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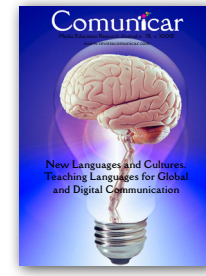

Visual Communication Design for Mobile Learning Apps: User Interface Usability and Learning Engagement

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ABSTRACT
This study explored the visual communication design for the mobile learning applications through user interface usability and learning engagement. This experiment also observed the mediating impact of cognitive load in the relationship between user interface usability and learning engagement. The method adopted for the study was quantitative method and the data was collected by adopting a questionnaire survey strategy. The data was collected from the higher education institutions in China located at different regions and the target population of the study were the current enrolled students at these institutions. The study tested the research hypotheses through structural equation modelling. CFA was used to evaluate the fitness of the measurement model. The findings of the study indicated that user interface, and student engagement were effective indicators of visual communication design. The study would be a great contribution as it dealt with emerging topic of visual communication design in the educational sector of China, advocating the use of mobile learning applications. The study would also offer significant insights to managers and policy makers. Future researchers could maneuver qualitative research design to analyze the perspectives, viewpoints and subjective opinions in the subject.

KEYWORDS
Visual Communication, Mobile Learning, Learning Engagement, User Interface Usability, Cognitive Load.

RESUMEN
Este estudio explora el diseño de la comunicación visual para las aplicaciones móviles de aprendizaje a través de la facilidad de uso de la interfaz de usuario y el compromiso de aprendizaje. También se observó el efecto mediador de la carga cognitiva en la relación entre la facilidad de uso de la interfaz de usuario y el compromiso de aprendizaje. El método adoptado para el estudio fue el cuantitativo y los datos se recogieron adoptando una estrategia de encuesta por cuestionario. Los datos se recopilaron en centros de enseñanza superior de China situados en distintas regiones y la población objetivo del estudio eran los estudiantes matriculados actualmente en dichos centros. El estudio puso a prueba las hipótesis de la investigación mediante un modelo de ecuaciones estructurales. Se utilizó el AFC para evaluar la idoneidad del modelo de medición. Las conclusiones del estudio indicaron que la interfaz de usuario y el compromiso de los estudiantes eran indicadores eficaces del diseño de la comunicación visual. El estudio supondría una gran contribución al tratar el tema emergente del diseño de la comunicación visual en el sector educativo de China, abogando por el uso de aplicaciones móviles de aprendizaje. El estudio también ofrecería importantes perspectivas a los gestores y responsables políticos. Los futuros investigadores podrían utilizar un diseño de investigación cualitativo para analizar las perspectivas, los puntos de vista y las opiniones subjetivas sobre el tema.

PALABRAS CLAVES
Comunicación Visual, Aprendizaje Móvil, Compromiso de Aprendizaje, Facilidad de Uso de la Interfaz de Usuario, Carga Cognitiva.

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1. Introduction

China has integrated several e-learning strategies and projects for the promotion of the knowledge sharing, and its availability in every medium for maximum learning outcomes. China has introduced several ICT and education projects to strengthen country's education promotion plan for the 21st century, many of which are projects for the integration and promotion of education at all levels (Wang et al., 2018). With the evolution in technology and advanced innovations, e-learning sector has embraced all these advancements and internet technologies to improve the quality of education and more fruitful learning experiences. For instance, e-learning developed its different other dimensions like mobile learning and distant learning, remote training and many other programs (Djeki et al., 2022).

The mobile phone technology is a most adopted and widely used technology, which has been claimed as a cheap and affordable technology with its vast applications in the educational sector (Krull & Duart, 2017). The modern era of innovative technology has equipped everyone with the most conveniently available technology of mobile phones, and these adoptions have provided everyone with an ocean of knowledge and training for learning different skills using different mobile learning online sources and apps (Gangaiamaran & Pasupathi, 2017). These mobile apps were primarily designed to enhance and polish the skills and as a more efficient source for acquiring better learning skills. The mobile learning source has enabled the learners to interact with their educational sources by staying far from the main head of the learning environment, and by using mobile apps, the communication of learning becomes even more smooth (Kumar Basak et al., 2018).

There has also been a growing trend of mobile usage and its applications benefits for the enhanced higher education systems, which has promoted the mobile learning apps among the Chinese students. The users of the mobile learning apps in China, have a high level of satisfaction by the factors of perceived content and responsiveness which most of the mobile learning apps provides and, in the context of China, the users have a positive perception about the quick response mechanism of the mobile learning apps which provide enhanced convenience in the learning motivation and learning procedures (Liu et al., 2018).

In China, the users' experience of the learning process using mobile learning apps has been empirically proven a significant factor in the learning performance of the students (Ke & Su, 2018) and it has been mentioned that user usability depends on the service, system, and information quality of the mobile apps. There are different apps introduced and designed for the distant learning of Chinese and international students. The current study has elucidated one of the COVID times developed apps *Tencent*, and its innovative performance for the students. A research study (Sayibu et al., 2021) has felt the significance of the *Tencent* app and the user usability experience of the application, and discussed the influential role of the *Tencent* app, its features and attributes in defining the efficiency of technology and performance for students. This study also explored the characteristics of the application and innovation provided to students in their learning

The main aim of the current study was to evaluate the user usability experience of mobile learning apps, the learning engagement, and the cognitive load of the students of the mobile learning apps, in the Chinese context. This study also addressed the learning capacity and motivation of students on the design and the user interface of visual communication design. The rationale behind this study was to compile various dimensional concepts by targeting the students at higher educational institutions in China. The study attributes both theoretical and practical contributions and implications. While it sheds light on the significance of the user usability interface of mobile learning apps in the Chines context, on learning engagement and cognition load of the students to contribute to the domain of knowledge, it also provides useful insights to policymakers and app developers of the mobile learning apps to attain guidance about the perceptions of their app users and make valuable improvements and updates to increase their application usage.

2. Literature Review

2.1. Theoretical Background and Conceptual Framework

Mobile devices are one of the most utilized technologies within the educational systems since numerous mobile learning applications have been introduced for the consumers to effectively perform in their educational career. The conceptual framework of the current investigation was based on determining the factors that were crucial for designing visual communication based mobile applications and to enhance the educational performance of the students within the context of China. These factors included the user interface usability and learning engagement which directly influenced the visual design communication for mobile applications. However, cognitive load was shown mediating the correlation between user interface usability, learning engagement, and visual

communication design for mobile applications in China to ensure a better and transformed educational system.

To support the conceptual framework of the undertaken study, the researcher has utilized the *"Mobile Learning Theory"*, which highlights the opportunities that are provided by mobile applications regarding efficient conceptualizing, studying, and learning (Bernacki et al., 2020). In addition, it has been supported by the educationists because they think that it is the fastest and easiest to access method based on a learner-driven experience. This theory is related to the current conceptual framework because it focuses on the efficiency of mobile learning applications within the education system which is also admired by the teaching professionals. Moreover, it significantly supports the research variables of the current study where user interface usability and learning engagement are required for promoting visual communication designs in mobile apps to make them more efficient and innovative, thus easing the capability of the learners to perform well in their academic career in the presence of cognitive load.

Another theory has been focused by the researcher to support the research framework of the present research named the *"Cognitive Load Theory"*, (Sweller, 1994) according to which cognitive learning focuses on meaningful learning. This theory involves a perspective to explore the capability of learners by exploring their learning memory so that proper learning could be ensured (Curum & Khedo, 2021). Cognitive load theory focuses on examining the learning capacity of learners which focuses on the learning engagement of the consumers. It also supports the user interface capability in assessing the learning perceptions of the users regarding the incorporation of visual communication design in the mobile learning apps, resulting in the formulation of mobile learning applications based on visual communication and efficient in understanding learning capabilities of individuals.

2.2. User Interface Usability and Visual Communication Design

In this modern era, mobile applications have been used intensively in education programs to enhance the learning capabilities of students. The users' interface usability is a crucial aspect for the success of mobile learning applications because it refers to the users' perceptions regarding any particular application (Parsazadeh et al., 2018). In addition, it has been opined that most of the information is available on the internet in a written pattern where students have difficulty in evaluating and understanding the information. Therefore, the current research focused on the usability perceptions of mobile learners because it enabled the application designers to understand the requirements of the learners more effectively and assist to formulate more useful mobile applications. This argument would also encourage mobile applications to design applications based on visual communication and deem it appropriate for focusing on the users' usability perceptions, which is the novelty of the present investigation.

In addition, visual aspects are also crucial objectives while designing a mobile application (Hammady et al., 2018). However, it is crucial to make the users' interface as simple as possible to achieve the objectives of visual designs. This highlights the significance of user usability interface while formulating visual communication designs, as it makes easy to understand the usability perceptions of the users regarding the mobile applications, which signifies a positive association between user usability interface and visual communication design. Furthermore, the learning contents in mobiles must ensure the engagement of the learners which could be made possible by considering user interface designs because mobile learning applications should be innovative and could not be designed at a similar policy just like some other typical mobile apps. Therefore, it has been determined that the user interface design should be focused on visual communication, which has been highlighted by the research framework of the current research. According to research by Nie (2018), the mobile applications thus based on visual communication design and user interface should be formulated on the following principles (as shown in Table 1).

Table 1: Principles Incorporated while Designing Visual Communication Mobile Learning Apps.

Visual Communication Principles	
Good conceptual model	A good conceptual model while designing the mobile applications based on visual communication determines the user interface and the user perceptions to modify and transform the applications innovatively and provide quality.
Identifiability	Moreover, the users could be able to understand the operating system of the application.
Corresponding Relationships	In addition, the information regarding the user interface should be effectively incorporated in the mobile applications to address the consumers' requirements.
Feedback Principle	Furthermore, there should be a feedback mechanism incorporation where the user interface could be recorded and be incorporated in the visual communication design.

Source: (Nie, 2018)

The above-stated principles highlight the importance of user interface while designing mobile learning applications based on visual communication. However, a broader scope is yet to be researched regarding the applicability of user interface usability for improving the designs of mobile learning applications on the basis of visual communication design.

To summarize, students within the educational systems in this modern era focus on mobile learning applications for improving their learning skills and capabilities. However, these mobile applications should be shifted toward the visual communications designs because it will enable the learners to enhance their learning capacities and motivate themselves to absorb greater knowledge as compared to physical learning systems which could be possible by understanding their usability perceptions. Moreover, an effective understanding of user interface usability will enable to enhance the cognitive learning of the students which will ultimately influence an effective visual communication design for mobile applications. Based on this, the hypothesis framed runs thus: **H1**: User interface usability significantly and positively influences visual communication design.

2.3. Learning Engagement and Visual Communication Design

In the visual communication design process, the students learn critically, creatively and reflectively. Although the learning process significantly improves when students show a high desire and motivation to learn. The critical thinking capacity of students also increases exerting a sharp influence on their academic performance (Adiloglu, 2011). Research indicates that the significant and noticeable outcome of learning engagement increases the motivation and desire to learn (Saris, 2020). Therefore, when the desire to learn is higher, the process of transmission of ideas, information and emotions increase through visual aids. Moreover, academic performance of students is likely to improve where the learning motivation is higher (Benden & Lauermann, 2022). Similar to this, research also indicated that the visual communication aids people in retaining information and formulates a potentially strong association contrary to the verbal communication (Bateman et al., 2023). Students are capable of memorizing key concepts learnt through visual communication for a longer run. But in this learning process, the student's motivation and higher level of involvement is important and noteworthy (Akbarov, 2022). Conversely discouraged and demotivated students cannot achieve excellent academic performance either equipped by effective visual communication design or not. According to Wileman (1993), the visual communication design is more effective as compared to the learning by words. Researchers argue that in the connected world, the capability to interact visually has become increasingly important. Apart from its wide implementation in academic institutions, the corporate sector is also rapidly adopting the visual communication design (Hermanto et al., 2021). So, whether working in teams, on a project or an effort towards formulating brand, it is critical to share ideas effectively. In the modern world, the images and videos have gained huge strength.

Park et al. (2023) explained that the students who entail a high desire to learn and have greater level of motivations understand the critical concepts easily through visual communication designs. Similarly, grabbing attention and building association has also increased due to visual communication designs. Students having a high potential to learn and understand can better perceive the message which is difficult to consider by texts only. According to the study by Kabrisky (1964), seventy five percent of the information processed by the brain is attained and stored from visual formats as through this medium information can adequately store in student's minds. However, it can be understood that their intention to store that information solely relies on their motivation and learning intention. Because students who are not motivated and involved in the process of learning can never attain effective results no matter how friendly user interface usability is provided to them. Similarly, according to Raiyn (2016), the visual information can be presented to students in different formats including movies, posters, images, diagrams and cards etc. Instructors in various institutions utilize these formats to portray a large quantity of information in such a manner that can be easily understand by students. So, those learners who possess potentially higher intention to learn can grasp these concepts efficiently and rapidly.

The mode of teaching and learning is also associated with the format of learning (Weinstein & Mayer, 1983). As researchers shows that students are more capable of learning critical concepts through visual communication design as compared to words or letters etc. or traditional modes of teaching (Worth, 2016). The conventional method of teaching has also showed a lack of student's interest. Therefore, it can be argued that learning platform also highly correlates with the desire of students and their motivation to learn. Wijaya and Bukhori (2017) explained that the motivation significantly impacts the learning capacity of students. The influence of motivation is usually far reaching as it enhances the energy level of individual, identifies

the persistence in accomplishing the particular objectives, and influences the types of learning methods and the thinking process of students. Therefore the platform or medium of learning is highly correlated with the student's desire to learn and their motivation level (Martin & Borup, 2022). Adiloglu (2011) studied that visual communication design also entails a sufficient time provision to students so that they can visualize their ideas and critical concepts in their memory through illustrations or other preferable ways. Therefore, if the students are motivated and highly engaged, the visual communication can help them to convey information and ideas that is easier to understand and is engaging. From the above discussion, the following hypotheses can be formulated:

H2: Learning engagement significantly impacts visual communication design.

H2a: Learner readiness significantly influences visual communication design.

H2b: Learner motivation significantly influences visual communication design.

2.4. Mediation of Cognitive Load

In modern world of advanced technology and visual communication design (VCD) have become a common mean for online communication and learning (Huang & Benyoucef, 2022). Within the context of visual communication design, different standards have been developed for this communication design, which can be effective in tracing back the software products availability in the 1980s. Different components of this system incorporate interface interaction design, interface technology development and interface visual design (Wu & Li, 2020). A "unified process-oriented interface design method" has been identified in past research, which can be used for organizing the design decisions on the basis of multiple technologies including design concept, design polymorphism, task analysis and abstract design. In this regard, the user interface usability is also considered to be vital. Nowadays the VCD is largely being utilized for designing different mobile apps and other related content. A study by Song et al. (2021), has shown that user experience incorporating immersion, credibility perception and social presence, can largely impact the intention of the users to continue the utilization of shorter video apps developed by using VCD. However, visualizations, integrating many complex layers can cause a hurdle in decision-making processes by reducing the users' cognitive capacity (Calvo et al., 2022). This might also influence the recognition, working memory and attention of the users, leading to cognitive load which can negatively impact the long-term memory storage of the users.

Past studies (Prati et al., 2021) have also emphasized users' experience and perceptions within the context of VCD in order to ensure effective outcomes. Therefore, different typography, colors, icons, images and other elements can be utilized in VCD to promote emotions and information in a user interface (Wu & Li, 2020). This approach can be effective in enhancing the aesthetics, accessibility and usability to a user interface, leading to the development of a memorable and persistent brand identity. However, complex information and data can lead to ineffective users' perceptions and interest, leading to insignificant outcomes. Therefore, in order to develop effective mobile learning apps, more focus is needed to be kept on the perceptions, experiences and interests of the users. For this purpose, complex layers in VCD should be avoided and more effective, simple and aesthetic content and images should be used to attract the users. This approach can also be effective in improving the cognitive ability of the associated learners.

Past research has also emphasized on learning engagement within the context of VCD. From past research it has also been observed that the students learning in a virtual environment, also suffer from different issues such as cognitive load and interface quality (Huang et al., 2020). It has been observed that inconsistent cognitive learning outcomes are obtained due to cognitive load. Therefore, it is crucial to explore the cognitive load structure while designing a virtual environment. According to Castro-Alonso et al. (2019), two formats are mainly utilized in the instructional visualizations which include dynamic visualizations (such as videos and animations) and static pictures. Both these formats are found to be engaging especially for the students of higher education. However, only engagement alone is not enough for effective learning. Therefore, lecturers, instructional designers and teachers can utilize the VCD's cognitive processing to achieve instructional effectiveness. Moreover, cognitive processing has also been effective in providing different ways to optimize the instructional visualization. The "cognitive theory of multimedia and the cognitive load theory" have proven to be effective paradigms which are used for designing the visualizations, by focusing on the learner's interest and motivation.

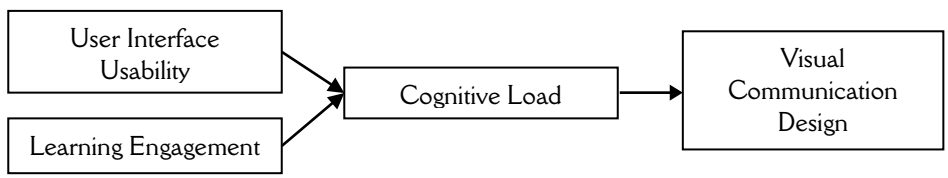
Studies (Feldon et al., 2019) have shown that cognitive load can negatively influence learner's motivation. However, learning in a virtual environment also helps in improving learning capabilities of the learners,

motivating them to utilize different learning apps. This also helps in increasing self-determination of the learners, improving their self-efficacy. In the virtual learning environment, learners are given full authority, without any external pressure, which is also found to be effective in influencing learner's interests (Yu et al., 2021). However, the incorporation of complex information and layers in the VCD can negatively influence the learning engagement of the learners, leading to ineffective outcomes. Therefore, while developing an effective mobile learning app by using VCD, important focus is needed to be given on learner's motivation and interests. This can help in preventing incorporation of any complex layers in VCD, which is effective to reduce cognitive load. Therefore, the present study has also been effective in determining the utilization of VCD for designing different mobile learning apps, focusing on user interface usability and learning engagement. In this regard, this study has also focused on the mediating role of cognitive load. Thus, based on the above discussion, the following hypotheses are devised for this research:

H3: Cognitive load mediates the relationship between user interface usability and visual communication design.
H4: Cognitive load mediates the relationship between learning engagement and visual communication design.
H4a: Cognitive load mediates the relationship between learner readiness and visual communication design.
H4b: Cognitive load mediates the relationship between learner motivation and visual communication design.

Figure 1 presents the relationship between the variables shown as the conceptual framework of the study.

Figure 1: Conceptual Framework of the Study.



3. Methodological Approach of the Research

The data was collected by adopting a questionnaire survey, designed based on an in-depth reviewing of the past literature and selecting the most appropriate and effective measurement scales for measuring the target variables of the study. The target audience of the study were the students of various Chinese higher educational institutions. The sample size of the study was 450, identified through convenience sampling method. Therefore, the data was collected only from those participants who were willing to participate in the study at their own ease. Online Google Forms were distributed to 450 students of different Chinese higher educational institutions. The online survey method was convenient in transferring the questionnaire to different geographical regions; moreover, this method has the attribute of vast spreading and facilitating studies with wider and more dispersed amount of thoughts of the respondents (Rice et al., 2017).

To measure the variables, scale items from previous studies were included, and all were measured on a five-point Likert scale. Cognitive load was measured based on the items included in the study of Gutiérrez Carreón et al. (2020); learner engagement was measured through two facets i.e., learner readiness and learner motivation which were measured through five items each and were inspired from the study of Aremu and Adeoluwa (2021); visual communication design was based on six items extracted from general interface usability criterion from Harpur and De Villiers (2015); and user interface usability was based on user perceptions based on the study by Klimova and Polakova (2020).

After getting the response sheet, Total 450 responses were received, and after initial screening of responses, 90 responses were excluded from the data sample owing to various discrepancies. Finally, there were 360 responses utilized for statistical procedures and results calculations. The SPSS software was used for the data analysis and for initial data screening and reliability computation, and the software of AMOS graphics was used for the validity concerns and SEM for hypotheses testing.

4. Results

4.1. Demographical Characteristics of Respondents

In any research study the demographical characteristics of respondents are very important because they help

the researcher in analyzing that the data has been collected from appropriate respondents. Table 2 shows that there were 360 respondents, 189 male and 171 female, constituting 52.5% and 47.5% respectively. On the basis of their age group, majority of the respondents were between the ages of 31 to 40 years constituting 113 (31.4%), 21 to 30 years (101) constituting 28.1%, followed by 97 (26.9%) between the age group of 41 to 50 years and 49 (13.6%) respondents more than 50 years old. Based upon their education level 151 (41.9%) of the respondents were undergraduate, 77 (21.4%) were holding a bachelor's degree, 93 (25.8%) were holding a master's degree; however, 39 (10.8%) were holding any other degree program or diplomas. Out of the total 360 respondents, a large majority, 335 (93.05%) said that they used mobile learning applications, while 25 (6.95%) denied.

Table 2: Demographic Profile.

	Frequency	Percent
Gender		
Male	189	52.5
Female	171	47.5
Total	360	100.0
Age		
21-30 years	101	28.1
31-40 years	113	31.4
41-50 years	97	26.9
More than 50 years	49	13.6
Total	360	100.0
Education		
Undergraduate	151	41.9
Bachelors	77	21.4
Masters	93	25.8
Other	39	10.8
Total	360	100.0
Usage of other mobile learning applications		
Yes	335	93.05
No	25	6.95
Total	360	100.0

4.2. Descriptive Statistics

Descriptive summary of the variables was analyzed which includes the values of "minimum, maximum, mean, standard deviation and kurtosis". Descriptive statistics assist the researcher in the presentation of the research data into a simple and meaningful way. According to Fisher and Marshall (2009), the descriptive statistics test ensures the researcher that in the data set such patterns can be established which can meet and satisfy the required set standards of the data. Moreover, after arranging and summarizing the larger data set it would be easy for the researcher in further analysis and interpretation of data. The summary of the descriptive statistics against the variables under study is presented in Table 3.

The value of minimum for all observed variables (UP, CG, ENG, VCD, and LMOT) is 1, and maximum is 5. The mean values of UP, CG, ENG, VCD, LMOT are 3.27, 3.44, 3.42, 3.31 and 3.20 respectively. The values of standard deviation are 0.79, 0.94, 0.90, 1.07 and 1.18 respectively, while the values of kurtosis are -.487, -.651, -.385, -.357 and -.093 respectively.

Table 3: Descriptive Statistics.

	N	Minimum	Maximum	Mean	Std. Deviation	Kurtosis	Std. Error
UP	360	1.00	5.00	3.2744	.79487	-.487	.129
CG	360	1.00	5.00	3.4490	.94248	-.651	.129
ENG	360	1.00	5.00	3.4228	.90657	-.385	.129
VCD	360	1.00	5.00	3.3125	1.07500	-.357	.129
LMOT	360	1.00	5.00	3.2078	1.18145	-.093	.129
Valid N (listwise)	360						

Note: UP= User Interface Usability, CG= Cognitive Load, ENG= Learning Engagement, VCD= Visual Communication Design, LMOT= Learning Motivation.

4.3. KMO and Bartlett's Test

For conducting the factor analysis, it is important to establish the data suitability and sufficiency of the sample. Therefore, the KMO and Bartlett tests were conducted. According to Taherdoost et al. (2022), for the analysis of factor loading, data suitability and sample adequacy, the KMO and Bartlett test are preferred. As indicated by Taherdoost et al. (2022), the threshold value of KMO must fall between the given range of 0.6 to 1.0; however the value more than 0.9 is considered excellent. This test evaluates the data gathered on all the observed variables i.e., UP, CG, ENG, VCD, LMOT together. From the Table 4, it can be seen that the value of KMO is 0.914, while Bartlett test revealed the Chi-sqaure at 9084 and df 561 and Sig 0.00.

Table 4: KMO and Bartlett's Test.		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.914
Bartlett's Test of Sphericity	Approx. Chi-Square	9084.139
	df	561
	Sig.	.000

4.4. Rotated Component Matrix

After ensuring that the results of KMO and Bartlett tests are significant and sample is adequate, the researcher conducted the factor loading test for analyzing the correlation coefficient of the factors. According to Hadi et al. (2016), the threshold value of factor loading is above 0.4. The results of factors loading are presented in Table 5. The items of UP, CG, ENG, VCD, and LMOT are presented in separate columns which ensure that there are no cross loadings and also the value shown in the given table are above 0.4. For instance, UP is measured with 10 items, CG is measured with 8 items, ENG is measured with 5 items, VCD is measured with 6 items, and LMOT is measured with 5 items.

Table 5: Rotated Component Matrix.					
	Component				
	1	2	3	4	5
UP1	.626				
UP2	.671				
UP3	.645				
UP4	.676				
UP5	.657				
UP6	.655				
UP7	.645				
UP8	.719				
UP9	.670				
UP10	.618				
CG1			.622		
CG2			.680		
CG3			.638		
CG4			.632		
CG5			.651		
CG6			.718		
CG7			.791		
CG8			.778		
ENG1					.737
ENG2					.784
ENG3					.788
ENG4					.727
ENG5					.637
VCD1				.718	
VCD2				.709	
VCD3				.759	
VCD4				.790	
VCD5				.766	
VCD6				.773	
LMOT1		.917			
LMOT2		.913			
LMOT3		.904			
LMOT4		.896			
LMOT5		.921			

Note: UP= User Interface Usability, CG= Cognitive Load, ENG= Learning Engagement, VCD= Visual Communication Design, LMOT= Learning Motivation.

4.5. Construct Validity

The convergent validity of the model was studied through the application of CR, AVE, and Cronbach alpha values. The CR values are heralded as the composite reliability of the model and indicates the internal consistency of the variables. Previous studies have suggested values of 0.7 and above for both CR and Cronbach alpha, as these prove that the construct used for quantification of the variable was consistent and valid (Cheung & Wang, 2017). Table 6 indicates the value of α of UP, LMOT, CG, VCD and ENG is 0.84, 0.87, 0.78, 0.91 and 0.95 respectively, values of CR are 0.84, 0.95, 0.87, 0.91 and 0.80 respectively and the value of AVE are 037, 0.81, 0.47, 0.64 and 0.46 respectively. Values for all variables were higher than 0.7 thus suggesting that all constructs and their items were internally consistent and reliable. However, AVE values for usability perceptions, cognitive load, and learner motivation were less than threshold limit of 0.5. However, since CR and Cronbach alpha values were found to be significant the AVE values can be deemed acceptable, as most of them are approaching 0.5.

Table 6: Convergent Validity and Reliability.

	Items	A	CR	AVE
UP	10	.844	0.840	0.377
LMOT	8	.879	0.956	0.814
CG	5	.781	0.870	0.474
VCD	6	.916	0.917	0.649
ENG	5	.956	0.802	0.468

Note: UP= User Interface Usability, CG= Cognitive Load, ENG= Learning Engagement, VCD= Visual Communication Design, LMOT= Learning Motivation.

After the establishment of convergent validity, the researcher tested for the discriminant validity as well. The HTMT and Fornell Lacker criterion were both used for studying the discriminant validity of the model. It can be seen that the discriminant validity according to Fornell and Larcker (1981) wasn't established. Table 7 presents the results of Discriminant Validity-Fornell Lacker Criterion for the present data set.

Table 7: Discriminant Validity-Fornell Lacker Criterion.

	MSV	MaxR(H)	UP	LMOT	CG	VCD	ENG
UP	0.678	0.901	**0.614**				
LMOT	0.074	0.958	0.257***	**0.902**			
CG	0.678	0.913	0.824***	0.272***	**0.689**		
VCD	0.557	0.922	0.718***	0.108†	0.746***	**0.806**	
ENG	0.306	0.862	0.535***	0.232***	0.553***	0.479***	**0.684**

Note: UP= User Interface Usability, CG= Cognitive Load, ENG= Learning Engagement, VCD= Visual Communication Design, LMOT= Learning Motivation.

The discriminant validity was established by comparing the square root of AVE with the correlation coefficients (intra-item) and it was found that the discriminant validities were not present. However, when discriminant validity was computed through the HTMT criterion, no issues of validity were detected. According to Ab Hamid et al. (2017), HTMT is more sensitive to issues such as multicollinearity, and therefore it is a stringent method. While discriminant validity was established via HTMT, it was suggested that discriminant validity was present for the model. Table 8 presents the results of HTMT Analysis for the present data set.

Table 8: HTMT Analysis.

	UP	LMOT	CG	VCD	ENG
UP					
LMOT	0.275				
CG	0.816	0.290			
VCD	0.701	0.104	0.757		
ENG	0.704	0.277	0.775	0.628	

Note: UP= User Interface Usability, CG= Cognitive Load, ENG= Learning Engagement, VCD= Visual Communication Design, LMOT= Learning Motivation.

4.6. Model Fitness

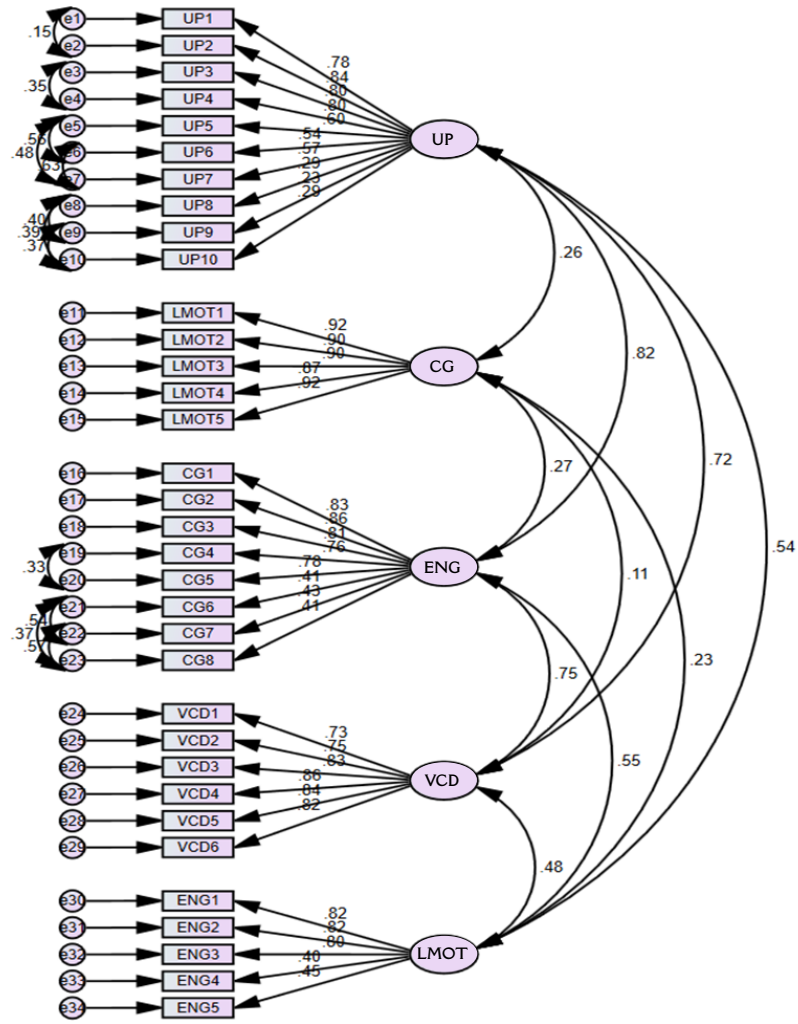
Once the construct validity and reliability for the model was established, the fitness of the measurement model through CFA was evaluated. It can be seen from Table 9 that the model was fit as all criteria were fulfilled. The value of CMIN/df was found to be less than 3, which is the requirement. Similarly, GFI was 0.824, greater than 0.8, CFI and IFI were .895, and .894, and RMSEA was 0.072. Since all of these markers were fine, it can be suggested that the model was structurally fit, and indicated no issues of validity, reliability, or fitness.

Table 9: Model Fitness.

Indices	Threshold range	Observed values
CMIN/df	Less than 3	2.848
GFI	Less than 0.8	.824
CFI	Less than 0.9	.895
IFI	Less than 0.9	.894
RMSEA	Less than 0.08	.072

Figure 2 shows CFA and number of factors for each variable as well the covariance between the variables and their error terms.

Figure 2: CFA and Factors for Each Variable.



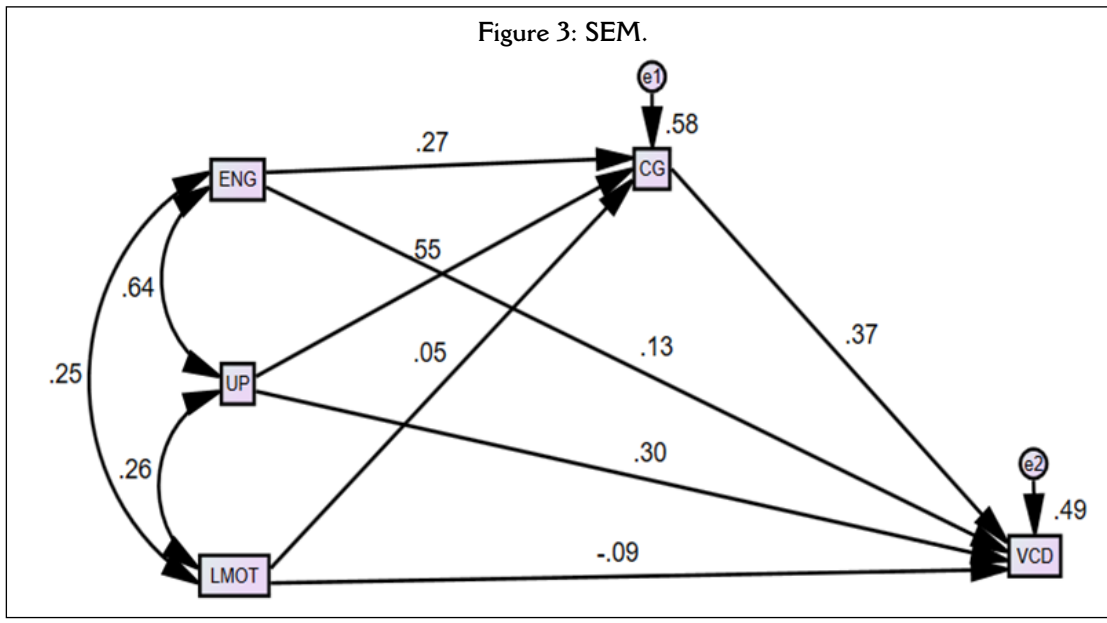
4.7. Hypotheses Testing

Following the evaluation of the measurement model, the structural relationships were tested via application of multivariate regression method i.e., SEM. Table 10 and Figure 3 show that there was a significant and positive effect of engagement, usability perceptions, and learner motivation on visual communication design of mobile applications. A unit increase in student engagement increases visual communication design by 12.6%, usability perceptions by 30.2%, and learner motivation was found to decrease visual communication design by 9.3%. Thus, the significant positive association was confirmed for usability perceptions and student engagement with the mobile applications.

Table 10: Standardized Regression Weights.

Parameter			Estimate	Lower	Upper	P
VCD	<---	ENG	.126	.023	.198	.016
VCD	<---	UP	.302	.209	.413	.006
VCD	<---	LMOT	-.093	-.166	-.036	.016

Figure 3: SEM.



The indirect effects of cognitive load were also studied, and it was found that factor has a significant mediation effect between learner readiness, and usability perceptions, and was found to be insignificant for learner motivation, as shown in Table 11.

Table 11: Mediation Association.

Indirect Path	Unstandardized Estimate	Lower	Upper	P-Value	Standardized Estimate
ENG --> CG --> VCD	0.118	0.074	0.181	0.001	0.100***
UP --> CG --> VCD	0.279	0.191	0.382	0.001	0.206***
LMOT --> CG --> VCD	0.016	-0.001	0.039	0.126	0.017

5. Discussion

The present research aimed to analyze the visual communication design for the mobile learning applications through the user interface usability and learning engagement. The mediating role of cognitive load was also observed. There were four hypotheses formulated in accordance with the research objectives and were tested through structural equation modelling. The first association between user usability and visual communication design was resulted to be positive and significant. This result complemented the study of (Yang & Ogata, 2023).

According to Chen et al. (2020), the user usability holds greater significance in attaining the positive and beneficial visual communication design. This is due to the fact that user usability undertakes the convenience of the user to interact with a website or a product. It means that the more convenience and user friendly a platform is, the better understanding of it can be observed among the users. The feasible and user-friendly usability is a significant predictor of effective visual communication design (Zhai, 2022). However, this study argues that the visual communication design is related with the emotional and aesthetic influence that is exerted by a design on its users, whereas the user interface usability and designs of interaction are related with the usability and functionality of the product.

The association between learning engagement and visual communication design also resulted as significant. The ability to involve in an effective process of learning behaviorally and motivationally is a significant predictor of visual communication design. In an era of rapidly advanced technologies and innovation, there are multiple effective and efficient learning platforms. When the learning engagement is high and effective, its significant effect on productive visual communication design can be observed. The results of this association complements the findings of (Liu et al., 2023). When the learning engagement of students is high, the effective conveyance of information and ideas through visual language can be observed among students. Wu and Li (2020) explained that students of visual design communication are capable of developing aesthetic and conceptual understanding regarding the design solution around them. But this learning process can be observed as even better, effective and efficient if the learning engagement is observed among students (Sun et al., 2023). A motivation to learn and getting involve in learning whole heartedly significantly contributes to effective and productive outcomes of visual communication design.

The mediation of cognitive load between user interface usability, learning engagement and visual communication design has also been observed in this study. After testing it through statistical techniques, it was observed that cognitive load is a significant mediator in the study. Cognitive load refers to the quantity or extent of information that can be processed by the working memory at a time (Sweller, 2020). Hence, based on the extent of cognitive load, the educational system can gain effective visual communication design outcomes. It refers to the extent to which students may entail potential to store information. It was also observed that apart from entailing a user-friendly interface and learning engagement, if the cognitive load fits within the capacity of a student's potential to absorb information, the visual communication design can result as beneficial for that education system. The mediation results also fits in accordance with the study by Paas and van Merriënboer (2020). In the context of user communication design and cognitive load holds greater importance because it deals with the strain experienced by the user when there is a lot of information to process. So researchers also argues that learners or students can effectively absorb information if it is provided in such a manner that it does not overload their mental capability (Pratama et al., 2017). Therefore, taking an adequate quantity of cognitive load and using it while receiving new information and converting it into long-term memory is essential in those education systems that has adopted digital learning application and has implemented it in their education system.

6. Conclusion, Implications and Recommendations

With the rapid advancement in technology, like other developed nations, China has also incorporated different virtual learning practices for the knowledge sharing and advance learning in its educational institutions. The present study aimed to assess the visual communication design for the mobile learning applications in China. The study incorporated user interface usability and learning engagement of students as predicting variables. The visual communication design was included as the independent variable and cognitive load as a mediating variable. To complete the research process, the researcher adopted a quantitative research methodology. The data was collected from the Chinese higher educational institutions, from where 360 questionnaires were collected. Both the techniques of self-administered and online distribution of questionnaires were administered. The data was analyzed through the reliable and widely implemented statistical techniques of SPSS and AMOS. Results indicated a significant association among user interface usability and visual communication design, whereas a significant association was observed between learning engagement of students and visual communication design. The mediating role of cognitive load also resulted to be statistically significant for user interface usability and was found partially significant for learning engagement as learner readiness showed insignificant association. The study therefore attained significant results including both direct and indirect associations among variables.

The present research holds greater significance theoretically as the research is based on the modern and emerging topic of visual communication design in China. Owing to advancements in visual communication design in the Chinese HEIs, this study contributes to the growing body of literature regarding user interface user ability and learning engagement in the domain of visual communication design. Owing to the scarcity of research in this domain, this study is particularly seen innovative. The originality of this study also lies in assessing the mediating role of cognitive load in the research framework, that also has not been tested in previous research. The practical importance of this study can also not be neglected. This study targeted the Chinese research context; therefore, it provided significant empirically proved association. First and foremost, it proved the mediating role of cognitive load as empirically significant; secondly, it proved a significant association between learning engagement and visual communication design, in the context of Chinese educational sector. This study would result in incorporating practices through which student's interest, desire to learn and motivation can increase. Thirdly, strategies regarding user interface usability and positive perceptions of usability, better outcomes and a positive influence on visual communication design were also observed. Last, but not the least, this study has provided a considerable amount of evidence to utilize mobile learning applications, their usability and design for better performance of students.

The present study also faced certain shortcomings. Firstly, this study was empirically investigated and therefore the researcher sacrificed the other methodological choice where opinions, viewpoints or perspectives of others could be incorporated, by making use of a qualitative research design. To overcome this methodological limitation, future researchers can investigate similar topics by conducting interviews and holding focus group discussion sessions with the target audience so that more rationale and adequate perspectives of respondents can be included in the study. Secondly, the present research incorporated a relatively small sample size because of cross-sectional constraint of research. The sample can also be enhanced in future to attain effective results. Thirdly, since China is ahead of other Asian countries in implementing mobile learning applications, the research focused on China alone. Future researchers can test other technically advanced nations such as Japan and USA where mobile learning practices are equally observed.

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