Towards a Longitudinal Understanding of Mobile User Experience: The Moodle App Case

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Abstract: Despite the availability of numerous models, instruments, and theoretical frameworks on user experience (UX) evaluation, significant challenges remain in understanding UX from a holistic perspective, both theoretically and methodologically. This work contributes to the UX research by integrating contextual perspectives with a specific focus on mobile applications. This study aims to evaluate user experience and to identify the key factors influencing efficiency, satisfaction, and the long-term acceptance of mobile applications[5]. In order to address these challenges, this study proposes a novel longitudinal and context-aware methodological framework that combines subjective self-reported measures with objective and behavioral data. This framework[7] is empirically validated through a three-phase longitudinal field study conducted under real-life usage conditions, by employing the Moodle mobile application.

Keywords: User experience, Longitudinal methods, Mobile applications, UX evaluation, Moodle mobile app.

1. Introduction

User experience (UX) is one of the most strongly marketed ideas in the area of HCI (Human-Computer Interaction), specifically due to the shortcomings of classic usability studies in understanding experiences produced in human-technology interaction (Abdul Ghani & Shamsuddin, 2020). UX introduces a broader understanding in HCI research, as its multiple facets need to be studied in different stages of interaction. These facets address various user needs, their corresponding instrumental and non-instrumental qualities, and the user's emotional responses (Hassenzahl & Tractinsky, 2006). The pragmatic (instrumental) dimension concerns the utilitarian aspects, such as usefulness and ease of use, whereas the hedonic or non-instrumental dimension relates to the affective, experiential or behavioral aspects (Hassenzahl et al., 2021). According to Roto (2011), UX focuses on task-related aspects (reliability, functionality, or usability) but also on emotions, personal values, aesthetics, and contextual preferences.

Understanding UX concepts and principles remains a challenging task due to the multiple perspectives on this field, which are systematized into various frameworks and UX models offering different constructs and measures (Rahman et al., 2025). According to Bevan (2009), user experience can be viewed as: a) a broader interpretation of usability beyond satisfaction, encompassing aspects such as beauty, fun, comfort or pleasure that contributes significantly to overall satisfaction with a product; b) distinct from usability which focuses almost exclusively on user performance in the achievement of pragmatic goals, and c) covering all the perceptions and responses of a user, regardless of the type of evaluation, with objective or subjective measures. In line with these approaches, the following two different goals were identified: the optimization of human performance and the fulfilment of user satisfaction regarding pragmatic and hedonic user goals.

At present, the market for mobile phones is very competitive, with more than 7.21 billion smartphones, covering about 90% of the global population. This number is expected to exceed 7.7 billion by 2028 (Statista, 2025a). As expected, the number of mobile applications exploded, leading to a smarter, interactive, and people-focused experience (Okonkwo, 2024). The market for smartphones will reach USD 620.3 billion by 2030, growing at a CAGR of 19.3% (Market Research Future, 2024). More than 2.26 million applications are available on the Google Play Store and 1.6 million apps on the Apple Store (Statista, 2025b). Downloads are expected to reach 299 billion in 2025, representing a 7.9% increase from 2024 and 65% from 2020 (TekRevol, 2025). These trends have encouraged researchers to investigate how users perceive, interact with, and relate to mobile applications, focusing more deeply on cognitive, emotional, and contextual dimensions of user experience.

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However, many mobile applications risk losing their relevance and are quickly abandoned after installation if they fail to fulfil the users' needs, expectations, and characteristics (Huseynov, 2020). Even if an application performs perfectly well from a technical point of view, its overall success relies on the ability to provide users with a positive and rewarding experience (van der Linden et al., 2023), while transparency and trust strengthen the acceptance of digital technologies (Ribeiro et al., 2024). Unlike traditional desktop systems, the mobile environment involves a high level of user context variability, such as mobility, crowding, poor lighting conditions, and multitasking. As a result, user experience becomes more sensitive to external factors, which increases the complexity of its analysis and evaluation. Therefore, UX evaluation requires a mixed-method approach, aligned with the dynamic nature of experience.

This study aims to quantitatively validate the longitudinal user experience within the Moodle mobile application by analysing the evolution of users' perceptions and satisfaction over time. For this purpose, the model proposed by Marinescu (2025) will be used. This model extends and adapts the Component model of User Experience (CUE) to the specificities of mobile interactions by introducing contextual, physical, social and technological factors. Each of the model's seven components represents a distinct stage in the formation and evaluation of user experience, directly shaped by variables such as the context of use, demographics, digital experience, and technology affinity. The study further investigates how these components influence satisfaction and how contextual and emotional factors contribute to the transformation of experience over time.

In line with the objective of this study, the following research questions have been formulated:

- **Q1:** How do users' pragmatic and hedonic perceptions evolve throughout their interaction with a mobile application, from initial use to long-term engagement?
- **Q2**: To what extent do emotions and attachment to the application influence users' intention for continued use and their recommendation behaviour?
- **Q3:** How does the overall level of user satisfaction influence application loyalty and long-term usage behaviours across different contexts?

The rest of this paper is organized as follows. In Section 2, the hypotheses of the new theoretical model are put forward. The methodology related to this study, including procedures, instruments, methods and statistical techniques is described in Section 3. Section 4 presents the main findings, including descriptive statistics, reliability and validity testing, and inferential analyses such as repeated-measures ANOVA/MANOVA, correlation, and regression techniques. Together, these techniques support the testing of the proposed hypotheses, leading to the empirical validation of this model. Finally, Section 5 presents the theoretical and practical implications of the study results, limitations and future research directions.

2. Research Background

Technological advancement is one of the driving forces in the new era of teaching and learning (Vevera & Rădoi, 2025). Digital education encompasses online courses, virtual classrooms, video, and interactive content, all accessible on various devices such as laptops, tablets, and smartphones. eLearning platforms support the creation of personalized educational experiences tailored to diverse training levels, age groups, and professional objectives.

Educational applications represent a complex case for UX evaluation, as they involve a wide range of cognitive, functional, emotional and motivational factors. In technology-enhanced learning environments, the user experience directly influences learners' engagement, performance, and satisfaction with the educational process (Martín-Gutiérrez et al., 2017). Previous studies emphasize that beyond usability and functionality, educational UX must account for affective responses, perceived relevance, and learners' sense of control and autonomy. (D'Mello & Graesser, 2012).

Research in mobile user experience (mUX) consistently emphasizes that learning activities are embedded in dynamic, real-world situations,

where interaction occurs across varying physical, social, and temporal contexts. Therefore, contextual factors such as location, connectivity, time pressure, and social setting become determinants of the overall user experience (Nikou & Economides, 2017). These characteristics underline the limitations of static and single-point UX evaluations.

Only a limited number of UX models address the dynamic relationships between pragmatic and hedonic perceptions, emotional responses, and satisfaction accumulated over time (Tähti & Arhippainen, 2004). The tendency is to focus selectively on functional attributes, design-related features, or immediate affective reactions (Karapanos et al., 2009).

Accordingly, a set of research hypotheses is formulated to empirically test the proposed UX model.

H1. Perceived product characteristics and user attributes influence the quality of interaction with the Moodle application.

H2. Interaction quality positively affects the formation of users' pragmatic and hedonic perceptions of the application.

H3. Initial user perceptions, both pragmatic (usefulness, efficiency) and hedonic (pleasure, attractiveness), positively influence subsequent interaction quality, shaping engagement intensity, feature exploration, and long-term usage behaviour.

H4. The usage context (e.g. device type, environmental conditions, mobility, network stability) affects user perceptions through its impact on interaction quality.

H5. Early user perceptions positively influence the development of emotional attachment to the application over time.

H6. Functional dependency, such as the integration of the application into daily routines and its perceived usefulness in recurring tasks, is driven by positive interaction experiences and accumulated satisfaction over time.

H7. Emotional attachment developed over time positively influences the user's intention to recommend the application to others.

H8. Accumulated experiences over time (familiarity) positively influence the overall level of user satisfaction with the application.
H9. User satisfaction positively influences the intention of continued use and the likelihood of recommending the application to others.

3. Methodology

Previous studies highlighted a lack of clear UX evaluation criteria in the e-learning field, particularly for mobile applications (Harrison et al., 2013). To address this gap, a new approach is proposed based on the UX evaluation model developed by Marinescu (2025) (see Figure 1). The model emphasizes the dynamic nature of the user experience, shaped by various usage context and emotional responses.

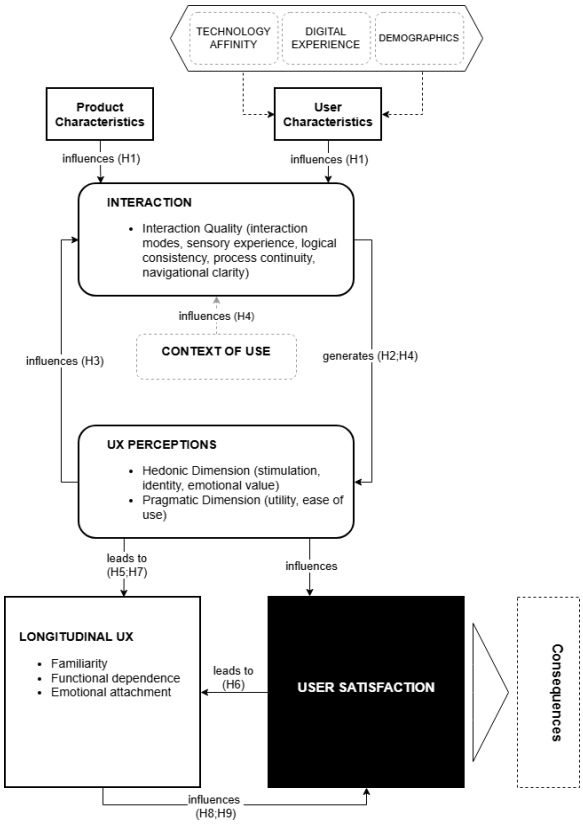

Figure 1. Research UX model for mobile app (Marinescu, 2025)

This approach examines pragmatic criteria, such as usability and functionality, together with hedonic and affective factors emerging from the real and repeated use of mobile applications. These criteria are organised into seven categories and eighteen corresponding

sub-categories or dimensions. Table 1 presents these categories and sub-categories, along with their descriptions.

Table 1. Categories and suggested UX criteria adapted from Marinescu (2025)

UX Category	UX Sub category	UX Criteria
Product characteristics	Usability	Ease of Use; Information Accessibility; Instrumental Quality
	Functionality	Function Findability; Functionality
	Structural clarity	Perspicuity; Structural Predictability
	System feedback	Feedback; Error Feedback
	Performance	Responsiveness; System Stability; Performance; Navigation Fluency
	Sensory experience	Animation Quality; Visual Stimulation
User characteristics	Motivation	Motivation; User Engagement
	Expectations	Confirmation; Comparative Evaluation
	Personality	Person-Product Fit; Perceived Confort
Context	Context of use	Contextual Reliability; Context Adaptability
Interaction	Interaction methods	Input Flexibility; Efficency; Predictability
	Interaction quality	Process Continuity; Logical Consistency; Navigational Clarity
UX perception	Pragmatic perception	Functional Integration; Perceived Usefulness; Memorability
	Hedonic perception	Attractiveness; Positive Affect
User satisfaction	Satisfaction	Continued Usage Intention; Recommendation Intention
Effects over time	Familiarity	Familiarity; Learnability
	Functional dependency	Frequency of Use (Moodle app)
	Emotional attachment	Emotional attachment
Digital Experience	Digital Experience	Digital Self-Efficacity; Prior Experience; General Familiarity
Technology affinity	Technology affinity	Frequency of Use (Mobile app); Openness to Technological Innovation; Technology-related Frustration; Digital Adaptability

3.1 Methods

For a comprehensive UX assessment, a longitudinal mixed-method design was adopted, combining both quantitative and qualitative elements. The qualitative component consisted of open-ended responses in a semi-structured questionnaire. For quantitative data, a questionnaire consisting of five parts was developed. The first part includes demographic data, while the second part (COM), comprising 42 items, serves as the primary source of data, covering all sub-categories of UX. Part three (COEF - 3 items) measures familiarity with mobile applications in the learning process, while part four (COAT - 4 items) measures the affinity for technology, reflecting attitudes such as curiosity, openness, and comfort with digital technologies.

The fifth part (CCO) includes six non-standardized items. These items capture real-time contextual dynamics, offering an additional methodological perspective. The full questionnaire, including all items grouped by dimension, is provided in Appendix A.

The UX model was operationalized as a longitudinal multivariate linear system. The longitudinal structure of the analysis can be expressed as:

$$Y_{i,d,t} = \alpha_t + \beta_1 DE_i + \beta_2 TA_i + \varepsilon_{i,d,t} \quad (1)$$

where $Y_{i,d,t}$ is the composite score of participant i on UX dimension d $(d = 1,...,18)$ measured at the time point $t \in \{T1, T2, T3\}$. These scores were computed as the arithmetic mean of the validated items for each dimension at each measurement stage and represent the observed longitudinal data. The parameter α_t represents the effect of time (within-subject factor), while DE_i represents previous experience (COEF), TA_i denotes technology affinity (COAT), and $\varepsilon_{i,d,t}$ is the residual term.

3.2 Context

At the end of the study, open-ended responses were collected to qualitatively assess the participants' perceptions of their user experience and gather suggestions for improvement. Recruitment advertisements were distributed to students, professors, and researchers from various universities in Bucharest via email, WhatsApp,

dedicated student information spaces and social networks. Participation in the study was voluntary, and no financial or other incentives were provided.

3.3 Participants

Registration and all subsequent phases were conducted on the UXAssist platform. The participants included professors, researchers and undergraduate students from universities in Bucharest, including the National University of Science and Technology Politehnica Bucharest, the Academy of Economic Studies, the University of Medicine and Pharmacy, and the University of Bucharest. They also included researchers affiliated with research institutes such as the National Institute for Research and Development in Informatics (ICI Bucharest).

Their ages ranged from 18 to 50 years, with a relatively equitable gender split. Data was collected at three time points in 2025: Time point 1 (T1) in May (n=157), Time point 2 (T2) in June (n=145), and Time point 3 (T3) in July (n=137). Only the results from the T3 sample were included in the final analysis. The sample included 63 (46%) women and 74 (54%) men. All participants were native Romanian speakers. The age ranged from 18 to over 40 years (M = 36.6; SD = 9.02).

More than half of the participants held a university degree (51.1%), while 28.5% were enrolled in or had graduated from a Master's program, and 20.4% had a doctoral-level education. All the participants owned a smartphone (Android: 75% and iPhone: 25%). Most of them are active users in information technology (29.9%), cybernetics and economic informatics (16.1%), economics and finance (11.7%), engineering (7.3%), health and medicine (5,1%) and research and development (7.3%).

3.4 Survey Instruments

A set of standardized and non-standardized instruments was employed to assess the mobile experience, adapted from validated questionnaires (USE, MAUQ, Attrakdiff, UEQ, meCUE etc) and deployed through the UXAssist platform. This custom-developed web-based platform was designed to facilitate a longitudinal research design by managing multiple assessment sessions and ensuring data consistency. The platform is accessible on various Internet-enabled devices, including smartphones, tablets, and laptops. The main features include questionnaire administration, monitoring the time spent using the mobile application via user-initiated "triggers" and recording the user's relative location via Wi-Fi positioning systems, with their explicit consent. The platform generates aggregated reports supporting statistical analysis and formulating practical recommendations for improving mobile applications.

3.5 Data Collection Procedure

Data was collected through a longitudinal field implemented over a three-month period and organized into three distinct stages (T1, T2 and T3). During the initial phase (T1), participants provided demographic data and information about their digital experience, their familiarity with mobile learning applications, and technology affinity (COEF and COAT). For each evaluation session, participants activated the *Start/Stop* function, which recorded the relative duration of Moodle usage. During this period, they interacted with the Moodle mobile app, within their natural usage environments, according to their own educational needs without imposed tasks or other constraints. A predefined maximum duration was established for all evaluation sessions to ensure comparability across participants.

The primary source of data was the COM questionnaire (multi-dimensional online questionnaire) deployed across all three measurement stages (T1–T3). This instrument assessed pragmatic, hedonic, interaction-related, and satisfaction-related aspects of user experience perceptions, enabling longitudinal comparisons.

Similarly, a contextual online questionnaire (CCO) was used to collect data on user activity, social context, location, and other factors related to Moodle usage. At the end of the evaluation period (T3), participants provided qualitative feedback through open-ended questions addressing both the positive and negative aspects of their experience. Only the participants who completed all three evaluation stages were

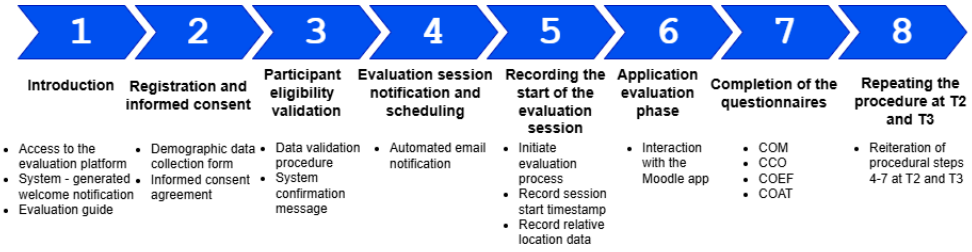

Figure 2. Data collection procedure

included in the final longitudinal analysis. The overall data collection workflow is illustrated in Figure 2.

4. Results

Data processing and a statistical analysis were performed using SPSS Statistics 26. The procedure consisted in verifying and cleaning the raw data, handling missing values, appropriately coding the responses, and reversing negatively worded items to ensure scoring consistency. For each dimension, individual scores were calculated as the average of the associated item values. The validation of the measurement instruments was conducted by assessing internal reliability as well as the convergent and discriminant validity of the included dimensions. To examine the longitudinal evolution of the UX model, a three-way multivariate analysis of variance (MANOVA) with repeated measures was performed across the three measurement stages (T1, T2, and T3). Time was specified as the within-subject factor, while digital experience (COEF) and technology affinity (COAT) were included as between-subject factors, each classified into low and high levels based on the sample mean. Multivariate effects of Time, COEF, COAT, and their interactions on the set of UX dimensions were evaluated using Pillai's Trace. The assumption of sphericity was examined for each dimension using Mauchly's test, and adjusted using the Greenhouse–Geisser correction.

To further clarify the multivariate findings, univariate repeated-measures ANOVAs were subsequently conducted at the construct level, allowing the identification of specific UX dimensions that exhibited significant changes over time and those that remained stable. Post-hoc pairwise comparisons with the Bonferroni correction identified significant differences between the measurement stages.

4.1 Validity of Measurement Instruments

Internal reliability reflects the consistency among items designed to measure the same construct within a specific dimension. Primary indicators for evaluating internal consistency are Cronbach's α and Composite Reliability (CR). Convergent validity was examined using Composite Reliability (CR) and Average Variance Extracted (AVE) for each dimension. Table 2 summarizes the quality indicators for the UX model dimensions across the three measurement points.

The results show that Cronbach's α for most of the model dimensions ranged from 0.70 to 0.95, establishing a good to excellent internal consistency. Dimensions such as Performance, Expectations, and Functional Feedback reported high α values above 0.90, establishing an excellent stability and a high degree of internal coherence. Usability, Functionality, and Sensory Characteristics displayed values close to the acceptable threshold at certain points but remained within tolerable limits. Small variations in dimensions such as Structural Clarity at T3 and Context of use at T2 show a minimal instability but do not affect construct validity. The AVE values were above the commonly accepted threshold of 0.50 (Fornell & Larcker, 1981), while Composite Reliability exceeded the recommended minimum levels (0.60), providing evidence of adequate convergent validity.

4.2 Descriptive Analysis

Standardized questionnaire items (using a 5-point Likert scale) were aggregated into composite scores corresponding to each dimension of the theoretical UX model. The descriptive analysis is presented in Table 3. The results show relatively high mean scores for the functional dimensions, suggesting a strong perception of

Table 2. Quality Indicators for Measurement Scales across the three measurement points

Dimension	Items	Factor loading			Cα (> .70)			CR (> .60)			AVE (> .50)		
		T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3
Usability	U1	0,688	0,804	0,812	0,655	0,702	0,699	0,813	0,834	0,833	0,594	0,627	0,624
	U2	0,820	0,816	0,777									
	U3	0,797	0,754	0,781									
Functionality	F1	0,873	0,863	0,881	0,688	0,659	0,710	0,865	0,854	0,873	0,762	0,746	0,775
	F2	0,873	0,863	0,881									
Structural clarity	CS1	0,948	0,935	0,858	0,884	0,849	0,641	0,947	0,933	0,848	0,899	0,874	0,736
	CS2	0,948	0,935	0,858									
Functional Feedback	FF1	0,958	0,934	0,899	0,911	0,854	0,762	0,957	0,932	0,894	0,918	0,873	0,808
	FF2	0,958	0,934	0,899									
Performance	P1	0,965	0,961	0,971	0,919	0,918	0,947	0,943	0,943	0,962	0,807	0,806	0,865
	P2	0,920	0,929	0,942									
	P3	0,816	0,843	0,930									
	P4	0,887	0,851	0,875									
Sensory characteristics	CS1	0,927	0,896	0,879	0,835	0,753	0,705	0,924	0,890	0,871	0,859	0,802	0,772
	CS1	0,925	0,894	0,879									
Motivation	M1	0,920	0,920	0,918	0,818	0,819	0,812	0,917	0,917	0,914	0,846	0,847	0,842
	M1	0,920	0,920	0,918									
Expectations	A1	0,959	0,954	0,964	0,912	0,901	0,925	0,958	0,953	0,964	0,919	0,910	0,930
	A1	0,959	0,952	0,965									
Personality	P1	0,939	0,910	0,898	0,866	0,791	0,759	0,937	0,906	0,892	0,882	0,827	0,806
	P1	0,936	0,912	0,898									
Context of use	CU1	0,881	0,835	0,855	0,713	0,567	0,632	0,874	0,822	0,845	0,777	0,698	0,731
	CU1	0,881	0,832	0,853									
Interaction modalities	MI1	0,782	0,892	0,948	0,670	0,904	0,928	0,820	0,940	0,954	0,603	0,839	0,875
	MI2	0,781	0,953	0,970									
	MI3	0,766	0,902	0,885									
Interaction quality	CI1	0,899	0,855	0,909	0,884	0,809	0,888	0,929	0,887	0,931	0,813	0,725	0,819
	CI2	0,957	0,906	0,952									
	CI3	0,847	0,789	0,851									
Pragmatic perception	PP1	0,769	0,918	0,925	0,629	0,905	0,916	0,802	0,941	0,947	0,574	0,841	0,857
	PP2	0,764	0,956	0,960									
	PP3	0,741	0,876	0,891									
Hedonic perception	PH1	0,892	0,886	0,867	0,744	0,725	0,671	0,887	0,879	0,859	0,796	0,784	0,752
	PH2	0,892	0,884	0,867									
Satisfaction	S1	0,717	0,786	0,799	0,702	0,745	0,700	0,835	0,855	0,835	0,628	0,663	0,632
	S2	0,850	0,831	0,907									
	S3	0,806	0,825	0,659									
Habit	O1	0,953	0,909	0,931	0,899	0,789	0,845	0,952	0,904	0,928	0,908	0,826	0,866
	O2	0,953	0,909	0,931									
Functional dependency	DF1	0,954	0,934	0,941	0,902	0,854	0,871	0,953	0,932	0,940	0,911	0,873	0,886
	DF2	0,954	0,934	0,941									
Emotional attachment	AE1	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Dimension	**Items**	**Factor loading**			**Cα**			**CR**			**AVE**		
Digital experience	ED1	0,737			0,771			0,873			0,698		
	ED2	0,947											
	ED3	0,808											
Technology affinity	AT1	0,863			0,828			0,889			0,677		
	AT2	0,517											
	AT3	0,900											
	AT4	0,941											

functional quality and usability of the Moodle mobile application. Usability remained relatively stable over time, (M = 4.45-4,51, SD = 0.41-0.44), revealing a consistently positive and homogeneous evaluation.

Functionality and Structural clarity also obtained very high scores suggesting a consolidation of perceived functional adequacy, low variability and strong consensus among users. Functional Feedback shows a high score that increased slightly over time (M = 4.45-4,58) with a gradual reduction in variability (SD from 0.82 to 0.52). This indicates homogeneous user perceptions, supporting a progressive consolidation of positive feedback. Performance scores remained high with a gradual decline over time. This suggests that user perceptions became more diversified toward the end of the study.

Motivation remained high across all stages and Expectations showed moderate and stable mean scores but high variability, suggesting polarized user perceptions. The Personality dimension became more homogeneous over time, suggesting an increasing alignment between the application and users' preferences. Context of use shows high scores, with a slight decrease from T2 (M = 4.55) to T3 (M = 4.47), indicating a positive perception with a minor decline over time. Interaction-related dimensions exhibited a high variability. Interaction quality showed a clear upward trend, increasing from M = 4.06 (SD = 1.04) at T1 to M = 4.52 (SD = 0.64) at T3, indicating a progressive improvement. In contrast, interaction modalities peaked at T2 (M = 4.59, SD = 0.54) before declining at T3 (M = 4.38, SD = 0.75), suggesting an increased heterogeneity of user perceptions in the final stage. Habit demonstrated a clear increasing trend, confirming the experience consolidation. The emotional attachment score increased over time with reduced variability, while Satisfaction remained consistently high, reflecting a stable and increasingly positive user experience.

4.3 Discriminant Validity

Discriminant validity ensures that each construct captures a distinct aspect of the model and does not overlap with other constructs. Across all three measurement points, the Fornell–Larcker criterion was satisfied for all constructs, with √AVE values consistently exceeding inter-construct correlations and no correlation surpassing the 0.85 threshold, confirming an adequate discriminant validity and supporting the interpretation of the constructs as distinct factors.

Table 3. Descriptive statistics T1, T2, T3

Dimension	Mean (T1)	SD	Min	Max	Mean (T2)	SD	Min	Max	Mean (T3)	SD	Min	Max
Usability	4,45	0,41	3,33	5,00	4,45	0,43	3,33	5,00	4,51	0,44	3,33	5,00
Functionality	4,45	0,47	3,00	5,00	4,45	0,44	3,50	5,00	4,54	0,48	3,00	5,00
Structural clarity	4,70	0,54	2,50	5,00	4,65	0,53	3,00	5,00	4,62	0,50	3,00	5,00
Functional Feedback	4,45	0,82	1,00	5,00	4,56	0,64	1,00	5,00	4,58	0,52	3,00	5,00
Performance	4,49	0,69	1,00	5,00	4,41	0,67	1,00	5,00	4,29	0,83	1,00	5,00
Sensory characteristics	4,11	0,97	1,50	5,00	4,15	0,82	1,50	5,00	4,20	0,91	1,00	5,00
Motivation	4,61	0,51	2,50	5,00	4,55	0,52	2,00	5,00	4,47	0,50	2,50	5,00
Expectations	3,72	1,08	1,00	5,00	3,73	1,05	1,00	5,00	3,76	1,02	1,00	5,00
Personality	4,04	0,90	1,00	5,00	4,30	0,64	1,50	5,00	4,28	0,54	2,50	5,00
Context of use	4,53	0,60	2,00	5,00	4,55	0,51	2,50	5,00	4,47	0,51	2,50	5,00
Interaction modalities	4,48	0,48	3,00	5,00	4,59	0,54	3,00	5,00	4,38	0,75	1,00	5,00
Interaction quality	4,06	1,04	1,00	5,00	4,22	0,70	2,00	5,00	4,52	0,64	2,00	5,00
Pragmatic perception	4,46	0,47	3,33	5,00	4,64	0,56	2,33	5,00	4,31	0,67	1,67	5,00
Hedonic perception	4,34	0,59	3,00	5,00	4,27	0,59	3,00	5,00	4,46	0,57	3,00	5,00
Satisfaction	4,52	0,48	3,00	5,00	4,44	0,38	3,33	5,00	4,45	0,46	3,00	5,00
Habit	4,61	0,65	2,00	5,00	4,68	0,47	2,50	5,00	4,78	0,42	2,50	5,00
Functional dependency	3,55	0,84	1,50	5,00	3,64	0,75	2,00	5,00	4,35	0,55	3,00	5,00
Emotional attachment	4,28	1,08	1,00	5,00	4,35	0,90	1,00	5,00	4,55	0,57	3,00	5,00

4.4 Global Analysis (MANOVA)

The multivariate analysis of variance revealed a significant effect of Time on the overall set of UX dimensions, demonstrating a global change in user experience across the three measurement points (Table 4). In addition, a significant Time × COAT interaction was observed, suggesting that UX evolution differed according to users' affinity for technology. No significant interactions involving COEF, either alone or in combination with COAT, were identified, suggesting that cognitive and experiential user characteristics did not substantially influence the global UX trajectory.

Table 4. Multivariate tests of the effects of Time, COEF and COAT on UX dimensions

Effect	Pillai's Trace	F	df1	df2	p	η^2p
Time	0.123	9.269	2	132	.000	.123
Time × COEF	0.014	0.953	2	132	.388	.014
Time × COAT	0.047	3.219	2	132	.043	.047
Time × COEF × COAT	0.004	0.272	2	132	.762	.004

Mauchly's test indicated that the assumption of sphericity was violated for most UX dimensions ($p < .05$). Consequently, degrees of freedom were adjusted using the Greenhouse–Geisser correction for the affected dimensions. This adjustment reduces the risk of Type I error inflation and ensures a more accurate estimation of the F statistic in the univariate analyses.

4.5 Univariate Analysis (ANOVA)

To further explore the multivariate findings, univariate repeated-measures ANOVAs were conducted for each UX dimension to identify which specific constructs exhibited significant changes over time. Table 5 presents the findings for all UX dimensions, demonstrating the global effect of Time on user experience. Dimensions such as Functional Feedback, Pragmatic Perception, Habit, and Functional Dependency demonstrated moderate to large variations, whereas Usability and Expectations remained relatively stable. This heterogeneous pattern suggests that user experience follows distinct trajectories across UX dimensions.

Table 5. ANOVA results (Time factor) for UX model dimensions

Dimension	Sphericity	df1	df2	F	p	η^2p
Usability	none	2	266	0,122	,885	,001
Functionality	none	2	266	1,592	,205	,012
Structural clarity	GG	2	266	1,616	,201	,012
Functional Feedback	GG	2	266	7,178	,001	,051
Performance	GG	2	266	3,681	,026	,027
Sensory characteristics	GG	2	266	4,003	,019	,029
Motivation	GG	2	266	3,831	,023	,028
Expectations	GG	2	266	1,117	,329	,008
Personality	GG	2	266	13,616	,000	,093
Context of use	none	2	266	3,595	,029	,026
Interaction modalities	GG	2	266	4,183	,016	,030
Interaction quality	GG	2	266	11,654	,000	,081
Pragmatic perception	GG	2	266	16,690	,000	,111
Hedonic perception	none	2	266	8,962	,000	,063
Satisfaction	GG	2	266	8, 615	,000	,061
Habit	GG	2	266	15,583	,000	,105
Functional dependency	GG	2	266	84,342	,000	,388
Emotional attachment	GG	2	266	4,517	,012	,033

4.6 Hypothesis Testing

Hypothesis testing aimed to examine whether the empirical results obtained through longitudinal statistical analyses support the research hypotheses (H1–H9) derived from the proposed conceptual UX model. Hypothesis testing was based on two complementary statistical approaches: repeated-measures ANOVA was applied to assess the temporal effects across the three measurement stages, while Pearson and Spearman correlation analyses were conducted to assess the strength and direction of the relationships between UX dimensions and external variables (COEF, COAT, CCO, and demographics). Ordinary least squares (OLS) regression analyses were additionally performed to examine the predictive and cross-temporal relationships between theoretically related UX constructs. Earlier dimension scores (at T1 or T2) were introduced as predictors of the related

Table 6. Results of Hypothesis Testing

Hypothesis	Result	Observations
H1	Partially supported	Modest effects were observed: user-related factors (Expectations, Personality) were relevant at T2, while product characteristics and external variables showed unstable effects over time.
H2	Partially supported	Weak relationships were found with pragmatic perception; clearer associations emerged with hedonic perception at T1/T2, but these effects attenuated at T3.
H3	Supported	Pragmatic perception at T1 significantly predicted interaction quality at T2; however, these effects did not persist at T3, while hedonic perceptions showed a limited influence.
H4	Supported	Dynamic effects were identified: emotional state (T1), adaptability (T2), and contextual reliability (T3) exhibited significant negative associations over time.
H5	Not supported	Neither bivariate correlations nor OLS regression analyses confirmed significant predictive effects.
H6	Not supported	Functional dependency followed an autoregressive pattern; predictors did not provide additional explanatory power beyond baseline levels.
H7	Supported	A strong relationship emerged only at T3 ($r = 0.684$), confirming a long-term effect rather than immediate associations.
H8	Supported	Familiarization showed a consistent positive correlation with other UX dimensions across the measurement stages ($r = 0.15–0.25$), indicating its stable contribution to UX evolution.
H9	Supported	Strong and stable relationships were observed, particularly at T1 and T3 ($r > 0.70$), highlighting satisfaction as a key driver of behavioral intentions.

outcomes assessed at subsequent time points (T2 or T3). A synthesis of the obtained results is presented in Table 6.

5. Conclusions

This work provides empirical evidence supporting a longitudinal and contextual perspective on mobile user experience (mUX), revealing its dynamic, cumulative and multi-dimensional nature. Applied to the Moodle mobile app, the three-point longitudinal evaluation covered the static and dynamic aspects of UX dimensions.

The longitudinal analyses (including ANOVA, MANOVA, and longitudinal correlation and regression techniques) provide the empirical validation of the proposed UX evaluation model for mobile applications. The results indicate heterogeneous temporal trajectories across the UX dimensions. Components such as satisfaction-related pragmatic aspects remained relatively stable, whereas other constructs, particularly those related to interaction, perception, and emotional attachment, exhibited significant variation across the measurement stages. The evaluation process was fully supported by the UXAssist platform, a web-based UX evaluation assistant. Despite the overall confirmation of the proposed hypotheses, either fully or partially, several limitations must be acknowledged. The generalizability of the findings is constrained by the characteristics of the sample and the specific nature of the investigated application.

To conclude, the answers to the research questions provide a coherent and integrative perspective on the nature of mobile UX. The findings demonstrate that UX progresses incrementally, with both the pragmatic and hedonic aspects contributing to satisfaction and long-term integration. Emotions and the role of attachment have been found to impact continued use as well as recommendation intentions only within the latter stages of interaction, confirming the assumption that affective loyalty develops through a gradual process. Finally, satisfaction has been identified as a predictor for both continued use and recommendation intentions, starting from the early stages, although affected by the role of contextual factors and temporal consistency.

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Appendix A. Questionnaire Items

All the questionnaires were administered in Romanian; the English wording provided here represents the translated version:

Dimension	Items
Usability	The application is easy to use; The information I need is easy to find within the application; The application provides predictable and coherent responses to my actions.
Functionality	The application's features are easy to locate and access; The application provides all the functions I need.
Structural Clarity	The structure of the application is clear and easy to follow; The organization of the application is predictable and consistent.
Functional Feedback	I receive useful information about the progress of the tasks I perform; Errors are presented in a way that is easy to understand.
Performance	The application responds quickly to my commands; The application operates without interruptions or crashes; The application runs efficiently without excessive device resource consumption; Navigation within the application is smooth, without noticeable delays.
Sensory Experience	The animations within the application are smooth and appealing; The interface is visually stimulating through attractive colours and graphical details.
Motivation	The application is motivating and encourages active use; The application maintains my interest during use.
Expectations	The application proved to be better than I expected; The application performs better than similar applications I have used.
Personality	The application fits my preferred way of working; I feel comfortable with the way the application is designed.
Context of Use	The application functions reliably in different environments (home, office, transportation means etc.); I can use the application without problems even when moving or performing other activities.
Interaction Methods	The application allows multiple ways to perform the same action; The application allows quick actions without unnecessary steps; It is always clear what will happen when I perform an action.
Interaction Quality	I was able to complete tasks without interruptions; I did not need to return to previous steps to continue my activity; While using the application, I always know where I am and what to do next.
Pragmatic Perception	The application's functions are well integrated and help me achieve my goals; The application's features are relevant to my activities; I can easily remember how to use the application, even after a longer break.
Hedonic Perception	The application is attractive and enjoyable to use; I feel good while using the application.
User Satisfaction	Overall, I am satisfied with this application; I intend to continue using this application; I would recommend this application to others.
Habit	I use the application effortlessly by habit; I no longer need an adaptation period because I am accustomed to using the application.
Functional Dependency	I frequently use the application in my daily activities; I frequently use the application in my educational activities.
Emotional Attachment	I prefer to use this application even if alternatives are available.

Contextual UX - non-standardized items

Item	Possible response options
What activity are you currently engaged in?	Attending a course; completing assignments; uploading/downloading materials; reading/reviewing course materials; taking or preparing for a test/ exam; communicating with professors or colleagues; checking announcements or schedules; other activities.
Where are you currently located?	At home; university; library; workplace; public space; means of transportation; other location.
How would you describe your current situation?	Alone; with colleagues/friends; with family; crowded environment; quiet environment; moving/travelling; relaxing; other situations.
Which device did you use to access the Moodle application?	Smartphone; tablet.
How would you rate your current internet connection?	Very good; good; satisfactory; poor; unstable.
How do you feel at this moment?	Very stressed; stressed; neutral; relaxed; very relaxed.