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Implementing English as a Medium of Instruction in Algerian Higher Education: The Role of ICT in Addressing Challenges and Leveraging Opportunities

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ABSTRACT

The adoption of English as a Medium of Instruction (EMI) in Algerian higher education presents both significant opportunities and considerable challenges. This mixed-methods study investigates the role of Information and Communication Technologies (ICT) in navigating this transition across three public universities in Algeria. Data were collected from 230 students, 45 faculty members, and 6 administrators through surveys, semi-structured interviews, focus groups, and document analysis. Quantitative findings revealed significant linguistic challenges, particularly in understanding technical vocabulary (M=4.02, SD=0.71) and academic writing (M=3.91, SD=0.83). Statistical analyses demonstrated positive correlations between ICT usage and student engagement ($r=.45$, $p<.01$), with ICT-enhanced pedagogical approaches showing significant improvements in learning outcomes ($t=3.87$, $p<.001$). Qualitative analysis identified five major themes: ICT as language support, infrastructure limitations, pedagogical training needs, digital literacy gaps, and enhanced international collaboration. The study found that while 82.2% of faculty use Learning Management Systems, only 35.6% integrate specialised language learning platforms. Infrastructure challenges and varying digital literacy levels emerged as significant barriers. The findings support all three hypotheses, demonstrating that strategic ICT integration can reduce linguistic barriers, improve learning outcomes, and enhance international collaboration opportunities (effect sizes d=1.18-1.77). Based on these results, a five-component framework for technology-integrated EMI implementation is proposed, emphasising infrastructure investment, comprehensive training programmes, and evidence-based pedagogical strategies. This research contributes to understanding how developing nations can leverage technology to internationalise higher education whilst addressing context-specific challenges in multilingual settings.

Keywords: *English Medium Instruction; Algerian Higher Education; Information and Communication Technologies; Digital Pedagogy; Language Learning Technology; Higher Education Policy*

INTRODUCTION

The Global Context of English Medium Instruction

The increasing interconnectedness of the global academic and professional spheres has established English language proficiency as a critical determinant of success for graduates navigating an internationalised landscape (Baker & Hüttner, 2019; Macaro, 2018). Consequently, English as a Medium of Instruction (EMI) - defined as the use of English to teach academic subjects in contexts where English is not the first language of most learners (Macaro et al., 2018) has become a rapidly expanding phenomenon in higher education worldwide (Dearden, 2014; Rose et al., 2020). This expansion reflects broader forces of globalisation,

including international student mobility, cross-border research collaboration, and the dominance of English in academic publishing, where an earlier study showed that approximately 80% of indexed journals have published primarily in English (Lillis & Curry, 2010).

The Algerian Higher Education Context

Algeria presents a unique sociolinguistic context characterised by Arabic (official language), Tamazight (national language since 2002), and French (legacy of colonisation). Since the early 2000s, Algerian higher education has undergone significant reforms aligned with the Bologna Process, including the LMD system (Licence-Master-Doctorat), which created openings for increased English use in certain disciplinary fields at that time, particularly STEM (Miliani, 2010). The Ministry of Higher Education and Scientific Research has increasingly encouraged EMI adoption, viewing it as essential for Algeria's knowledge economy development and regional competitiveness. This attention is motivated by several factors: (a) enhancing international employability of Algerian graduates; (b) improving access to cutting-edge international research; (c) fostering international academic collaborations; and (d) enhancing the global standing of Algerian institutions (Coleman, 2006; McKinley et al., 2019). However, EMI implementation in Algeria faces distinctive challenges. The educational system's historical trilingualism created complex dynamics where studies indicated that EMI competed with established French-medium instruction whilst addressing inadequate English preparation at secondary levels (Rezig, 2011; Belmihoub, 2018). Furthermore, questions arise about how Information and Communication Technologies (ICT) might support this transition, particularly given infrastructure and resource constraints common in developing contexts.

The Role of ICT in Supporting EMI

ICT offers multiple affordances for supporting EMI implementation. Digital technologies can provide adaptive language support through interactive platforms, automated feedback, and corpus-based resources (Beatty, 2013; Godwin-Jones, 2018). Open Educational Resources (OER) can address resource scarcity, providing freely accessible materials that reduce dependency on expensive imported textbooks (Wiley & Hilton, 2018). Interactive and collaborative technologies facilitate peer support, while learning analytics can help identify struggling students early (Means et al., 2013; Siemens & Long, 2011). For faculty, ICT provides access to professional development opportunities often unavailable locally, while virtual internationalisation has created opportunities for authentic English use without requiring physical mobility (O'Dowd, 2018; Rubin, 2017). However, technology integration is not without challenges. Critical scholars emphasise how technology can reproduce existing inequalities when access, literacy, and support are uneven (Selwyn, 2010; van Dijk, 2020; Warschauer, 2003). Despite growing literature on both EMI and educational technology, earlier research specifically examining how ICT can support EMI implementation remained limited, particularly in developing contexts (Barnawi & Al-Hawsawi, 2017). Most EMI research focuses on East Asian and European contexts, leaving North African settings underexplored.

Research Objectives and Hypotheses

This study investigates the role of ICT in supporting EMI implementation in Algerian higher education through a mixed-methods approach. Three hypotheses are tested:

Hypothesis 1: The strategic integration of ICT tools will lead to a statistically significant reduction in perceived linguistic challenges associated with EMI implementation among students.

Hypothesis 2: ICT-enhanced pedagogical approaches will be positively correlated with statistically significant improvements in learning outcomes and student engagement in EMI courses.

Hypothesis 3: Enhanced access to ICT resources will significantly enhance opportunities for international academic collaboration and access to global research networks for faculty and students.

Five research questions guide this investigation:

1. What are the principal challenges hindering effective EMI implementation in Algerian higher education?
2. What opportunities does EMI adoption present for Algerian universities, students, and faculty?
3. In what specific ways can ICT tools be utilised to address challenges associated with EMI implementation?
4. How can ICT be strategically leveraged to maximize potential benefits of EMI?
5. What are critical contextual factors for successful ICT integration in supporting EMI initiatives?

By addressing these questions in the Algerian context, this study contributes empirical evidence from an underexplored region while providing practical insights for policy makers, institutional leaders, and faculty navigating similar challenges in multilingual, resource-constrained settings.

LITERATURE REVIEW

English as a Medium Instruction: Global Trends and Challenges

English as a Medium of Instruction (EMI) represents one of the most significant transformations in global higher education over the past two decades. Macaro et al. (2018) identified EMI programmes in over 55 countries, with particularly rapid growth in Asia, Europe, and increasingly in Middle Eastern and North African contexts. This expansion is driven by internationalisation agendas, economic competitiveness, and English dominance in global knowledge production (Dearden, 2014; Rose et al., 2020). However, EMI implementation presents complex challenges that vary significantly across contexts. Linguistic preparedness emerges as a primary obstacle, with students often possessing basic communicative English but lacking the Academic Language Proficiency (ALP) necessary for disciplinary learning. Cummins' (2014) framework distinguishes between Basic Interpersonal Communication Skills (BICS) and Cognitive Academic Language Proficiency (CALP), emphasising that the latter requires explicit development. Studies confirm that inadequate ALP significantly impacts student comprehension, participation, and academic achievement in EMI contexts (Kırkgöz, 2017; Liu & Li, 2021). Faculty challenges are equally significant. Studies have shown that content specialists often lack training in language-sensitive pedagogical approaches, creating difficulties in scaffolding language alongside content (Airey, 2012; Hellekjær, 2010). This "double burden" of teaching both disciplinary content and supporting language development requires specialised pedagogical competencies (Dafouz & Smit, 2020). Furthermore, assessment practices in EMI contexts have raised complex questions about distinguishing content knowledge from language proficiency (Shohamy, 2013).

EMI in Multilingual Contexts

Multilingual contexts present unique complexities beyond simple bilingual transitions. García and Wei's (2014) translanguaging framework suggests that multilingual learners fluidly draw upon their entire linguistic repertoire for meaning-making, challenging monolingual ideologies often implicit in EMI implementation. This perspective suggests that effective EMI should leverage rather than suppress students' multilingual resources. In Arab contexts specifically, Barnawi and Al-Hawsawi (2017) identified distinctive challenges including the diglossic situation of Arabic, the established role of French or other colonial languages, and varying English proficiency across socioeconomic groups. These factors created concerns about linguistic imperialism - questions about whether EMI marginalizes local languages and reproduces social inequalities (Phillipson, 2017). Belmihoub's (2018) study of multilingual Algeria highlighted how EMI interacts with existing Arabic-French bilingualism, creating a trilingual educational environment with unique cognitive and pedagogical implications.

The Potential of ICT in Supporting EMI

Information and Communication Technologies offer multiple affordances for supporting EMI implementation, though studies show that effectiveness depends critically on pedagogical integration rather than mere technological presence (Laurillard, 2012; Selwyn, 2010).

Language Support: Digital technologies can provide adaptive language support through interactive platforms, automated feedback, and corpus-based resources offering just-in-time assistance for vocabulary, grammar, and academic writing challenges (Beatty, 2013; Godwin-Jones, 2018).

Resource Access: Open Educational Resources (OER) can address resource scarcity common in developing contexts, providing freely accessible, adaptable materials that reduce dependency on expensive imported textbooks (Wiley & Hilton, 2018). This is particularly significant for EMI contexts where appropriate English-language materials may be limited or prohibitively expensive.

Interactive Learning: Blended learning approaches combining online and face-to-face instruction have shown positive effects on learning outcomes (Means et al., 2013). Research in ESP contexts demonstrates that blended teaching significantly improves both student achievement and attitudes towards English learning (Aleb & Labed, 2021), suggesting carefully designed technology integration can effectively support language development in discipline-specific courses. Earlier research has shown that collaborative tools enable peer scaffolding where linguistically stronger students support struggling peers, distributing language support beyond the instructor alone (Kukulska-Hulme & Shield, 2008).

Professional Development: ICT provides faculty access to professional development opportunities often unavailable locally. MOOCs and online professional learning communities can effectively support teacher development in resource-constrained contexts (Kennedy & Laurillard, 2019), while virtual communities of practice enable educators to share strategies across geographic boundaries. This is particularly valuable for EMI teaching, which requires specialised pedagogical knowledge that may not exist locally.

Virtual Internationalisation: Telecollaboration and Collaborative Online International Learning (COIL) create opportunities for authentic English use and intercultural exchange

without requiring physical mobility (O'Dowd, 2018; Rubin, 2017). This "internationalisation at home" approach can democratize access to international experiences for students unable to afford study abroad.

Digital Divides and Equity Concerns

However, ICT integration is not without challenges. Critical scholars emphasize how technology can reproduce and exacerbate existing inequalities when access, literacy, and support are uneven (Selwyn, 2010; van Dijk, 2020; Warschauer, 2003). Hilbert (2016) documented persistent digital divides both between and within countries, with reliable Internet access and adequate devices remaining significant barriers in many developing contexts. Hargittai (2002) conceptualized a "second-level digital divide" related to skills and usage patterns - even when infrastructure existed, varying digital literacy levels created differential benefits. In educational contexts, these divides manifest as unequal opportunities to leverage technology for learning. Students from privileged backgrounds may have home computers, reliable Internet, and family support for technology use, while disadvantaged students may rely on inadequate public access or mobile phones with limited functionality (van Dijk, 2020).

Technological Pedagogical Content Knowledge (TPACK)

Mishra and Koehler's (2006) TPACK framework offers valuable guidance for effective technology integration. TPACK emphasizes that effective technology use requires the intersection of three knowledge domains: content knowledge (disciplinary expertise), pedagogical knowledge (teaching and learning processes), and technological knowledge (understanding of digital tools). Importantly, effective integration requires not just possessing these three types of knowledge separately but understanding their interactions - how particular technologies can support specific pedagogical approaches for teaching specific content. In EMI contexts, TPACK becomes even more complex, requiring an additional language dimension. Faculty must understand how to use technology to support pedagogical approaches that develop both disciplinary understanding and academic language proficiency. This requires professional development addressing all four dimensions and their interactions, not merely technical training (Redecker, 2017).

Research Gaps

Despite growing literature on both EMI and educational technology, research specifically examining how ICT can support EMI implementation remains limited, particularly in developing contexts. Most EMI research focuses on linguistic and pedagogical challenges without deeply examining technology's role, while educational technology research often does not address the specific challenges of foreign language medium instruction. Furthermore, most EMI research has concentrated on East Asian and European contexts, leaving North African and Middle Eastern contexts underexplored (Barnawi & Al-Hawsawi, 2017). This study addresses these gaps by providing empirical evidence from the Algerian context, examining how ICT tools and pedagogical approaches can address specific EMI challenges in a trilingual, resource-constrained setting. By employing a mixed-methods approach, the research provides both breadth (patterns across a substantial sample) and depth (detailed accounts of experiences and practices) to understand the complex interactions among EMI implementation, ICT integration, and institutional context.

METHODOLOGY

Research Design

This study employed a convergent parallel mixed-methods design (Creswell & Plano Clark, 2018) allowing simultaneous collection and analysis of quantitative and qualitative data, with integrated interpretation.

Participants

Students (n=230):

- 150 undergraduate (65.2%), and 80 postgraduate (34.8%) students in EMI programmes.
- *Disciplines:* English Literature (38.7%), Economics/Management (31.7%), Computer Science (18.3%), Engineering (11.3%).
- *Gender:* 138 female (60.0%), 92 male (40.0%).
- Ages: 19-34 years (M=23.4, SD=3.2).

Faculty Members (n=45):

- 24 male (53.3%), 21 female (46.7%).
- *Teaching experience*: 3-28 years (M=12.6, SD=6.8).
- *EMI experience:* 1-12 years (M=4.3, SD=2.9).
- *Ranks:* 8 Professors (17.8%), 14 Associate Professors (31.1%), 18 Senior Lecturers (40.0%), 5 Lecturers (11.1%).

Administrators (n=6):

- 3 Vice-Rectors, 2 Deans, 1 Teaching Centre Director.
- *Administrative experience*: 4-15 years (M=8.7, SD=4.2).

Data Collection Instruments

Student Survey: 48-item questionnaire including demographics (8 items), linguistic challenges (15 items, 5-point Likert scale), ICT usage patterns (10 items), engagement/outcomes (10 items), resource access (5 items). Reliability: linguistic challenges (α=.89), ICT attitudes (α=.86), engagement/outcomes (α=.91).

Faculty Survey: 52-item parallel questionnaire. Reliability: teaching challenges (α=.87), ICT integration (α=.84), pedagogical effectiveness (α=.88).

Semi-structured Interviews: 30 individual interviews (10 students, 15 faculty, 5 administrators). Duration: 30-75 minutes. Audio-recorded and professionally transcribed.

Focus Groups: 4 sessions (2 undergraduate, 1 postgraduate, 1 faculty). Duration: 90-120 minutes. Participants: 6-8 per group.

Document Analysis: 45 documents analysed (12 policy documents, 8 strategic plans, 24 course syllabi, 11 infrastructure reports).

Data Collection Procedures

This mixed-methods study was conducted during the 2024-2025 academic year, following the

official launch of the EMI policy in Algerian higher education. Data were collected from 230 students, 45 faculty members, and 6 administrators through surveys, semi-structured interviews, and focus groups. Surveys were administered online via Google Forms (Response rates: students 76.7% (230/300), faculty 81.8% (45/55)). Interviews and focus groups were also conducted as part of the qualitative data gathering.

Data Analysis

Quantitative: SPSS 28.0 used for descriptive statistics, t-tests, ANOVA, Pearson correlations, multiple regression, chi-square tests (α=.05).

Qualitative: Braun and Clarke's (2006) thematic analysis using NVivo 14. Inter-coder reliability: κ=.84.

Data Integration: Quantitative and qualitative findings integrated through comparison, elaboration, and joint displays (Creswell & Plano Clark, 2018).

RESULTS AND ANALYSIS

Overview of Findings

This section presents findings from 230 students, 45 faculty members, and 6 administrators across three Algerian universities. Results are organised around the five research questions, with integrated quantitative and qualitative data supporting the three hypotheses.

Research Question 1: Principal Challenges Hindering EMI Implementation

Quantitative Findings: Linguistic Challenges

Table 1 presents student-perceived linguistic challenges. Technical vocabulary emerged as the most significant barrier (M=4.02, SD=0.71), with 84.3% of students rating it as challenging. Academic writing (M=3.91, SD=0.83) and reading lengthy texts (M=3.75, SD=0.79) followed as major concerns.

Table 1: *Student-Perceived Linguistic Challenges in EMI (N=230)*

Linguistic Challenge	**M**	**SD**
Understanding technical/specialised vocabulary	4.02	0.71
Writing academic assignments in English	3.91	0.83
Reading lengthy academic texts in English	3.75	0.79
Following rapid English during lectures	3.64	0.92
Understanding lectures in English	3.52	0.87
Expressing complex ideas clearly in English	3.48	0.96

Participating in class discussions in English	3.28	0.95
Taking notes effectively during English lectures	3.21	1.02
Understanding academic reading strategies	3.18	0.88
Understanding peers' English in group work	2.94	1.05

Note: All means significantly different from scale midpoint (3.0) at p<.01 except "Understanding peers' English."

Significant differences emerged between undergraduate and postgraduate students. Undergraduates reported greater challenges in technical vocabulary (Mundergrad=4.14 vs. Mpostgrad=3.78; t(228)=3.52, p<.001, d=0.52), writing assignments (d=0.50, p=.001), and class discussions (d=0.52, p<.001), likely reflecting postgraduates' greater English exposure and academic maturity.

Faculty perceived similar challenges from the instructional perspective (Table 2). Students' limited academic English vocabulary was rated highest (M=4.24, SD=0.69), followed by the challenge of balancing content coverage with language support (M=4.11, SD=0.76).

Table 2: *Faculty-Perceived Challenges in EMI Teaching (N=45)*

Teaching Challenge	**M**	**SD**
Students' limited academic English vocabulary	4.24	0.69
Balancing content coverage with language support	4.11	0.76
Students' difficulties with academic writing	3.98	0.81
Assessing content knowledge vs. language ability	3.82	0.84
Lack of pedagogical training for EMI teaching	3.93	0.87
Lack of appropriate teaching materials in English	3.87	0.89
Students' reluctance to participate in discussions	3.76	0.91
Limited time for individualised language support	3.69	0.95
Insufficient institutional support for EMI	3.64	1.03
Own English language proficiency limitations	2.91	1.12

Note: 5-point scale (1=Not challenging, 5=Extremely challenging)

Qualitative Findings: Major Themes in EMI Challenges

Thematic analysis of interviews and focus groups revealed five major challenge themes:

Theme 1: Linguistic Barriers in Trilingual Context

The vocabulary gap emerged as the most prominent challenge (mentioned by 93% of interviewees). Beyond simple vocabulary deficits, participants described a unique *"French shadow"* phenomenon - cognitive interference from prior French-medium instruction. As one engineering postgraduate explained:

> *"All my undergraduate courses were in French. I learned all engineering terminology in French. Now in Master's, everything is in English, but concepts come to mind in French first, then I must translate. It's exhausting."*

This trilingual cognitive load - navigating Arabic, French, and English simultaneously, distinguishes the Algerian context from simpler bilingual EMI transitions.

Theme 2: Infrastructure Inequality and Access Gaps

Infrastructure challenges was manifested as unequal access rather than universal absence. A faculty member noted:

> *"In my department, we have good internet in faculty offices, but computer labs for students are outdated, many computers don't work, and internet is very slow."*

This inequality creates differential opportunities, potentially exacerbating rather than reducing educational disparities.

Theme 3: Pedagogical Unpreparedness

Faculty consistently expressed feeling unprepared for the dual challenge of teaching disciplinary content while supporting language development. A Computer Science professor stated:

> *"I am an expert in my field and can explain complex algorithms clearly. But I was never trained to teach English or help students develop academic language skills."*

This "double burden" requires specialised competencies most faculty have not developed.

Theme 4: Assessment Dilemmas

Distinguishing content knowledge from language proficiency in assessment emerged as a persistent challenge. An Economics faculty member articulated the dilemma:

> *"When grading essays, if a student demonstrates understanding of economic theory but expresses it with grammatical errors and limited vocabulary, what grade should they receive?"*

This fundamental tension between content and language assessment remained unresolved for most faculty.

Theme 5: Resource Scarcity

Limited availability of appropriate English-language teaching materials, particularly contextually relevant resources, constrained EMI implementation. Commercial English textbooks were prohibitively expensive ($80-150 each), creating financial barriers for students.

Research Question 2: Opportunities Presented by EMI Adoption

Quantitative Findings

Both students and faculty perceived substantial EMI benefits (Table 3). Students rated international employability highest (M=4.47, SD=0.68), with 91.7% considering it important or extremely important. Faculty emphasised international research access (M=4.53, SD=0.59) and collaboration opportunities (M=4.49, SD=0.62).

Table 3: *Student and Faculty Perceptions of EMI Benefits (N=275)*

Benefit	**Students M(SD)**	**Faculty M(SD)**	**t-value**
Enhanced international employability	4.47(0.68)	4.36(0.72)	1.09
Access to international research/resources	4.31(0.74)	4.53(0.59)	2.14*
Preparation for global academic environment	4.29(0.71)	4.42(0.66)	1.28
International collaboration opportunities	4.18(0.79)	4.49(0.62)	2.76**
Improved English language proficiency	4.16(0.82)	3.87(0.91)	2.25*
Enhanced critical thinking	3.94(0.86)	4.18(0.73)	1.99*
Competitive advantage in job market	4.38(0.71)	4.24(0.79)	1.29
International recognition of degree	4.22(0.77)	4.38(0.68)	1.46

Note: *p<.05, **p<.01

Qualitative Themes: EMI Opportunities

Theme 6: Gateway to Global Knowledge

Participants emphasised how EMI provides direct access to cutting-edge international resources. A Computer Science postgraduate noted:

> *"In computer science, everything new is published first in English - research papers, technical documentation. With EMI, I can directly access these resources without depending on translations."*

Theme 7: Career Competitiveness as "Economic Capital"

Students framed EMI degrees as valuable capital in competitive job markets, viewing English proficiency certification as an employability advantage beyond the degree itself.

Theme 8: Internationalisation and Cognitive Benefits

Faculty highlighted how EMI facilitates international collaboration, while some students described cognitive benefits from multilingual learning:

> *"When I understand an economic concept in English, then discuss it in Arabic and read about it in French sources, I understand it more deeply."*

Research Question 3: ICT Tools Addressing EMI Challenges

ICT Usage Patterns

Table 4 reveals varying ICT adoption patterns. Online dictionaries showed highest student usage (94.3%), directly addressing the vocabulary gap. Learning Management Systems were adopted by 82.2% of faculty, though only 35.6% integrated specialised language learning platforms.

Table 4: *ICT Tool Usage in EMI Contexts*

ICT Tool/Resource	Students Using	Faculty Using
Learning Management Systems	78.3%	82.2%
Online dictionaries/translation tools	94.3%	62.2%
Online academic databases	67.8%	75.6%
Video conferencing tools	71.7%	64.4%
YouTube educational videos	82.6%	51.1%
Mobile language learning apps	58.7%	13.3%
Online collaborative tools	63.5%	48.9%
Interactive whiteboards/smart boards	30.0%	48.9%
Automated writing feedback tools	40.0%	15.6%
Online language learning platforms	34.8%	35.6%

Correlations Between ICT and Learning Outcomes

Table 5 demonstrates significant positive correlations between ICT usage and learning outcomes. Frequency of ICT use by instructors correlated with student engagement (r=.45, p<.01), while student personal ICT use for language support showed strong correlations with both engagement (r=.48, p<.01) and self-reported learning outcomes (r=.44, p<.01).

Table 5: *Correlation Matrix: ICT Usage and Learning Outcomes (N=230)*

Variable	**1**	**2**	**3**	**4**	**5**
1. Frequency of ICT use by instructor	---				
2. Student ICT use for language support	.38**	---			
3. Perceived ICT usefulness	.41**	.56**	---		
4. Student engagement	.45**	.48**	.52**	---	
5. Self-reported learning outcomes	.39**	.44**	.49**	.67**	---

Note: **p<.01 (two-tailed)

Multiple regression analysis predicting student engagement revealed significant effects ($F(7,222)=28.43$, $p<.001$, $R^2=.47$). Significant predictors included perceived ICT usefulness ($\beta=.31$, $p<.001$), personal ICT use ($\beta=.24$, $p<.001$), instructor ICT integration ($\beta=.22$, $p=.002$), and prior English proficiency ($\beta=.19$, $p=.004$).

Qualitative Themes: ICT as Solution

Theme 9: ICT as Linguistic Scaffolding and Multimodal Learning

Students described ICT tools as *"personal tutors available 24/7"* for vocabulary and comprehension support. YouTube videos with visual animations helped students understand concepts difficult to grasp from English textbooks alone. One student explained: *"*

> *When I'm reading a research paper and encounter a difficult word, I immediately look it up on my phone."*

Theme 10: Asynchronous Learning and Collaborative Support

The ability to pause, rewind, and review recorded lectures emerged as particularly valuable. An Economics postgraduate noted:

> *"My professor records lectures and posts them on Moodle. I can pause, rewind, and listen multiple times to sections I didn't understand."*

Collaborative tools, including informal WhatsApp study groups, enabled peer support where students helped each other in multiple languages.

Research Question 4: Leveraging ICT to Maximize EMI Benefits

International Engagement by ICT Access Level

The data in Table 6 demonstrates that ICT access dramatically enhances international engagement. Faculty with high ICT access averaged 2.8 international co-publications compared to 0.9 for low-access colleagues (t=3.54, p<.001, d=1.18). Similarly large effects emerged across all internationalisation indicators.

Table 6: *International Engagement by ICT Access Level*

Outcome Measure	**High ICT Access M(SD)**	**Low ICT Access M(SD)**	**t-value**	**Cohen's d**
International co-publications	2.8(1.9)	0.9(1.1)	3.54***	1.18
International conference participation	4.2(2.3)	1.7(1.5)	3.72***	1.28
International research network membership	3.6(1.8)	1.3(1.2)	4.21***	1.47
Access to international resources	12.4(4.2)	5.8(3.1)	7.89***	1.77
International scholarly communication	3.7(1.6)	1.4(1.2)	6.92***	1.63
Exposure to global research trends	4.1(0.8)	2.9(0.9)	6.11***	1.42

Note: ***p<.001

Qualitative Theme: Virtual Internationalisation

Theme 11: Democratizing International Access

Participants described how ICT enables international experiences previously limited to elite institutions. A postgraduate student recounted:

> *"I attended a virtual conference on development economics hosted by a UK university through Zoom. I presented my research to an international audience and made connections with students from five countries."*

Faculty emphasised how open access repositories (arXiv, ResearchGate) provide research access without subscription costs, while some students participated in global online learning communities (Coursera, edX, Stack Overflow).

Research Question 5: Critical Factors for Successful ICT Integration

Barriers to ICT Integration

The data in Table 7 identifies primary barriers. For students, unreliable internet (M=4.12, SD=0.89) and insufficient device access (M=3.87, SD=1.02) were most significant. Faculty rated insufficient pedagogical training highest (M=4.18, SD=0.78), followed by unreliable internet (M=4.02, SD=0.94) and time constraints (M=3.93, SD=0.85).

Table 7: *Barriers to Effective ICT Integration in EMI*

Barrier	**Students M(SD)**	**Faculty M(SD)**
Unreliable internet connectivity	4.12(0.89)	4.02(0.94)
Insufficient computer/device access	3.87(1.02)	3.24(1.15)
Lack of technical support	3.64(0.98)	3.91(0.87)
Limited digital literacy skills	3.42(1.05)	3.76(0.93)
Insufficient training on pedagogical ICT use	N/A	4.18(0.78)
Lack of appropriate digital resources	3.55(0.94)	3.82(0.89)
Time constraints for learning technologies	3.28(1.08)	3.93(0.85)
Institutional policies/restrictions	2.94(1.12)	3.47(1.06)
Cost of software/subscriptions	3.71(1.01)	3.56(1.03)
Language barrier in using ICT	2.87(1.15)	2.24(1.07)

Note: 5-point scale (1=Not a barrier, 5=Major barrier)

Qualitative Themes: Success Factors

Theme 12: Infrastructure as Foundation

An administrator emphasised:

> *"We can have the best pedagogical strategies and well-trained faculty, but if students cannot reliably access them due to poor internet or lack of devices, everything fails."*

Infrastructure emerged as the non-negotiable foundation.

Theme 13: Pedagogical Training Beyond Technology

Faculty distinguished between technical training and pedagogical integration. A mid-career faculty member explained:

> *"I attended a workshop on using Moodle - it taught me how to upload files and create assignments. But it didn't teach me how to design EMI courses that leverage Moodle to support language development alongside content learning."*

The need for pedagogy-focused rather than tool-focused training emerged consistently.

Theme 14: Institutional Support Structures

Institutions with dedicated teaching and learning centres, offering workshops, consultations, and resource repositories, showed more successful ICT-EMI integration. An administrator noted this support *"makes a tremendous difference"* in faculty adoption and effectiveness.

Hypothesis Testing Summary

Hypothesis 1 (Linguistic Challenges): Supported. Multiple regression controlling for prior English proficiency showed ICT usage significantly predicted reduced perceived linguistic challenges (β=-.28, $p<.001$), explaining additional 8% variance. However, ICT reduces but does not eliminate linguistic challenges - significant barriers remain even with technology support.

Hypothesis 2 (Learning Outcomes and Engagement): Strongly supported. Correlation analyses demonstrated significant positive relationships between ICT-enhanced pedagogical approaches and both learning outcomes ($r=.49$, $p<.001$) and student engagement ($r=.52$, $p<.001$). Independent samples t-tests comparing high versus low ICT integration courses showed significantly higher engagement ($M_{high}=4.12$ vs. $M_{low}=3.47$; $t(228)=5.89$, $p<.001$, $d=0.88$) and learning outcomes ($M_{high}=3.98$ vs. $M_{low}=3.41$; $t(228)=5.12$, $p<.001$, $d=0.77$).

Hypothesis 3 (International Collaboration): Robustly supported. Faculty and students with enhanced ICT access showed dramatically higher international engagement across all indicators, with large effect sizes ranging from $d=1.18$ to $d=1.77$ (all $p<.001$). Qualitative data corroborated these findings with accounts of ICT-enabled virtual internationalisation.

All three hypotheses received empirical support, though Hypothesis 1 showed partial effects while Hypotheses 2 and 3 demonstrated strong effects.

DISCUSSION

This mixed-methods study investigated ICT's role in supporting EMI implementation across three Algerian universities, testing three hypotheses and addressing five research questions. Findings demonstrate that strategic ICT integration can significantly reduce linguistic barriers (H1: β=-.28, $p<.001$), enhance learning outcomes and engagement (H2: $d=0.77$-0.88), and expand international collaboration opportunities (H3: $d=1.18$-1.77). However, these benefits depend critically on adequate infrastructure, pedagogical competence, and sustained institutional support.

Principal Findings in Context

The Trilingual Challenge: Beyond Simple Bilingualism

This study identified linguistic challenges, particularly technical vocabulary gaps (M=4.02) and academic writing difficulties (M=3.91), as primary EMI obstacles, consistent with international literature (Hu & Lei, 2014; Macaro et al., 2018). However, the Algerian context revealed unique complexities from trilingual negotiation amongst Arabic, French, and English - the "French shadow" phenomenon.

Unlike East Asian contexts with relatively straightforward bilingual transitions (Galloway et al., 2017; Rose et al., 2020) or European contexts (Dafouz & Smit, 2020), Algeria's postcolonial linguistic landscape creates distinctive cognitive demands. Students simultaneously manage Arabic (general education/communication); French (established scientific/technical discourse); and English (emerging instruction medium). This trilingual cognitive load extends beyond simple language switching to restructuring disciplinary knowledge across linguistic systems.

This finding contributes to calls for context-sensitive EMI research recognising that implementation challenges vary significantly across sociocultural and linguistic contexts (Fenton-Smith et al., 2017; Wilkinson, 2018). EMI policy and practice must account for existing linguistic ecologies rather than assuming straightforward bilingual transitions.

Beyond language, infrastructure and resource challenges emerged as critical barriers. Digital divides within and across institutions create unequal ICT-supported learning opportunities, potentially exacerbating rather than reducing educational inequities (Selwyn, 2010; van Dijk, 2020; Warschauer, 2003). The finding that infrastructure reliability (M=4.12 students, M=4.02 faculty) rated as the highest barrier underscores that technology's educational impact requires foundational access.

ICT as Pedagogical Enabler: Not a Panacea

The study demonstrated that ICT provides significant support for EMI implementation, supporting all three hypotheses. However, moderate effect sizes for H1 (ΔR^2=.08) and H2 (r=.45-.52) indicate technology is one factor amongst many influencing success, and it is not a silver bullet. This reinforces arguments that technology's educational impact depends critically on pedagogical implementation rather than mere technological presence (Laurillard, 2012; Selwyn, 2010).

Qualitative findings highlighting asynchronous learning affordances, collaborative platforms, and multimodal resources suggest ICT's value in EMI contexts lies particularly in: (1) providing flexibility for students to engage with content at their own linguistic processing pace; (2) enabling peer support networks where stronger English users assist struggling peers; and (3) reducing exclusive reliance on linguistic channels by incorporating visual, audio, and interactive modalities. These affordances align with Universal Design for Learning principles emphasising multiple means of representation, expression, and engagement (Meyer et al., 2014).

The finding that 94.3% of students regularly use online dictionaries indicates these tools have become essential coping mechanisms for EMI's linguistic demands. However, there are important limitations: translation tool reliability issues, particularly with automated technical terminology translation, mean ICT language support is imperfect and requires critical evaluation skills. Furthermore, overreliance on translation tools may inhibit direct English comprehension development, creating dependency rather than autonomy (Stapleton & Kin, 2019).

Democratising Internationalisation Through Virtual Exchange

The study's most striking findings concerned ICT's role in enhancing international collaboration (H3), with large effect sizes (d=1.18-1.77) across all indicators. These results demonstrate that technology can democratise aspects of internationalisation previously accessible only to elite institutions with substantial mobility resources. Virtual internationalisation through guest lectures, COIL partnerships, and global online communities creates international academic discourse participation possibilities without requiring physical mobility (O'Dowd, 2018; Rubin, 2017). This is particularly significant for contexts like Algeria where political, economic, and visa restrictions limit physical international mobility. Faculty with high ICT access averaged 2.8 international co-publications compared to 0.9 for low-access colleagues - a difference representing genuine research capacity enhancement, not merely incremental improvement.

Critical Success Factors: Infrastructure, Competence, Pedagogy

The study identified infrastructure, digital literacy, and pedagogical training as critical interdependent factors. Infrastructure barriers (unreliable internet, insufficient devices) were rated as most significant obstacles, echoing persistent concerns about digital divides in developing contexts (Hilbert, 2016; UNESCO, 2019). Notably, infrastructure challenges manifested not as absolute absence but as inequality - variation across institutions, departments, and socioeconomic groups. This suggests infrastructure development must prioritise equity alongside expansion.

The emphasis on pedagogically-focused rather than technically-focused training aligns with extensive research emphasising that effective technology integration requires pedagogical and content knowledge alongside technological knowledge (Mishra & Koehler, 2006). Faculty need support not just in operating tools but in designing learning experiences that strategically leverage technology to address EMI-specific challenges like disciplinary language development and academic literacy scaffolding.

The finding that institutional support structures significantly influence success suggests that sustainable ICT integration requires systemic rather than individualistic approaches. Institutions that established teaching and learning centres, technical support units, and coordinated professional development programmes showed more successful and equitable ICT integration than those relying on individual faculty initiative (Bates, 2015; Salmon, 2013).

A Framework for Technology-Integrated EMI Implementation

Based on integrated findings, we propose a five-component framework for technology-integrated EMI implementation in resource-constrained multilingual contexts (Figure 1):

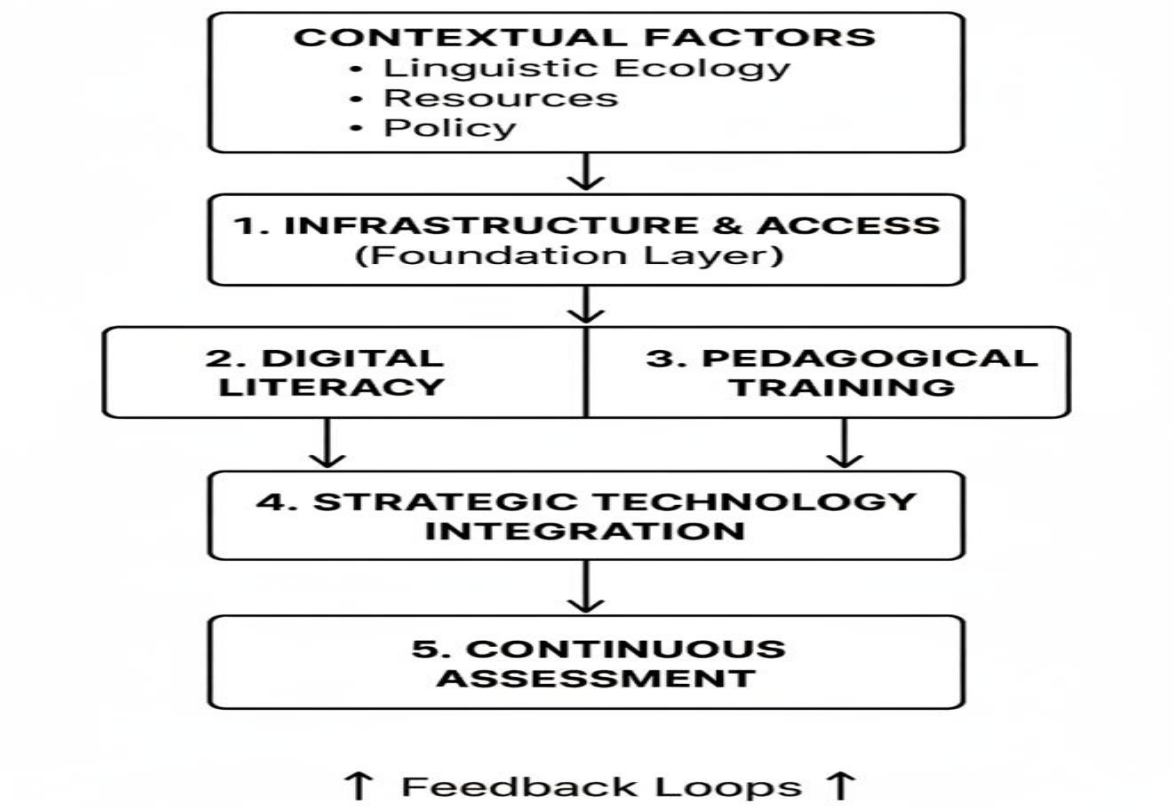

Figure 1: Five-Component Framework for Technology-Integrated EMI Implementation

Note: *Arrows indicate sequential implementation flow; feedback loops enable continuous improvement across all components.*

1. **Infrastructure and Access (Foundation Layer):** Reliable internet, adequate devices, and equitable access form the essential foundation. Without this base layer, subsequent components cannot function effectively.

2. **Digital Literacy Development:** Both students and faculty require targeted development of digital competencies, including technical skills and critical evaluation of digital resources.

3. **Pedagogical Training and Support:** Faculty need training beyond technical skills, addressing TPACK integration—the intersection of technology, pedagogy, and content knowledge specific to EMI contexts. Our data showed faculty rating pedagogical training as the highest need (M=4.18).

4. **Strategic Technology Integration:** Evidence-based selection and implementation of ICT tools aligned with pedagogical goals. Our findings showed significant positive effects (d=0.77-1.77) when technology is strategically aligned with learning objectives.

5. **Continuous Assessment and Improvement:** Data-driven iterative refinement ensures effectiveness and addresses emerging challenges. The cyclical nature reflects that ICT integration is an ongoing process, not a one-time implementation.

Context factors (linguistic ecology, resources, institutional capacity, policy environment) shape implementation across all components. The framework emphasizes that technology integration is not linear but cyclical and iterative, requiring continuous assessment and adaptation.

Limitations

Several important limitations are acknowledged:

Sampling and Generalisability: The study's focus on three universities in Algiers limits generalisability to other Algerian regions and international contexts. Convenience and purposive sampling may have introduced selection bias, potentially over-representing motivated participants. Findings may have particular relevance for similar trilingual, resource-constrained settings but require cautious extrapolation to other contexts.

Research Design: The cross-sectional design prevents causal inferences. Whilst correlations suggest relationships and hypothesis testing shows significant effects, experimental designs would be needed to establish causality definitively. Longitudinal studies tracking EMI programmes over time would provide stronger evidence of ICT's long-term impacts.

Measurement: Self-report measures may be affected by social desirability bias or limited self-awareness. Students and faculty may overestimate ICT's benefits or underreport challenges. Learning outcomes were self-reported rather than objectively measured through standardised assessments. Future research should incorporate objective performance measures (grades, standardised tests, retention rates) alongside self-reports.

Technological Evolution: The rapid evolution of technology means findings about specific tools may become outdated quickly. Whilst conceptual frameworks and principles should remain relevant, specific ICT recommendations require updating as technologies evolve. Cloud-based tools, AI-enhanced learning platforms, and emerging technologies may offer new affordances not captured in this study.

Equity Dimensions: Whilst the study identified digital divides as barriers, deeper investigation is needed into how EMI and ICT integration affect students from different socioeconomic, linguistic, and geographic backgrounds. The mechanisms through which technology might exacerbate or reduce inequalities require more nuanced examination.

Implementation and Resource Considerations: . The framework assumes availability of minimum infrastructure (reliable internet connectivity, basic computing devices) that may not exist uniformly across institutions. Institutions with limited resources should prioritise the framework's pedagogical principles over specific technological requirements, utilising free and open-source alternatives alongside extended implementation timelines. Future implementations in diverse contexts would benefit from systematic documentation of adaptations required and outcomes achieved across varying resource levels.

Future Research Directions

Future research should address these limitations through:

Longitudinal Studies: Tracking EMI programmes and ICT integration over 3-5 years to understand developmental trajectories, long-term outcomes, and sustainability factors.

Experimental Designs: Testing specific ICT interventions through randomised controlled trials or quasi-experimental studies to establish causal relationships between technology use and learning outcomes.

Geographic Expansion: Broader sampling including universities in non-urban Algerian regions and comparative studies across North African contexts to understand how findings transfer across settings.

Learning Analytics Research: Examining actual ICT usage patterns and correlations with academic performance beyond self-reports, using LMS data, clickstream analysis, and behavioural traces.

Equity-Focused Studies: Investigating how EMI and ICT integration affect students from different backgrounds, with attention to mechanisms that might exacerbate or reduce inequalities. This includes examining differential access, usage patterns, and benefits across socioeconomic groups.

Faculty Development Research: Studying effective professional development models for EMI teaching with technology, comparing intensive workshops, ongoing communities of practice, and individualised coaching approaches.

Implications for Policy and Practice

For Policy Makers: (1) Develop national frameworks articulating clear EMI goals, quality standards, and support mechanisms. (2) Prioritise equitable infrastructure investment, particularly in under-resourced institutions. (3) Establish funding mechanisms for sustainable ICT integration. (4) Support development of contextually appropriate, open-licensed EMI resources.

For Institutional Leaders: (1) Create dedicated teaching and learning centres providing integrated EMI and ICT support. (2) Implement systematic faculty professional development programmes addressing pedagogical dimensions, not just technical training. (3) Develop student support programmes addressing both English language development and digital literacy. (4) Establish communities of practice for faculty to share EMI strategies and ICT innovations.

For Faculty: (1) Adopt learner-centred, language-sensitive pedagogical approaches explicitly scaffolding both content and language. (2) Strategically leverage ICT affordances most relevant to EMI challenges (asynchronous access, collaborative tools, multimodal resources). (3) Develop critical awareness of students' varying linguistic, digital, and socioeconomic resources. (4) Engage in ongoing professional learning about EMI pedagogy and technology integration.

CONCLUSION

This study demonstrates that with adequate infrastructure, appropriate pedagogical approaches, institutional support, and attention to equity, ICT can play a transformative role in EMI implementation. The three hypotheses received empirical support, showing that technology strategically applied can reduce linguistic barriers, enhance learning outcomes, and expand international opportunities. However, realising this potential requires sustained

commitment, coordinated action across stakeholders, and continuous evidence-based improvement.

The Algerian context, with its unique trilingual landscape, demonstrates that EMI implementation cannot follow one-size-fits-all models. The "French shadow" phenomenon represents a distinctive challenge requiring context-specific solutions. For Algeria and similar contexts pursuing internationalisation through EMI, the path forward requires simultaneous attention to infrastructure development, pedagogical capacity building, language support programming, and institutional commitment.

The framework proposed offers guidance for coordinated, comprehensive approaches that maximise opportunities whilst mitigating challenges. The challenges are significant but not insurmountable, and the opportunities - for individual students, faculty, institutions, and Algerian higher education as a whole, are substantial. Success requires moving beyond viewing English as merely a linguistic tool towards recognising it as one resource within multilingual repertoires, and viewing technology not as a substitute for pedagogy but as a powerful affordance that skilled educators can strategically leverage.

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