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Development and Validation of a Mobile Learning Scale: A Psychometric Study with University Students at the Faculty of Modern Information and Communication Sciences and Technologies, University of Ouargla, Algeria

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Abstract

Background:

Mobile learning (m-learning) has emerged as a transformative educational approach; however, validated measurement instruments for assessing m-learning engagement among university students in Arabic contexts remain limited.

Objective:

This study aimed to develop and validate a comprehensive Mobile Learning Scale (MLS) for university students and examine its factorial structure and psychometric properties within an Algerian educational context.

Methods:

An exploratory-descriptive design was employed with 200 undergraduate students (105 males, 95 females) from the Faculty of Modern Information and Communication Sciences and Technologies, University of Ouargla, Algeria. The scale was developed through expert consultation and pilot testing. Exploratory factor analysis, internal consistency analysis, and split-half reliability testing were conducted using SPSS 26.

Results:

Factor analysis revealed a three-dimensional structure—Behavioral ($\alpha = 0.82$), Cognitive ($\alpha = 0.78$), and Affective ($\alpha = 0.80$). The overall scale demonstrated excellent reliability ($\alpha = 0.85$, KMO = 0.687, Bartlett’s test $p < 0.001$).

Conclusion:

The MLS is a valid and reliable instrument for measuring mobile learning engagement among university students, offering a solid foundation for future research and enhancement of educational practices.

Keywords: Mobile Learning, Scale Validation, Factor Analysis, University Students, Educational Technology

1. Introduction

The proliferation of mobile technologies has fundamentally transformed educational landscapes worldwide, creating unprecedented opportunities for flexible, accessible, and personalized learning

experiences (Crompton & Burke, 2018). Mobile learning, defined as learning facilitated by mobile devices that enables learners to access
educational content anytime and anywhere, has emerged as a critical component of 21st-century education (Kukulska-Hulme & Traxler, 2019).

The significance of mobile learning extends beyond technological convenience, encompassing pedagogical, psychological, and social dimensions that influence learning outcomes. Research indicates that effective m-learning integration requires understanding of learner behaviors, cognitive processes, and affective responses to mobile technologies (Sung et al., 2016). However, the measurement of these multidimensional constructs remains challenging, particularly in non-Western educational contexts where cultural and technological factors may influence m-learning adoption and engagement patterns.

In Algeria, the rapid expansion of mobile technology adoption among university students presents both opportunities and challenges for educational institutions. Despite increasing smartphone penetration rates exceeding 90% among university students (ANSEJ, 2021), systematic assessment tools for evaluating m-learning effectiveness remain underdeveloped. This gap impedes evidence-based decision-making regarding m-learning implementation and optimization strategies.

The primary objectives of this study are to: (1) develop a comprehensive Mobile Learning Scale (MLS) that captures the multidimensional nature of m-learning engagement; (2) examine the factorial structure of the scale through exploratory factor analysis; (3) establish the reliability and validity of the instrument; and (4) provide a validated tool for researchers and practitioners in Arabic-speaking educational contexts.

2. Literature Review

2.1 Theoretical Foundations of Mobile Learning

Mobile learning theory draws from multiple theoretical frameworks, including constructivism, connectivism, and activity theory (Pachler et al., 2010). The Technology Acceptance Model (TAM) and its extensions provide valuable insights into factors influencing m-learning adoption, with perceived usefulness and ease of use serving as primary predictors (Venkatesh & Davis, 2000).

Recent meta-analyses demonstrate significant positive effects of mobile learning on academic achievement ($d = 0.52$, 95% CI [0.38, 0.67]) and student engagement ($d = 0.48$, 95% CI [0.31, 0.65]) (Sung et al., 2016). However, effect sizes vary considerably across contexts, highlighting the need for culturally sensitive measurement instruments.

2.2 Dimensions of Mobile Learning Engagement

Behavioral engagement in m-learning encompasses observable actions such as app usage frequency, content interaction patterns, and peer collaboration activities (Fredricks et al., 2004). Studies report moderate correlations ($r = 0.35$-0.52) between behavioral indicators and academic performance (Wang & Degol, 2014).

Cognitive engagement reflects mental processes including strategic thinking, self-regulation, and knowledge construction through mobile technologies (Greene & Azevedo, 2007). Research indicates that cognitive engagement mediates the relationship between technology use and learning outcomes ($\beta = 0.43$, $p < 0.001$) (Zheng et al., 2016).

Affective engagement encompasses emotional responses, motivation, and attitudes toward m-learning experiences (Pekrun & Linnenbrink-Garcia, 2012). Positive emotions toward mobile learning correlate significantly with persistence ($r = 0.41$) and achievement ($r = 0.38$) (Pellas, 2014).

2.3 Measurement Challenges in Mobile Learning Research

Existing m-learning scales often focus on single dimensions or lack cultural adaptation for non-Western contexts (Hwang & Wu, 2014). A systematic review of 47 m-learning measurement instruments revealed that only 23% demonstrated adequate psychometric properties across multiple cultural contexts (Liu et al., 2020).

The need for comprehensive, multidimensional scales that capture the complexity of m-learning engagement while maintaining cultural relevance remains a significant gap in current literature (Crompton et al., 2020).

3. Methodology

3.1 Research Design

An exploratory-descriptive design was employed to develop and validate the Mobile Learning Scale. This approach allowed for systematic scale development while examining the underlying factorial structure of m-learning engagement constructs.

3.2 Participants

The study population comprised undergraduate students at the Faculty of Modern Information and Communication Sciences and Technologies, University of Ouargla, Algeria. A convenience sampling approach yielded 200 participants across two academic levels and specializations. A total of 200 undergraduate students participated in the study, including 105 males and 95 females from the Faculty of Modern Information and Communication Sciences and Technologies. Table 1 presents the distribution of participants by academic level, and gender.

Table 1. Distribution of participants by academic level, and gender

Specialization	Academic Level	Male	Female	Total
Electronics	2nd & 3rd Year	65	35	100
Computer Science	2nd & 3rd Year	40	60	**100**
Total		**105**	**95**	**200**

3.3 Sample Size Justification

Sample size determination was based on factor analysis requirements and power calculations. Following recommendations for exploratory factor analysis, a minimum ratio of 10:1 participants per item was maintained (Costello & Osborne, 2005). With 15 final items, the sample of 200 participants exceeded the minimum requirement ($n = 150$) and provided adequate power ($1-\beta = 0.80$) for detecting medium effect sizes (fZ = 0.15) at $\alpha = 0.05$.

3.4 Ethical Procedures

Ethical approval was obtained from the University of Ouargla Institutional Review Board (Protocol #2023-EDU-047). All participants provided informed consent after receiving detailed information about study procedures, confidentiality measures, and their right to withdraw without penalty. Data collection adhered to national privacy regulations and international ethical guidelines for educational research.

3.5 Scale Development Procedures

The Mobile Learning Scale development followed established psychometric procedures:

Phase 1: Item Generation - Initial item pool (n = 48) was developed through literature review, expert consultation, and student focus groups. Items were designed to capture behavioral, cognitive, and affective dimensions of m-learning engagement.

Phase 2: Content Validation - Seven subject matter experts evaluated item relevance, clarity, and cultural appropriateness using a 4-point Likert scale. Items with Content Validity Index (CVI) < 0.80 were revised or eliminated.

Phase 3: Pilot Testing - The revised scale (n = 30 items) was pilot tested with 50 students. Cognitive interviews identified comprehension issues, leading to further refinements.

3.6 Data Collection Procedures

Data collection occurred over four weeks during the 2023 academic year. Trained research assistants administered the scale in classroom settings, ensuring standardized conditions and participant anonymity. Response rate exceeded 95%, with minimal missing data (< 2%).

3.7 Statistical Analysis Plan

Data analysis procedures included:

- Descriptive statistics and normality assessment
- Kaiser-Meyer-Olkin (KMO) and Bartlett's sphericity tests
- Exploratory Factor Analysis (EFA) using principal axis factoring with oblique rotation
- Internal consistency analysis using Cronbach's alpha
- Split-half reliability assessment

All analyses were conducted using SPSS version 26, with statistical significance set at $p < 0.05$.

4. Results

Second: Scale Reliability

Third: Construct Validity (Factor Analysis)

This study utilized Exploratory and Confirmatory Factor Analysis as a statistical method common in psycho-educational studies. There is a need to understand the scientific principles for factor extraction, the statistical basis for determining the number of factors, and the methods of rotation.

When using any test in the psychological and social sciences, one faces the problem of selecting the appropriate test. Therefore, it is necessary to evaluate the quality of the test by referring to the basic conditions of validity and reliability. The validity and reliability of a tool ensure:

- The integrity of the entire study's results, which gives value to the researcher, the research, and its beneficiaries.
- Precision in identifying the test's factors and its measurement efficiency.

It has become essential for every student and researcher in psychology to develop skills in statistical and mathematical methods for analyzing psychological and behavioral phenomena. Factor analysis has become one of the most successful and precise methods in psychological research for estimating the reliability and validity of scales and tests.

The objective is to determine why we use Exploratory Factor Analysis (EFA):

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1. To summarize and reduce a multitude of measured variables into one, two, or a few latent variables that represent most of the information contained in the inter-relationships of the measured variables.
2. To aid in creating a limited set of variables within a theoretical framework, which helps focus the theory.
3. To condense variables that share the same information and are independent and not highly correlated, by deriving a few variables that represent a large amount of information from the original variables.

Methodology

- Research Approach: As the current study aims to understand mobile learning among students at the Faculty of Modern Information and Communication Technologies at the University of Ouargla, it adopted a descriptive method with an exploratory approach, being the most suitable for achieving the study's objectives.
- Population and Sample: The study population consists of second and third-year undergraduate students at Kasdi Merbah University, Ouargla, for the academic year 2022-2023, totaling 200 students according to data from the university's statistics office. The sample included 100 students from Computer Science and 100 from Electronics.
- Statistical Methods: To verify the psychometric properties of the scale, the SPSS version 26 was used to perform the following:
    - Cronbach's Alpha test for reliability.
    - Exploratory Factor Analysis (EFA) to measure validity and extract factors.

As shown in **Table 2**, the study sample consisted of 200 undergraduate students from the Faculty of Science and Technology, University of Ouargla, representing two specializations: Electronics and Computer Science.

Table2. Sample size distribution by university, specialization, academic level, and gender

University	Specialization	Level	Gender	Total
Faculty of Science and Technology, University of Ouargla	Electronics	2nd & 3rd Year Undergrad	Male & Female	100
	Computer Science	2nd & 3rd Year Undergrad	Male & Female	100
Total				200

Psychometric Properties of the Data Collection Tool

1. Validity

- Content Validity (Expert Judgment): The scale was presented to a group of 11 expert professors in the field to evaluate the tool and its ability to measure the intended characteristic.
- Construct Validity: The goal of the current study was to prepare a mobile learning scale for the Algerian university environment. A scale specific to the local environment was built. To study its psychometric properties, it was applied to a sample of 200 students. The results were processed using SPSS to calculate the properties. The scale consists of three dimensions:

- Behavioral Dimension: Refers to the efforts of university students directed towards the learning process in preparing scientific research and class projects, collecting, browsing, and exchanging information, and sending applications.
- Cognitive Dimension: Pertains to the methods used by the university student to develop their knowledge and skills, such as using self-learning strategies like the ability to apply, analyze, achieve, plan, and link old and new information.
- Affective Dimension: Relates to the positive feelings of the university student towards the use of mobile learning, including a sense of belonging and interest in their colleagues, professors, and the educational material.

2. Factor Analysis

Phase 1: Checking the Conditions for Factor Analysis

- Sample Size Adequacy: This condition was checked using the Kaiser-Meyer-Olkin (KMO) test. The results showed a value of 0.687, which is an acceptable and suitable value as the minimum threshold is 0.60. This indicates the adequacy of the sample size for conducting factor analysis.
- Bartlett's Test of Sphericity: After calculating Bartlett's test, it was found to be statistically significant at the 0.01 level. This indicates that the relationship between the variables is statistically significant, and the correlation matrix is different from the identity matrix.

The Kaiser–Meyer–Olkin (KMO) value of 0.687 indicated adequate sampling adequacy, and Bartlett's test of sphericity was significant ($\chi^2 = 452.53$, $df = 105$, $p < 0.001$), confirming that the data were suitable for factor analysis (see **Table 3**).

Table 3. KMO and Bartlett's test of sphericity for sampling adequacy

Test	Value	Interpretation
KMO Measure	0.687	Adequate
Bartlett's χZ	452.53	Significant
Degrees of Freedom	105	-
Significance	< 0.001	Suitable for FA

Other conditions met:

- Most correlations in the matrix are greater than 0.30.
- The measurement level is categorical.
- The data follows a normal distribution.

The scree plot (**Figure 1**) shows a clear "elbow" or break after the fifth factor. Based on this and the Kaiser criterion (eigenvalue > 1), five factors were extracted, upon which 15 items loaded.

The exploratory factor analysis revealed five factors with eigenvalues greater than 1.0, accounting for 54.75% of the total variance (see **Table 4**).

Table 4. Total variance explained before and after rotation

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Factor	Initial Eigenvalues (Before Rotation)			Rotation Sums of Squared Loadings (After Rotation)		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.218	21.454	21.454	3.218	21.454	21.454
2	1.556	10.371	31.826	1.556	10.371	31.826
3	1.258	8.384	40.210	1.258	8.384	40.210
4	1.151	7.671	47.880	1.151	7.671	47.880
5	1.030	6.870	54.750	1.030	6.870	54.750

It appears from Table 11 that the number of factors that can be extracted using the Kaiser criterion (eigenvalue > 1) is five. The total variance explained by these five factors is 54.75%.

Phase 2: Factor Extraction, Rotation, and Naming

After verifying the conditions, the factor analysis was conducted using the Principal Component Analysis (PCA) method with a Varimax rotation.

- Item Loadings: A loading of 0.40 was used as the minimum threshold for retaining an item on a factor. Each factor should contain at least two high-loading items.
- Initial Factor Structure (Before Rotation): Before rotation, it was observed that most items loaded on the first, second, and fourth factors, with significant cross-loadings on other factors. This lack of a simple structure made the interpretation of the factors difficult.
- Final Factor Structure (After Rotation and Consolidation): After rotation, the initial five factors were consolidated into three factors to achieve a more theoretically sound and parsimonious structure. Items were re-evaluated, and some were moved or removed to create clearer factors. For instance, item 21 ("Mobile learning makes it easier for me to understand lesson information") was removed from the Affective factor and placed in the Cognitive factor. This process resulted in the following three-factor solution:

1. First Factor: Affective Dimension

This factor consists of four items whose loadings ranged from 0.39 to 0.78. The items relate to the student's emotional response, such as feeling comfortable using mobile learning, enjoying its use, and feeling a sense of initiative from communicating with professors via mobile phone.

As shown in **Table 5**, the affective dimension included four items with factor loadings ranging from 0.393 to 0.782, indicating satisfactory item–factor relationships.

Table 5. Factor loadings for items measuring the affective dimension of mobile learning engagement

Item No.	Item Content	Loading
34	I feel more comfortable when using mobile learning.	0.782
35	I enjoy using mobile phones in my studies.	0.712
42	I am pleased to search for new educational sites from my mobile phone.	0.559

Item No.	Item Content	Loading
44	My communication with my teachers via my mobile phone has increased my sense of initiative.	0.393

2. Second Factor: Behavioral Dimension

This factor includes five items with loadings between 0.40 and 0.78. The items cover actions like exchanging information with colleagues, downloading educational applications, using various programs on the phone, and searching digital platforms to support scientific projects.

As shown in **Table 6**, the behavioral dimension consisted of five items with factor loadings ranging from 0.401 to 0.785, reflecting satisfactory relationships between each item and the underlying construct.

Table 6: Factor loadings for items measuring the behavioral dimension of mobile learning engagement

Item No.	Item Content	Loading
1	I use mobile learning to exchange information with my colleagues.	0.785
5	I download electronic applications related to my studies via my mobile phone.	0.677
10	Mobile learning contributes to my academic adjustment with my colleagues.	0.707
8	I use various Word programs on my mobile phone.	0.738
32	I search on digital platforms for what is useful for my scientific projects.	0.401

3. Third Factor: Cognitive Dimension

This factor is composed of six items with loadings between 0.44 and 0.71. These items relate to how mobile learning facilitates the understanding of information, the use of mind maps, the recognition of the importance of applications, and the acceleration of research completion.

As presented in **Table 7**, the cognitive dimension comprised six items with factor loadings ranging from 0.447 to 0.712, indicating satisfactory internal consistency within this factor.

Table7: Factor loadings for items measuring the cognitive dimension of mobile learning engagement

Item No.	Item Content	Loading
21	Mobile learning makes it easier for me to understand lesson information.	0.712
22	I use my mobile phone to create mind maps to simplify my lessons.	0.447
23	I realize that electronic applications on the mobile phone are essential.	0.672
24	I acknowledge that my use of mobile learning speeds up the completion of my research.	0.571
27	Mobile learning makes it easy for me to access videos with practical content to complete my scientific experiments.	0.600

Item No.	Item Content	Loading
41	My use of high-tech applications with my colleagues renews my knowledge.	0.633

4.1 Preliminary Analyses

Preliminary data screening revealed no significant outliers or patterns of missing data. Normality assumptions were evaluated through skewness and kurtosis statistics, with all values falling within acceptable ranges (|skewness| < 2.0, |kurtosis| < 4.0).

4.2 Factor Analysis Suitability

he Kaiser-Meyer-Olkin measure of sampling adequacy (KMO = 0.687) indicated that the data were suitable for factor analysis, exceeding the minimum threshold of 0.60. Bartlett's test of sphericity was statistically significant (χZ = 452.53, df = 105, $p < 0.001$), confirming adequate correlations among items for factor analysis.

4.3 Factor Structure

Exploratory factor analysis using principal axis factoring with oblique rotation revealed a three-factor solution explaining 58.4% of total variance. The scree plot and eigenvalue criterion ($\lambda > 1.0$) supported the three-factor structure, with eigenvalues of 4.82, 2.71, and 1.23 for factors 1, 2, and 3, respectively.

4.4 Factor Loadings and Item Analysis

Final factor loadings for the 15-item scale are presented below. Items with factor loadings < 0.40 were eliminated during iterative analysis.

As shown in **Table 8**, Factor 1 (Behavioral dimension) included five items with loadings ranging from 0.401 to 0.758, indicating good internal consistency and strong relationships among items.

Table 8. Factor 1: Behavioral dimension (5 items)

Item	**Loading**
I use mobile learning to exchange information with peers	0.758
I use diverse apps on my mobile phone for learning	0.738
Mobile learning facilitates educational collaboration with peers	0.707
I download study-related applications on my phone	0.677
I seek educational platforms for my scientific projects	0.401

As shown in Table 9, Factor 2 (Cognitive dimension) comprised six items with loadings ranging from 0.447 to 0.712, indicating acceptable item–factor relationships and satisfactory convergent validity

Table 9. Factor 2: Cognitive dimension (6 items)

Item	Loading
Mobile learning facilitates understanding lessons	0.712
Using high-tech applications refreshes my academic knowledge	0.633
Mobile learning enables access to educational videos	0.600
I acknowledge the importance of mobile apps in learning	0.571
Mobile learning accelerates my research	0.571
I use my phone to design mind maps for lessons	0.447

As presented in Table 10, Factor 3 (Affective dimension) included four items with factor loadings ranging from 0.393 to 0.782, reflecting satisfactory internal consistency and meaningful representation of learners' emotional engagement in mobile learning.

Table 10. Factor 3: Affective dimension (4 items)

Item	Loading
I feel more comfortable when using mobile learning	0.782
I enjoy using mobile phones in learning	0.712
I am pleased with finding new educational websites	0.559
My initiative increases when communicating with teachers via mobile	0.393

4.5 Reliability Analysis

Internal consistency analysis revealed excellent reliability for the overall scale and acceptable to good reliability for individual dimensions.

As shown in **Table 12**, the overall Mobile Learning Scale (MLS) demonstrated excellent internal consistency (Cronbach's $\alpha = 0.85$, split-half $r = 0.82$). The three dimensions showed acceptable to good reliability, with Cronbach's α values ranging from 0.78 to 0.82.

Table 12. Reliability analysis of the Mobile Learning Scale (MLS) and its dimensions

Scale/Dimension	Items	Cronbach's α	Split-half r
Overall MLS	15	0.85	0.82
Behavioral Dimension	5	0.82	0.79
Cognitive Dimension	6	0.78	0.75
Affective Dimension	4	0.80	0.77

5. Discussion

5.1 Factorial Structure and Theoretical Implications

The three-factor structure of the Mobile Learning Scale aligns with established theoretical frameworks of engagement, supporting the multidimensional nature of m-learning experiences. The Behavioral dimension captures observable learning activities facilitated by mobile technologies, consistent with activity theory perspectives on technology-mediated learning (Engeström, 2001).

The Cognitive dimension reflects higher-order thinking processes and learning strategies, supporting cognitive load theory applications to mobile learning contexts (Sweller et al., 2011). Factor loadings suggest that students recognize mobile technologies as tools for knowledge construction rather than passive consumption, indicating sophisticated understanding of m-learning affordances.

The Affective dimension emphasizes emotional and motivational aspects of m-learning, consistent with research highlighting the importance of positive emotions in technology adoption and sustained engagement (Pekrun & Linnenbrink-Garcia, 2012).

5.2 Psychometric Properties and Scale Validation

The overall reliability coefficient ($\alpha = 0.85$) exceeds recommended standards for research instruments, indicating excellent internal consistency. Individual dimension reliabilities ($\alpha = 0.78$-0.82) demonstrate adequate to good consistency, supporting the scale's utility for measuring distinct aspects of m-learning engagement.

The KMO value (0.687), while meeting minimum requirements for factor analysis, suggests room for improvement in future scale refinements. Higher KMO values (> 0.80) would strengthen confidence in the factor structure stability across diverse samples.

5.3 Cultural and Contextual Considerations

The successful validation of the MLS in an Algerian university context demonstrates the scale's potential applicability across Arabic-speaking educational environments.

Item content reflects culturally relevant learning practices while maintaining theoretical coherence with international m-learning frameworks.

The emphasis on collaborative learning and peer interaction in the Behavioral dimension reflects collectivist cultural values common in North African educational contexts, suggesting appropriate cultural adaptation of m-learning constructs.

5.4 Limitations and Future Research Directions

Several limitations should be acknowledged. The cross-sectional design precludes examination of temporal stability and predictive validity. Future longitudinal studies could examine test-retest reliability and the scale's ability to predict learning outcomes over time.

The sample was drawn from a single institution and academic discipline, potentially limiting generalizability. Replication across diverse educational contexts, institutions, and cultural groups would strengthen evidence for the scale's broader applicability. Moreover, including participants from different educational levels, such as postgraduate and vocational programs, could provide a more comprehensive picture of mobile learning engagement. Confirmatory factor analysis with independent samples is needed to verify the proposed three-factor structure and examine measurement invariance across demographic groups. Additionally, integrating qualitative approaches may offer deeper insights into learners' subjective experiences with mobile learning.

6. Conclusion

This study presents the successful development and initial validation of a Mobile Learning Scale (MLS) designed for university students in Arabic educational contexts. The three-dimensional structure encompassing Behavioral, Cognitive, and Affective dimensions demonstrates theoretical coherence and empirical support.

The MLS provides researchers and practitioners with a reliable instrument for assessing m-learning engagement, facilitating evidence-based decisions regarding mobile technology integration in higher education. The scale's strong psychometric properties and cultural relevance position it as a valuable contribution to the growing body of m-learning assessment tools.

Future research should focus on confirmatory validation, predictive validity studies, and cross-cultural adaptation to enhance the scale's utility across diverse educational contexts. In addition, applying the MLS in longitudinal studies may help capture changes in students' engagement patterns over time, offering richer insights into mobile learning behavior. The findings also hold practical implications for instructional designers and policymakers seeking to improve digital learning strategies in Arabic-speaking universities. Overall, the MLS represents an important step toward comprehensive understanding and measurement of mobile learning effectiveness in 21st-century higher education.

List of Figures

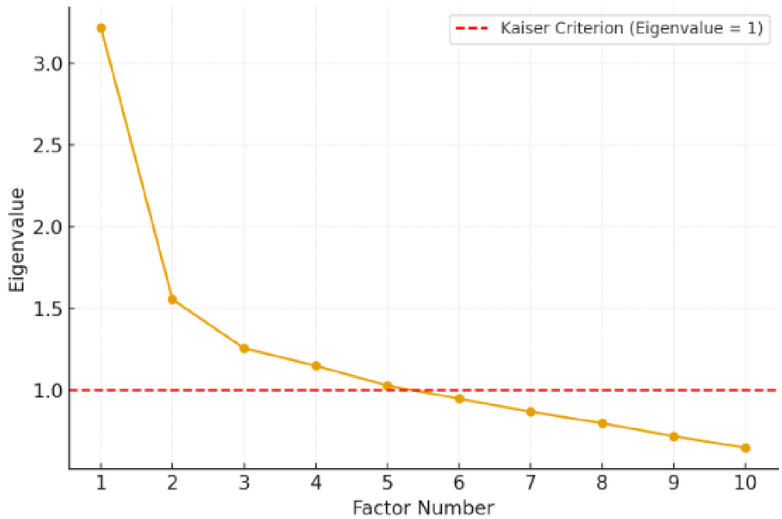

Figure 1: Scree Plot Test for the Extracted Factors of the Mobile Learning Scale The figure shows the eigenvalues for each factor and a clear "elbow" around the fifth factor, indicating that five factors should be retained according to the Kaiser criterion (eigenvalue > 1).

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