Towards an Integrated Framework for Online Learning Success in Moroccan Higher Education and Its Relevance to Environmental Science and Technology

Meryem Ziz[1], Sophia Faris[2], and Khalifa Mansouri[3]*

[1,2,3]Modeling and Simulation of Intelligent Industrial Systems, Higher Normal School of Technical, Education, Mohammedia, Morocco.

Abstract. Online learning represents a sustainable and technology-driven approach to higher education and plays a critical role in advancing Environmental Science and Technology (EST) education in developing countries. This study evaluates an integrated model of online learning success in Morocco by synthesizing insights from TAM, ECM, D&M ISS, SRL, and TTF frameworks. Data were collected via survey from 207 students engaged in hybrid learning and analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM). Findings show that perceived ease of use, system/service/information quality, and perceived usefulness strongly predict student satisfaction, which in turn drives continuity intention. Self-regulated learning and task–technology fit emerged as the strongest predictors of performance impact. These results highlight the importance of usability, system quality, and student self-management not only for general online education sustainability but also for equipping students to succeed in domains such as EST, where adaptability, digital skills, and sustainable models are critical.

Keywords: Online Learning, Student Satisfaction, Continuity Intention, Environmental Science and Technology, Structural Equation Modeling

1. Introduction

The transformation of higher education through digital platforms has implications not only for pedagogy but also for sustainability and capacity building in Environmental Science and Technology (EST). By enabling remote participation and hybrid models, universities can minimize physical infrastructure use, reduce travel-related emissions, and provide more inclusive access to education across disciplines that are vital for sustainable development. Digital environments also facilitate cross-campus collaboration, guest lectures from international experts, and the sharing of specialized Environmental Science and Technology resources such as virtual labs, environmental datasets, and simulation tools.

Over the past decade, online learning has significantly influenced the transformation of higher education in Morocco. Beyond expanding access and flexibility, it has fostered the digitalization of teaching practices, encouraged pedagogical innovation, and enhanced institutional resilience, particularly during and after the COVID-19 pandemic. Moroccan universities have increasingly integrated learning management systems, virtual classrooms, and blended learning models, enabling broader participation and supporting continuous professional development among educators. These shifts have not only redefined instructional delivery but have also contributed to the modernization and internationalization of Moroccan higher education, aligning it more closely with global digital education standards.

There are also open questions about how well online systems develop the interdisciplinary competencies required in Environmental Science and Technology, such as systems thinking, data literacy, and applied problem-solving, especially for lab- and field-oriented components. Addressing these challenges requires examining factors that drive student satisfaction, persistence (continuance intention), and perceived performance in digital environments, while considering both technological attributes and pedagogical design.

Building on an earlier integrative framework [1], this study aims to validate an integrated success model for online learning in Moroccan higher education and to demonstrate its relevance for developing effective EST-focused education strategies. The model integrates system, information, and service quality with instructional elements such as instructor presence, collaborative learning. By testing the relationships among these constructs, the study seeks to identify the most influential levers for improving student outcomes and informing program design.

Research objectives:

1 Corresponding author: zizmeryem7@gmail.com

- Validate an integrated model of online learning success in Morocco.
- Identify key factors affecting student satisfaction, continuity, and perceived performance.
- Draw practical implications for strengthening Environmental Science and Technology education as part of sustainable higher education strategies, including recommendations for platform design, instructor practices, and support services.

This paper is organized as follows. Section 2 presents a comprehensive review of the theoretical and empirical literature underpinning online learning success, with particular attention to its relevance in Environmental Science and Technology education. Section 3 outlines the research methodology, including the study design, sample characteristics, measurement constructs, and analytical procedures employed. Section 4 reports the empirical results derived from the structural equation modeling analysis. Section 5 provides an in-depth discussion of the findings, highlighting theoretical implications and practical considerations for Moroccan higher education institutions. Finally, Section 6 concludes the study by summarizing the main contributions, delineating limitations, and proposing directions for future research.

2. Literature Review

Several theoretical frameworks shape the understanding of online learning success, each highlighting different but complementary drivers of student experience and outcomes:

Technology Acceptance Model (TAM) [2] highlights perceived ease of use and perceived usefulness as drivers of adoption.

Expectation Confirmation Model (ECM) [3]emphasizes satisfaction as a predictor of system continuance, the model is represented in figure 1.

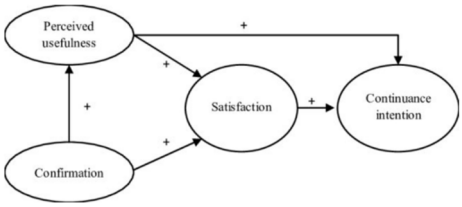

Fig. 1*:* Expectation confirmation model (ECM)

DeLone & McLean IS Success (D&M ISS) [4], presented in figure 2, identifies system, service, and information quality as essential for online learning outcomes.

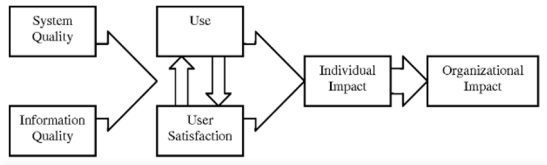

Fig 2: Delone and Mclean information success model (D&M ISS)

Task Technology Fit (TTF)[5] suggests learning outcomes improve when digital tools align with user tasks.

Self-Regulated Learning (SRL) [6] emphasizes independent learning strategies as central to online learning success.

For EST, these frameworks are especially significant. Training in environmental disciplines requires interdisciplinary digital simulations, virtual labs, and access to large data sets. Thus, usability, motivation, and task–technology alignment directly influence how students engage with technology-intensive domains such as renewable energy and sustainability management.

Despite a growing global body of evidence supporting integrated models of online learning success, relatively few studies have rigorously validated these frameworks within the contexts of developing and emerging economies, where infrastructural constraints, linguistic diversity, and institutional variability may alter how key constructs operate. In particular, empirical work that simultaneously tests technology acceptance, self-regulation, information systems quality, and task–technology alignment remains scarce outside high-income settings. This study addresses that gap by providing a context-sensitive validation for Moroccan higher education, offering evidence on how these interrelated factors predict satisfaction, persistence, and perceived performance among Moroccan students. By doing so, it not only extends the generalizability of integrated success models but also generates actionable insights tailored to Morocco's policy priorities, resource conditions, and pedagogical practices.

3. Methodology

3.1.Research Design

A quantitative, cross-sectional survey design was adopted to capture a snapshot of learners' experiences and perceptions at a specific point in time. This approach enables the measurement of key constructs—such as satisfaction, continuance

intention, and perceived performance—and the examination of relationships among variables across a broad participant pool. Data were gathered through an online questionnaire to maximize reach and convenience for respondents distributed across institutions and regions. The instrument was administered in French, aligning with Morocco's academic and administrative language practices, and ensuring linguistic accessibility for the majority of students and faculty. To enhance clarity and response quality, the survey employed closed-ended items with Likert-type scales, complemented by brief demographic questions (e.g., program, level of study, and connectivity context). Where appropriate, items were adapted from validated scales in the online learning and information systems literature, with minor wording adjustments for the Moroccan higher education context.

3.2. Participants

The sample comprised 207 Moroccan university students who had each participated in hybrid (online and face-to-face) courses within the preceding academic period. Participants were recruited from multiple public universities and faculties to ensure heterogeneity in institutional context and program structure. Respondents represented a broad diversity of disciplines in addition to STEM fields, as well as a range of education levels (from first-year undergraduates to master's and doctoral candidates). This diversity allowed for comparisons across academic stages and disciplinary cultures.
Participants also varied in their prior exposure to online learning tools and their self-reported digital competence, encompassing differences in access to reliable internet, device type (laptop, desktop, tablet, or smartphone), and familiarity with common platforms such as LMSs, videoconferencing software, and collaborative document tools. Although the study was not restricted to students in Environmental Science and Technology (EST), a substantial share of respondents was enrolled in STEM programs, which often include project-based, lab-oriented, or data-intensive components. As a result, the findings retain strong relevance for environmental and engineering education, where hybrid modalities must support interdisciplinary learning, practical skill development, and collaboration.
To support external validity, the sample intentionally included students with varying degrees of digital infrastructure maturity. Basic demographic and academic characteristics (e.g., age, gender, year of study, field of study, and prior online learning experience) were collected to enable subgroup analyses and to contextualize interpretations of satisfaction, persistence, and perceived performance within hybrid learning environments.

3.3. Constructs and Measurement

Constructs included:
- Technological factors: perceived ease of use (PEOU) [7], perceived usefulness (PU) [8], system/service/information quality (SSI) [9], innovation characteristics.
- Task and psychological factors: task–technology fit (TTF) [10], self-regulated learning (SRL) [11], expectation confirmation [12], social/teaching presence [13].
- Outcomes: satisfaction (SSF) [14], continuity intention (CTI) [15], performance impact (PI)[13].
All measured on 5-point Likert scales (1 = strongly disagree, 5 = strongly agree).

3.4. Data Analysis

Reliability and validity of the measurement model were assessed through multiple complementary indicators. Internal consistency was first examined using Cronbach's α for each latent construct. To address limitations of α with congeneric measures, Composite Reliability (CR) was also computed, targeting values between 0.70 and 0.95 to indicate adequate construct reliability without redundancy. Convergent validity was evaluated via Average Variance Extracted (AVE), with AVE ≥0.50 indicating that, on average, the construct explains more than half of the variance in its indicators.
In addition, indicator reliability was inspected by reviewing standardized outer loadings; items with loadings below 0.70 were flagged for potential revision or removal, balancing statistical improvement with content validity. Discriminant validity was examined using the Fornell–Larcker criterion (square root of AVE greater than inter-construct correlations) and cross-loadings.
Structural Equation Modeling [16] was conducted using SmartPLS to test the hypothesized relationships among constructs within a Partial Least Squares (PLS-SEM) framework The PLS approach was selected due to its suitability for prediction-oriented research, complex models with multiple latent variables, and non-normal data. The analysis followed a two-step procedure: (1) evaluation of the measurement model as detailed above, and (2) evaluation of the structural model, including path coefficients, t-values.

4. Results

4.1. Reliability and Validity

All constructs demonstrated acceptable internal consistency and reliability based on multiple criteria. Specifically, Cronbach's alpha values were at or above 0.57, indicating tolerable internal consistency for exploratory work, while

Composite Reliability (CR) values met or exceeded 0.77, falling within the recommended range for latent variable measurement. Convergent validity was supported by Average Variance Extracted (AVE) values greater than 0.50 for all constructs, signifying that each latent variable captured more than half of the variance in its indicators. Item-level inspection further showed satisfactory standardized loadings for most indicators, with any marginal items retained only when theoretically essential to preserve content coverage. Together, these results provide evidence that the measurement model is reliable and exhibits adequate convergent validity for subsequent structural analysis.

4.2.Hypothesis Testing

Out of 16 hypotheses, 8 were significant ($p < 0.05$):
- Ease of use → Usefulness ($\beta = 0.534$, $p < 0.001$).
- Usefulness → Satisfaction ($\beta = 0.413$, $p < 0.001$).
- Service/System/information quality → Satisfaction ($\beta = 0.232$, $p < 0.01$).
-Technology/Task/Individual characteristics → Task technology fit ($\beta = 0.658$, $p < 0.01$).
- Satisfaction → Continuity intention ($\beta = 0.391$, $p < 0.001$).
- Task–technology fit → Performance impact ($\beta = 0.128$, $p < 0.01$).
- Self-regulated learning → Performance impact ($\beta = 0.925$, $p < 0.001$).
- Continuity intention → Performance impact ($\beta = 0.070$, $p < 0.05$).

5. Discussion

This study provides empirical evidence that core constructs from the Technology Acceptance Model (TAM), Self-Regulated Learning (SRL), the DeLone and McLean Information Systems Success model (D&M ISS), and Task–Technology Fit (TTF) collectively play a decisive role in predicting Moroccan students' satisfaction, continuance intention, and perceived academic outcomes in online learning environments. Specifically, perceived usefulness and perceived ease of use (TAM) were positively associated with satisfaction and intentions to persist, indicating that students are more likely to value and continue using platforms they find beneficial and straightforward. SRL factors, such as goal setting, strategic planning, time management, and self-monitoring, were strong predictors of perceived performance, highlighting the importance of learner autonomy and metacognitive skills in hybrid and fully online contexts.
- Usability and Usefulness (TAM): Ease of use significantly increased perceptions of usefulness, which strongly contributed to satisfaction. This echoes global findings but underscores the importance of usability for Moroccan students with varying ICT proficiency.
- System/Service/Information Quality (D&M ISS): Technical stability and quality of information content significantly influenced satisfaction, reinforcing the need for reliable platforms.
- Self-Regulated Learning (SRL): The strongest predictor of performance impact, demonstrating that EST-related programs must actively cultivate student autonomy, reflective learning, and adaptability to handle complex sustainability challenges.
- Task–Technology Fit (TTF): Online tools must support simulations, lab data analysis, and interdisciplinary projects common in EST. Proper alignment yields improved performance outcomes.
Interestingly, social presence and expectation confirmation were not significant predictors. In Morocco, satisfaction and engagement may be more strongly shaped by system quality and self-regulation than by interpersonal interaction.
The diagram in figure 3 represents those relationships and the validated hypothesis.

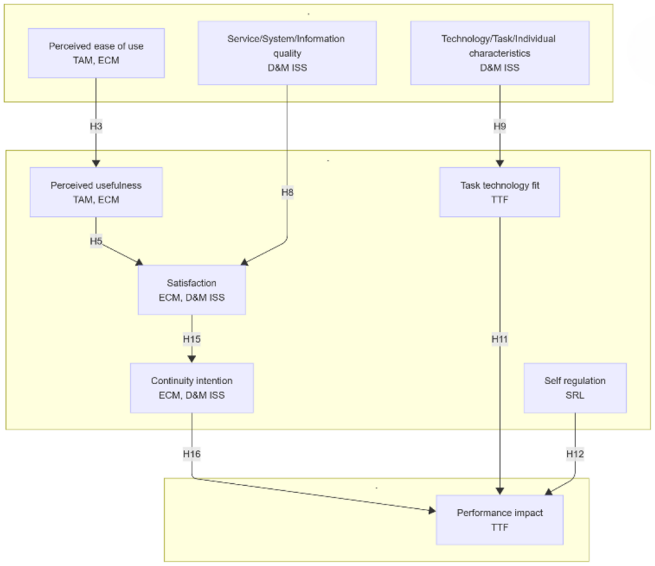

Fig 3. the refined approach

6. Conclusion

This research validates an integrated model of online learning success within the context of Moroccan higher education and highlights its practical implications for the design and delivery of Environmental Science and Technology (EST) programs. By empirically confirming the relationships among key determinants—such as system, information, and service quality; learner engagement and self-efficacy; and pedagogical factors including instructor presence, collaborative learning, and assessment alignment—the study provides a coherent framework for enhancing student satisfaction, continuance intention, and perceived performance in digital and hybrid environments.

For our key findings: Usability, perceived usefulness, and platform quality drive student satisfaction, satisfaction predicts continuity of online platform use and task–technology Fit and SRL are critical for perceived learning performance, with SRL being the strongest predictor.

For practical Implications: For online learning in general institutions must invest in user-friendly platforms, robust systems, and accessible information. And for EST education specifically programs must integrate digital tools aligned with sustainability tasks (e.g., simulation of energy systems, climate modeling) and promote SRL skills. For sustainability in education: Online learning supports green transitions by reducing infrastructure energy use and enabling remote access to environmental education. For Limitations: The convenience sample restricts generalizability; future work should include longitudinal studies and EST-specific course evaluations. Future Work should explore how online learning in Environmental Science and Technology impacts graduate employability, sustainability literacy, and contributions to national environmental strategies.

References

1. Ziz M, Faris S, Mansouri K (2023) JATIT, TOWARDS A NEW STUDENTS SATISFACTION MODEL IN ONLINE ENVIRONEMENTS FOR ACADEMIC PERFORMANCE. . Vol
2. Al-Rahmi WM, Yahaya N, Aldraiweesh AA, et al (2019) Integrating Technology Acceptance Model With Innovation Diffusion Theory: An Empirical Investigation on Students' Intention to Use E-Learning Systems. IEEE Access 7:26797–26809. https://doi.org/10.1109/ACCESS.2019.2899368
3. Li L, Wang Q, Li J (2022) Examining continuance intention of online learning during COVID-19 pandemic: Incorporating the theory of planned behavior into the expectation–confirmation model. Front Psychol 13:1046407. https://doi.org/10.3389/fpsyg.2022.1046407
4. DeLone WH, McLean ER (1992) Information Systems Success: The Quest for the Dependent Variable. Information Systems Research 3:60–95. https://doi.org/10.1287/isre.3.1.60
5. Al-Rahmi AM, Shamsuddin A, Alismaiel OA (2020) Task-Technology Fit Model: The Factors Affecting Students' Academic Performance in Higher Education. ujer 8:6831–6843. https://doi.org/10.13189/ujer.2020.081249
6. Ergen B, Kanadli S (2017) The Effect of Self-Regulated Learning Strategies on Academic Achievement: A Meta-Analysis Study. EJER 17:55–74. https://doi.org/10.14689/ejer.2017.69.4
7. Davis FD (1989) Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology. MIS Quarterly 13:319. https://doi.org/10.2307/249008
8. Hashim H, Mohamad SA, Che Hamzah H, et al (2023) The Role of Perceived Usefulness and Confirmation in Influencing Student's Satisfaction on Online Distance Learning. AJUE 19:. https://doi.org/10.24191/ajue.v19i2.22232
9. Alenezi AR E-learning acceptance: Technological key factors for successful students' engagement in E-learning system
10. Alyoussef IY (2021) E-Learning Acceptance: The Role of Task–Technology Fit as Sustainability in Higher Education. Sustainability 13:6450. https://doi.org/10.3390/su13116450
11. Fauzi A, Widjajanti DB (2018) Self-regulated learning: the effect on student's mathematics achievement. J Phys: Conf Ser 1097:012139. https://doi.org/10.1088/1742-6596/1097/1/012139
12. Bhattacherjee A (2001) Understanding Information Systems Continuance: An Expectation-Confirmation Model. MIS Quarterly 25:351. https://doi.org/10.2307/3250921
13. Alraggad A (2025) The effect of social interaction on academic performance: The moderating influence of cultural background. 2576-8484 9:1276–1286. https://doi.org/10.55214/25768484.v9i4.6245
14. Abuhassna H, Nawajha SA, Awae F, et al (2024) An analysis of educational outcomes and user satisfaction in webex following COVID-19: An expectation-confirmation model. J Autonom Intell 7:1550. https://doi.org/10.32629/jai.v7i5.1550
15. Yassine S, Khalifa M, Franck P (2017) Towards a Multidimensional Model to Study a Critical Success Factors Affecting Continuity and Success in E-Learning Systems. In: 2017 10th International Conference on Developments in eSystems Engineering (DeSE). IEEE, Paris, pp 129–134
16. Anderson JC, Gerbing DW Structural Equation Modeling in Practice: A Review and Recommended Two-Step Approach