 demonstrates that all items from each construct met or exceeded the minimum factor loading threshold, as recommended by Awang [10] and Kashif *et al*., [62]. Factor loadings represent the correlation between observed variables (items) and their underlying latent construct, with higher values indicating that the items strongly represent the construct they are intended to measure. The generally accepted threshold for factor loadings is 0.5 or higher, which signifies that the items contribute significantly to explaining the variance of the construct.

### *4.4 Convergent Validity*

Convergent validity is a measure that confirms whether multiple indicators or items accurately represent the construct they are intended to measure [7,8,29,65]. This concept is crucial in construct validation as it assesses the extent to which items that are supposed to measure the same construct are indeed related. According to Brown [25], convergent validity reflects the consistency and strength of relationships among items that are predicted to load onto a single latent construct, ensuring that the items are not only correlated but are measuring the same underlying concept. The assessment of convergent validity involves calculating the Average Variance Extracted (AVE), which quantifies the amount of variance captured by a construct relative to the variance due to measurement error. An AVE value of 0.5 or higher indicates that more than half of the variance observed in the items is accounted for by the construct, thereby confirming convergent validity [7,8,29,39]. This threshold ensures that the indicators have substantial shared variance and adequately reflect the construct they are intended to measure.

In this study, as illustrated in Table 5, all constructs demonstrated AVE values exceeding the minimum threshold of 0.5, validating that each set of indicators reliably converges on its respective latent construct. This finding supports the robustness of the measurement model, affirming that the constructs are well-defined and that the items effectively capture the intended dimensions of the constructs. This process not only enhances the credibility of the measurement model but also ensures that the constructs are being accurately measured, thereby strengthening the overall validity of the research findings. The results of the convergent validity analysis are presented in Table 5 below:

**Table 5**
Average variance extracted for all constructs

| Codes | Construct | AVE (Above 0.5) |
|---|---|---|
| 1 | Perceived Usefulness (PUS) | 0.620 |
| 2 | Perceived Ease of Use (PUE) | 0.609 |
| 3 | Learning Motivation (LS) | 0.617 |
| 4 | Technology Self-Efficacy (TSE) | 0.590 |
| 5 | Google Meet Application Mandarin Learning (MZL) | 0.610 |

Based on Table 5, the AVE values for all constructs exceeded the minimum threshold of 0.5, indicating strong convergent validity. Among the constructs, perceived usefulness had the highest AVE at 0.620, while technology self-efficacy had the lowest at 0.590. Therefore, it can be concluded that the measurement model successfully achieved convergent validity.

*4.5 Construct Validity*

Construct validity is established when a model's fitness indices meet the necessary criteria across three key categories: absolute fit indices, incremental fit indices, and parsimonious fit indices [7,8, 62,131]. These categories ensure that the model accurately represents the data and the theoretical constructs it aims to measure. Absolute fit indices, such as the Root Mean Square Error of Approximation (RMSEA), assess how well the proposed model reproduces the observed data, with a value less than 0.08 considered acceptable [7]. Incremental fit indices compare the proposed model to a null or baseline model to evaluate improvement, with the Comparative Fit Index (CFI) being commonly used; values closer to 1 indicate a better fit, and a CFI value of 0.90 or higher is typically satisfactory [8]. Parsimonious fit indices, such as the Normed Chi-Square ($\chi 2/df$), assess the model's simplicity relative to its fit, with an acceptable $\chi 2/df$ ratio ranging between 1 and 5, indicating a balance between model complexity and fit quality [7,8]. Table 5 summarizes these fitness indices categories and the acceptable levels according to the literature, highlighting the standards required for achieving construct validity in the model.

**Table 6**
Fitness indices

| Name of category | Name of index | Level of acceptance | Result | Status |
|---|---|---|---|---|
| Absolute Fit Index | RMSEA | RMSEA < 0.08 (Hu & Bentler, 1999) | 0.062 | Achieved |
| Incremental Fit Index | CFI | CFI > 0.90 | 0.956 | Achieved |
| | TLI | TLI > 0.90 | 0.952 | |
| | IFI | IFI > 0.90 | 0.956 | |
| Parsimonious Fit Index | Chi-Square/df | Chi-Square/df < 5.0 (Hu & Bentler, 1990) | 2.326 | Achieved |

Table 5 indicates that this model met all three categories of fitness indices: (1) the RMSEA value was less than 0.08 (specifically, 0.062), confirming the absolute fit index; (2) this model achieved an incremental fit index by securing a CFI value (0.956) above the recommended threshold of 0.90; (3) regarding the parsimonious fitness index, which was gauged using the Chisq/df, a value of 2.326 was obtained. This value is below the recommended threshold of 5.0 as suggested by Bentler [23], Awang [10,11]. Consequently, this study successfully established the construct validity of this model GMLS.

*4.6 Discriminant Validity*

Discriminant validity was rigorously assessed to confirm that the constructs within the model are distinctly unique and not merely reflections of each other [10-12]. This involves verifying that the correlation between any pair of constructs is sufficiently low to prevent redundancy, which can occur when constructs are too highly correlated, suggesting they might measure the same underlying factor [29]. To perform this validation, a discriminant validity index summary was constructed, presented in Table 7. This table highlights the diagonal values in bold, which represent the square roots of the Average Variance Extracted (AVE) for each construct, ensuring they are greater than the off-diagonal values, which are the correlation coefficients between pairs of constructs. This arrangement helps to visually affirm that each construct shares more variance with its indicators than with other constructs, thereby supporting the distinctiveness of the constructs.

**Table 7**
Discriminant validity index summary

| Construct/ Codes | PUS | PEU | LS | TSE | MZL |
|---|---|---|---|---|---|
| Perceived Usefulness (PUS) | ***0.620*** | | | | |
| Perceived Ease of Use (PEU) | 0.130 | ***0.609*** | | | |
| Learning Motivation (LS) | 0.386 | 0.217 | ***0.617*** | | |
| Technology Self-Efficacy (TSE) | 0.312 | 0.371 | 0.239 | ***0.590*** | |
| Google Meet Application Mandarin Learning (MZL) | 0.361 | 0.359 | 0.262 | 0.151 | ***0.610*** |

Discriminant validity was confirmed for each sub-construct in the model, as evidenced by each construct's AVE surpassing its correlation with any other construct (Table 7) [7,8,29]. This is further validated by the fact that the diagonal values (highlighted in bold) are greater than any other corresponding row or column values. Thus, discriminant validity is established for all sub-constructs within the framework, meeting the necessary thresholds as illustrated in Table 7.

*4.7 Composite Reliability (CR)*

Composite reliability is used to assess reliability in structural equation models [7,8,29]. Estimates of composite reliability of 0.7 or higher indicate good reliability, whereas scores ranging from 0.6 to 0.7 are deemed acceptable [7,29]. The findings of this study are presented in Table 8 below:

**Table 8**
Composite Reliability (CR)

| Codes | Construct | CR (Above 0.6) |
|---|---|---|
| PUS | Perceived Usefulness | 0.907 |
| PEU | Perceived Ease of Use | 0.903 |
| LS | Learning Motivation | 0.906 |
| TSE | Technology Self-Efficacy | 0.878 |
| MZL | Google Meet Application Mandarin Learning | 0.886 |

Table 8 shows that the composite reliability scores for all constructs in this model exceed the minimum threshold of 0.6, indicating satisfactory reliability. perceived usefulness has the highest composite reliability at 0.907, and Technology Self-Efficacy has the lowest, though still robust, at 0.878. These results confirm that the model demonstrates adequate reliability across all measured constructs.

*4.8 Normality Assessment*

The normality of the data for all items measuring the constructs in the study was assessed through skewness values, as outlined by Asnawi [9], Awang [10-12], Hair *et al*., [29], Kashif *et al*., [62], and Mohamad *et al*., (82]. Skewness values within the range of -2 to 2 are generally deemed acceptable, indicating that the data do not significantly deviate from normal distribution [29]. In this regard, skewness alone provides sufficient evidence to confirm normality, as it directly reflects the symmetry of the distribution, a core assumption of many parametric tests. Unlike kurtosis, which pertains to the peakedness or tail heaviness of the distribution, skewness is more critical for detecting substantive departures from normality that affect hypothesis testing and estimation. Moreover, researchers such as George and Mallery [44] and Kline [65] have noted that as long as skewness is within acceptable limits, normality can be reasonably assumed without necessarily examining kurtosis, especially in large samples where the central limit theorem ensures robustness. Therefore, the present study focused on skewness as the primary indicator, and kurtosis was not considered a necessary diagnostic. Skewness is crucial for evaluating the symmetry of the distribution of the variables. It provides essential insights into whether the data lean towards the left or right tail of the distribution, affecting both the validity of statistical analyses and the interpretation of findings [52,113]. The results concerning the normality of the data are presented in Table 9.

**Table 9**
Normality assessment results

| No | Construct/Item | Skewness |
|---|---|---|
| | **Perceived Usefulness (PUS)** | |
| 1 | Google Meet enhances my understanding of Mandarin. | -0.862 |
| 2 | Google Meet helps me improve my Mandarin skills. | -0.726 |
| 3 | Google Meet is valuable for practicing Mandarin conversation. | -0.461 |
| 4 | Google Meet significantly contributes to my overall Mandarin learning experience. | 0.736 |
| 5 | Google Meet enhances my ability to learn Mandarin effectively. | -0.914 |
| 6 | Google Meet is beneficial for my Mandarin proficiency. | -0.929 |
| | **Perceived Ease of Use (PEU)** | |
| 1 | Google Meet is efficient for Mandarin classes. | -0.269 |
| 2 | Google Meet ’s features make Mandarin learning easy. | -1.021 |
| 3 | Google Meet is straightforward for Mandarin learning. | -1.281 |
| 4 | Google Meet boosts my confidence in Mandarin learning. | -0.828 |
| 5 | Google Meet ’s interface helps me understand Mandarin better. | -0.626 |
| 6 | I can easily access Google Meet ’s tools for Mandarin learning. | -0.747 |
| | **Learning Motivation (LS)** | |
| 1 | I am eager to learn Mandarin through Google Meet. | -0.926 |
| 2 | I am willing to put extra effort into Mandarin lessons on Google Meet. | -0.269 |
| 3 | I stay motivated to learn Mandarin on Google Meet, even when it's challenging. | -0.703 |
| 4 | I am confident in improving my Mandarin skills with Google Meet. | -0.857 |
| 5 | I enjoy Mandarin classes on Google Meet. | |
| 6 | I am motivated to excel in Mandarin learning through Google Meet. | -0.539 |
| | **Technology Self-Efficacy (TSE)** | |

| | | |
|---|---|---|
| 1 | I feel confident using Google Meet for Mandarin learning. | -1.009 |
| 2 | I can easily navigate Google Meet features. | -0.953 |
| 3 | I can handle technical issues on Google Meet for Mandarin classes. | -0.636 |
| 4 | I adapt quickly to Google Meet updates and new features. | -0.916 |
| 5 | Overall, I am confident in using Google Meet for my Mandarin studies. | -0.721 |
| | **Google Meet Application Mandarin Learning (MZL)** | |
| 1 | Google Meet has improved my Mandarin skills. | -1.205 |
| 2 | I am more engaged learning Mandarin on Google Meet than with traditional methods. | -1.018 |
| 3 | I am satisfied with learning Mandarin on Google Meet. | -1.214 |
| 4 | Google Meet has greatly enhanced my Mandarin knowledge. | -1.126 |
| 5 | I plan to continue using Google Meet for Mandarin learning. | -1.051 |

The skewness values for all components in the model are within the acceptable range of -2 to 2, as shown in Table 8, which aligns with the norms stated by Awang [10-12], Kashif *et al*., [62] Mohamad *et al*., [83], and Asnawi [9].This indicates that the distribution of the data for each component does not significantly deviate from a normal distribution. Adhering to these norms is essential for validating the statistical analyses conducted in this study, as it ensures that the data are symmetrically distributed, thereby enhancing the reliability and accuracy of the results derived from the data.

## 5. Conclusion

This study aimed to develop and validate a survey instrument to measure Mandarin learners' acceptance of the new technology, Google Meet, for Mandarin learning. The Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA) conducted suggest that the instrument, known as the Google Meet Application Mandarin Learning Scale was successfully developed. The EFA recommended the removal of one item each from the constructs of perceived usefulness, perceived ease of use, learning motivation, and technology self-efficacy, and two items from the Google Meet application Mandarin learning due to their failure to achieve the minimum factor loading of 0.50 in the pilot study data. The subsequent CFA confirmed that Google Meet Application meets the criteria for convergent validity, construct validity, and discriminant validity. Additionally, assessments of unidimensionality and normality indicated that the items within the GMLS instrument are valid. Thus, the findings from the EFA and CFA confirm that the GMLS is a reliable model for measuring Mandarin learners' acceptance of using Google Meet for language learning.

### *5.1 Recommendation for Future Study*

This study advocates extending the use of the Google Meet Application Mandarin Learning Scale (GMLS) across diverse research contexts and geographical regions. Initially developed and validated in Malaysia with local learners, who primarily view Mandarin as a second/foreign language, GMLS addresses a different context in countries where Mandarin is a foreign or third language, particularly in Western settings where learners typically grow up monolingual and may exhibit distinct learning attitudes. For example, in Malaysia's collectivist culture, learning motivations are often influenced by external factors, such as guidance from parents or teachers [32,50], whereas in more individualistic societies, motivations may stem from personal goals or self-initiative [20,57]. Adapting GMLS for such varied cultural and educational contexts could shed light on its adaptability and effectiveness, helping refine the tool to ensure its relevance across a globally diverse educational landscape.

Additionally, this study suggests adapting GMLS for use in different languages, particularly those using the Latin alphabet, such as English, Spanish, or French. This expansion would enable a broader

exploration of technology acceptance across linguistic boundaries, helping identify how cultural and linguistic variations affect technology adoption. Such adaptations would make GMLS more applicable in global educational settings, where digital tools like Google Meet are integral to language learning, providing insights into the effectiveness of online platforms in diverse educational contexts.

Future research should also explore additional factors influencing the acceptance of new technologies like Google Meet for Mandarin learning. These factors could include learning strategies, the learning environment, learning attitude and the quality of instructional feedback. Additionally, examining the impact of moderating variables such as the format of learning materials, age, gender, and ethnicity could further enhance the robustness and applicability of GMLS. Incorporating these variables would provide deeper insights into how various student populations engage with technology in language education, helping tailor learning experiences to meet the needs of a broader range of learners and potentially increasing the effectiveness of technology-integrated language learning programs.

**Acknowledgement**
The authors wish to extend their sincere appreciation to Universiti Sains Islam Malaysia (USIM) for the generous research grant (Geran Penyelidikan USIM RACER 2025-Grant No: P1-18-17225-UNI-RACER-FPBU] that supported this study. The financial assistance provided has been instrumental in the successful completion of this research.

**Conflict of Interest Statement**
The authors declare that there is no conflict of interest regarding the publication of this study.

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