

Integration of Information and Communication Technologies (ICT) in the Teaching of Life and Earth Sciences in Lower- and Upper-Secondary Schools of the Drâa-Tafilalet Region, Morocco: Current Status, Constraints, and Perspectives



Intégration des Technologies de l'Information et de la Communication (TIC) dans l'enseignement des Sciences de la Vie et de la Terre au collège et au lycée dans la région de Drâa-Tafilalet, Maroc : état des lieux, contraintes et perspectives

| Salahddine didi ¹ |

¹: Sultan Moulay Slimane University | Department of Geology | Beni Mellal | Morocco |

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ABSTRACT

Background: The integration of Information and Communication Technologies in Education (ICTE) is now an essential pedagogical requirement, particularly for an experimental discipline such as Life and Earth Sciences (LES). Although several national programs have been implemented in Morocco to scale up this integration, whether these investments have translated into lasting changes in teachers' classroom practices remains an open question. **Objectives:** This study, conducted among 120 LES teachers working in lower-secondary (collège) and upper-secondary (lycée) schools of the Regional Academy of Education and Training (AREF) of Drâa-Tafilalet, aims to provide an overview of equipment, training, and classroom use of ICT, and to identify the main constraints encountered. **Methods:** We recruited a stratified random sample of LES teachers across the five provinces of the academy and collected data through a validated 17-item online questionnaire, complemented by semi-structured interviews with a purposive subsample. Descriptive statistics and visualizations were computed in Microsoft Excel. **Results:** The results show a high rate of personal equipment ownership (98.2% of teachers own a personal computer) and frequent Internet use (73.5% daily), but pedagogical integration of ICT remains largely driven by self-training (55% of trained teachers) rather than structured institutional training. The main constraints identified are insufficient computer equipment in schools (73.5%), the length of school curricula (47.8%), and classroom overcrowding (38.1%). **Conclusions:** These findings are consistent with prior regional studies and recent international research, confirming a persistent gap between public policy ambitions and classroom reality. As the sample is restricted to one regional academy and the analysis is based on descriptive percentages, the findings should be read as regional and exploratory rather than nationally representative. Recommendations are made regarding continuing education, equipment, and pedagogical support for LES teachers.

Keywords: Digital pedagogy; Educational technology adoption; Secondary-school science education; Southeastern Morocco; Continuing teacher education; Self-training.

1. INTRODUCTION

Information and Communication Technologies (ICT) have profoundly transformed all sectors of activity, including education. No modern education system today can avoid reflecting on the integration of these tools into teaching and learning practices. In Morocco, this dynamic has been institutionally supported by Lever 10 of the National Charter for Education and Training (Royaume du Maroc [COSEF], 1999), and subsequently translated into structuring programs such as GENIE (Generalization of Information and Communication Technologies in Education), aimed at equipping schools with computer hardware and training pedagogical actors in its use, and formalised through successive ministerial notes governing digital resource use in schools (Messaoudi & Talbi, 2012; Ministry of National Education of Morocco [MEN], 2009). More than two decades after the launch of this dynamic, the question of whether these institutional investments have actually translated into real changes in classroom practice remains fully relevant.

For an experimental discipline such as Life and Earth Sciences (LES), ICT offers particularly valuable pedagogical potential: modelling of biological and geological phenomena that are difficult to observe directly, simulations, use of image and video banks, and processing of experimental data. These tools help compensate for certain material limitations of school laboratories and strengthen the active, motivating character of learning, including at the tertiary level (Perreault, 2005). They also bring students closer to objects of study that are inaccessible to direct observation, thereby fostering an inquiry-based scientific approach, and contribute more broadly to teachers' own professional development as reflective practitioners (Lebrun, 2011).

Nevertheless, despite the efforts made by Moroccan educational authorities, several converging studies point to a persistent gap between stated ambitions and observed classroom reality (Benamar et al., 1998; El Bachari et al., 2010; El Ouidadi et al., 2011; Maouni et al., 2014). This concern has been confirmed and deepened by more recent work focused specifically on LES teaching. Nafidi et al. (2018), in a national survey conducted among teachers from several Moroccan academies, confirmed that genuine pedagogical integration of ICT into LES teaching and assessment practices does not yet exist, and that most teachers' digital competencies are acquired through self-training rather than structured institutional training, a grassroots pattern already visible a decade earlier in the initiatives documented among innovative Moroccan teachers (Ahaji et al., 2009).

In the same vein, El Madhi et al. (2014), in a study specifically devoted to the constraints associated with ICT integration in LES teaching in Morocco, identified a converging set of structural obstacles (insufficient equipment, lack of training, classroom overcrowding) that hinder teachers' appropriation of these tools, despite their unanimous recognition of the pedagogical value of ICT for the discipline. These difficulties are not specific to the Moroccan context. Internationally, Pelgrum (2001), drawing on a survey conducted in more than twenty countries, showed that lack of time, insufficient teacher training, and shortage of equipment are the most frequently cited obstacles to ICT integration in schools, while Cuban (2001) highlighted, in the North American context, the persistent gap between massive public investment in school computer equipment and the limited resulting transformation of actual pedagogical practices. More recent international evidence confirms that this gap has not closed: systematic reviews and large cross-national studies continue to report that teacher attitudes, self-efficacy, digital competence, and institutional support (rather than equipment alone) remain the decisive levers of effective technology integration (Akram et al., 2022; Andić et al., 2025; Peng et al., 2023; Zeng et al., 2022). These works suggest that the difficulties observed in the Moroccan education system are part of a broader problem, shared by many education systems, regarding the difficult translation of equipment policies into effective pedagogical uses.

It is in this context that the present research was conducted, as part of an action-research project completed at the Regional Centre for Education and Training Professions (CRMEF) of the Drâa-Tafilalet region. This research pursues two complementary objectives: first, to diagnose the current state of ICT integration in LES teaching at the lower- and upper-secondary levels of the AREF Drâa-Tafilalet; and second, to identify the structural and pedagogical constraints that hinder this integration, with a view to formulating operational recommendations adapted to the regional context under study.

1.1 Problem Statement and Research Questions

The integration of ICT into LES teaching has become a pedagogical necessity. However, despite the numerous measures taken to generalize these technologies within the Moroccan education system, several difficulties continue to hinder their effective use. The central problem of this study can be formulated as follows: what difficulties hinder the integration of ICT into LES teaching, and to what extent do teachers manage to draw on its advantages to facilitate learning and develop students' competencies?

This question is broken down into two complementary sub-questions: (i) to what extent is the computer infrastructure required for ICT use in LES teaching available, and is this infrastructure actually used? (ii) to what extent do teachers possess the competencies required for a pedagogically relevant use of these technologies? These two dimensions (infrastructural and human) appear inseparable for effective ICT integration in the discipline.

1.2 Conceptual Framework

ICT can be defined as the set of tools and devices enabling the storage, processing, transmission, and reception of information in digital form, whether computers, networks, software, or audiovisual media. Applied to the educational field, they give rise to the concept of ICTE (ICT for Education), which covers all pedagogical uses of these tools, whether in the preparation of lessons, their implementation in class, or the assessment of learning.

In the specific case of LES, Moroccan Ministerial Note No. 66 of April 28, 2011, on the use of digital resources in learning identifies four types of pedagogical uses: simulation of phenomena that are difficult to observe, virtual navigation software enabling the use of satellite imagery, graphical representations of experimental data, and computer-assisted experimentation (EXAO) (Jalvy et al., 1993; Faure-Vialle, 2004; Ministry of National Education of Morocco [MEN], 2011). ICT integration in the discipline thus pursues several pedagogical aims: strengthening the experimental character of teaching, compensating for laboratory equipment shortages, managing instructional time, fostering learner motivation, and promoting learner autonomy.

2. METHODS

2.1 Study design and participants

We did a descriptive, cross-sectional, mixed-methods study among Life and Earth Sciences (LES) teachers working in lower-secondary (collège) and upper-secondary (lycée) public schools of the Regional Academy of Education and Training (AREF) of Drâa-Tafilalet, Morocco, an academy spanning five provinces (Errachidia, Ouarzazate, Tinghir, Zagora, Midelt) with predominantly rural and mountainous geography.

Eligible teachers were actively teaching LES, including geology modules, in the academy during the study period. We used stratified random sampling, with province and teaching cycle (collège vs lycée) as strata, coordinated electronically with the pedagogical inspectorate of each province. The 120 teachers returned valid, complete questionnaires and were included in the analysis. Because the sampling frame was regional rather than national, findings should be generalised only to the AREF Drâa-Tafilalet context (Figure 1).

2.2 Procedures

Data were collected with a structured, 17-item questionnaire administered online (Google Forms) between April 1, 2026 and May 1, 2026, covering five domains: general information (3 items), computer equipment (2 items), ICT training (2 items), pedagogical use of ICT (6 items), and constraints and improvement proposals (4 items). Items on training modality and on constraints permitted multiple responses; corresponding percentages therefore do not sum to 100%. Content validity was assessed by two LES-didactics experts, whose review led to reformulation of five items and merging of two redundant items. Internal consistency was acceptable (Cronbach's $\alpha=0.76$) for an exploratory, multidimensional instrument (Nunnally, 1978). A pilot test with seven teachers, not included in the final sample, confirmed item clarity and indicated a mean completion time of 15 min. Convergent and discriminant validity were not assessed by confirmatory factor analysis, a limitation we return to in section 5. A semi-structured interview guide, informed by the questionnaire's five domains, was subsequently administered to a purposive subsample of practising teachers from the same provinces, to contextualise the quantitative findings (Figure 1).

2.3 Outcomes

The primary outcomes were: personal computer ownership and Internet-use frequency; receipt and modality of ICT training; self-reported classroom use of ICT (including modelling of biological and geological phenomena); teacher-perceived learner comprehension and interaction; and self-reported constraints on, and proposals for, ICT use. All outcomes were self-reported by teachers; none were independently observed (Figure 1).

2.4 Statistical analysis

We summarised quantitative data as frequencies and percentages and produced corresponding charts in Microsoft Excel. At the time of this analysis, data were available as pre-aggregated percentages for the full sample ($n=120$) rather than as respondent-level records; a chi-square test of independence comparing teaching cycle or seniority subgroups therefore, could not be computed, irrespective of statistical software, and no such test is reported (Figure 1).

Once respondent-level data are consolidated, the planned inferential analysis is: cross-tabulation of each binary or categorical indicator by teaching cycle and by seniority group, a chi-square test with Yates' correction where expected cell counts are below 5, and effect-size estimation with Cramér's V alongside the p value. Interview transcripts were analysed thematically to complement the quantitative results (Figure 1).

2.5 Ethics

Participation was voluntary. Teachers were informed of the study's purpose and of the anonymous, confidential handling of their responses before completing the questionnaire, and gave informed consent electronically before participation.

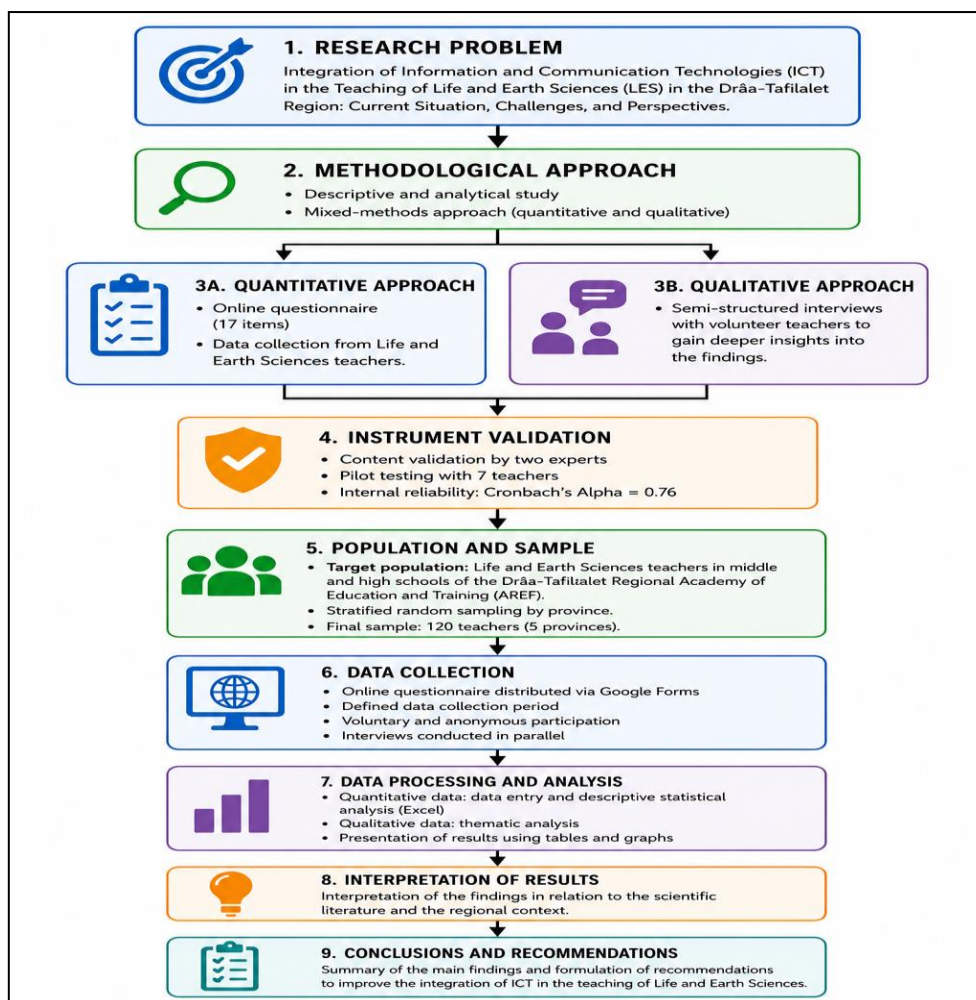


Figure 1: Synthetic schematic of the research methodology.

3. RESULTS

3.1 General Sample Characteristics

The surveyed sample is composed of 52.2% men and 47.8% women. Regarding the teaching cycle, 51.3% of respondents teach at the lower secondary level (*collège*) and 48.7% at the upper secondary level (*lycée*) (Figure 2). With respect to professional seniority, the sample comprises four groups: less than 1 year (6.2%), 1 year (45.1%), 2 years (13.3%), and more than 3 years (35.4%), representing 100% of the sample (Figure 3).

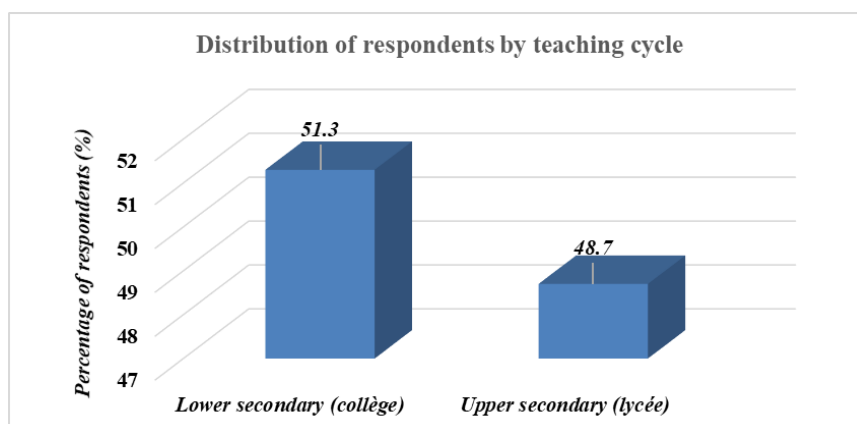


Figure 2: Distribution of respondents by teaching cycle.

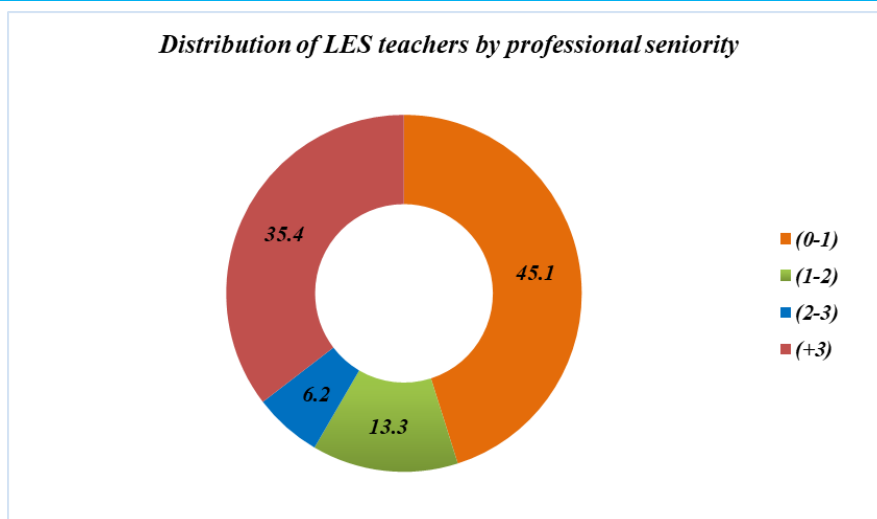


Figure 3: Distribution of LES teachers by professional seniority (n = 120).

3.2 Personal Computer Equipment and Internet Use

Almost all surveyed teachers (98.2%) reported owning a personal computer, reflecting strong interest in computer tools. Regarding Internet use frequency, 73.5% of teachers reported daily use, 25.7% reported occasional or rare use, and 0.8% reported never using it (Table 1).

Table 1: Personal equipment and Internet use among surveyed LES teachers.

Indicator	Category	Percentage
Personal computer ownership	Yes	98.2%
	No	1.8%
Internet use frequency	Always (daily)	73.5%
	Sometimes or rarely	25.7%
	Never	0.8%

3.3 Teacher Training in ICT

Regarding training, 67.3% of teachers reported having received computer training, compared to 32.7% who had never received any (total = 100%; Figure 4). Among trained teachers, self-training was the predominant modality (55.0%), followed by training through the GENIE program (17.5%) and continuing professional development (16.2%). Other training sources accounted for 11.3% (Figure 5).

These results indicate that the development of digital competencies relies more on individual initiative than on institutional training programs.

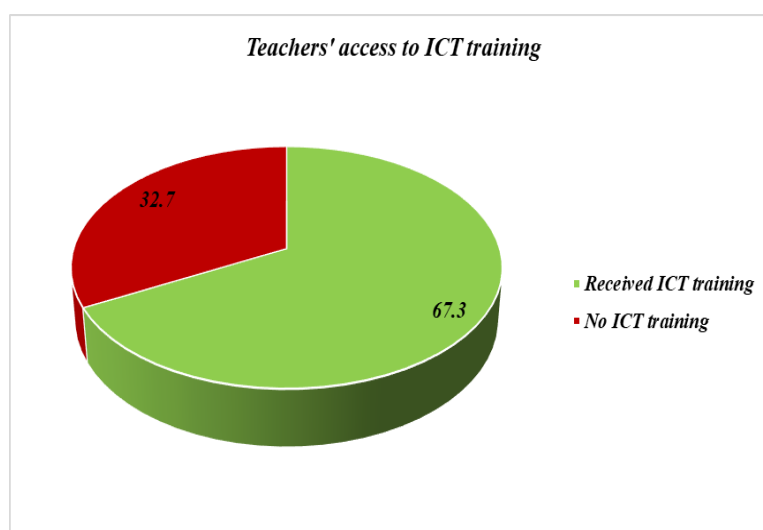


Figure 4: Teachers' access to ICT training

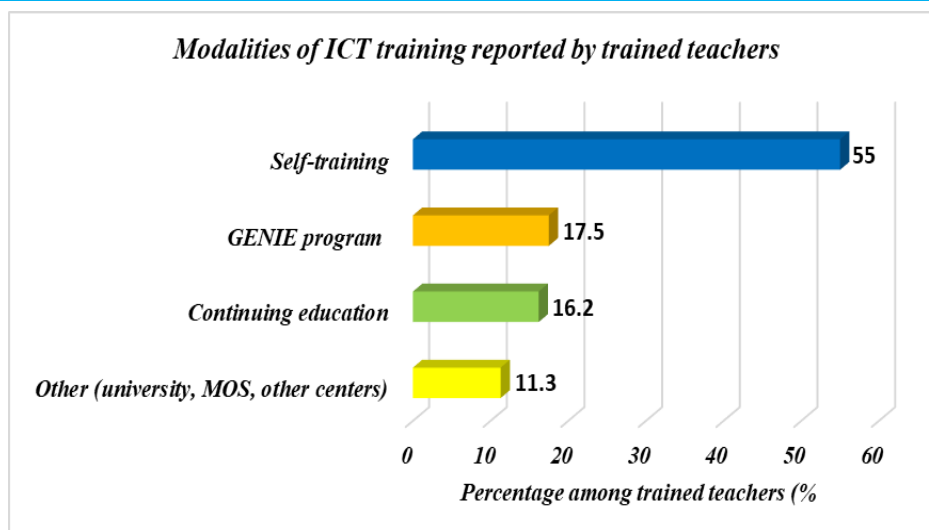


Figure 5: Modalities of ICT training reported by trained teachers.

3.4 Pedagogical Uses of ICT in Class

A large majority of surveyed teachers (92.9%) report using ICT in their pedagogical tasks (Figure 6). Among these uses, 87.6% concern lesson preparation and 75.2% classroom session management. Regarding the modeling of biological and geological phenomena, 88.5% of teachers report using it, mainly to facilitate understanding of phenomena (71.6%), make lessons more attractive (65.7%), and simplify concepts (64.7%) (Figure 7). Regarding reception by learners, 72.6% of teachers consider that the phenomena studied are well understood thanks to ICT, and 74.3% rate learners' interaction with the concepts taught as good when digital support is used.

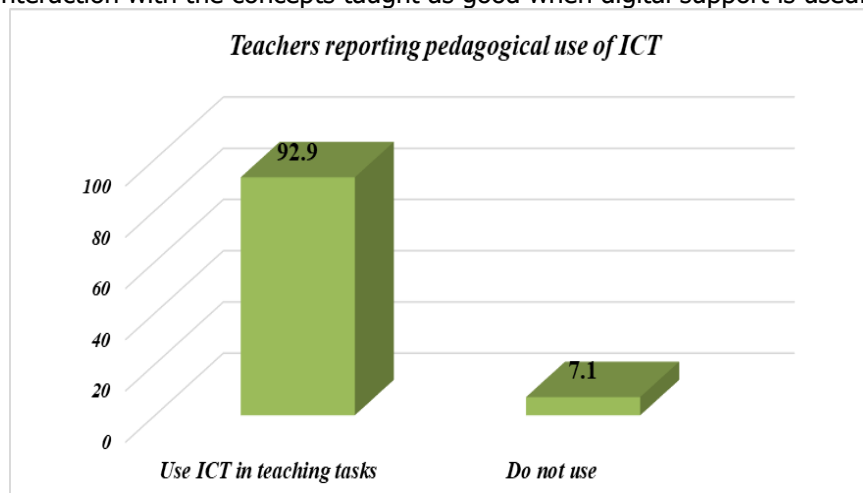


Figure 6: Teachers reporting pedagogical use of ICT.

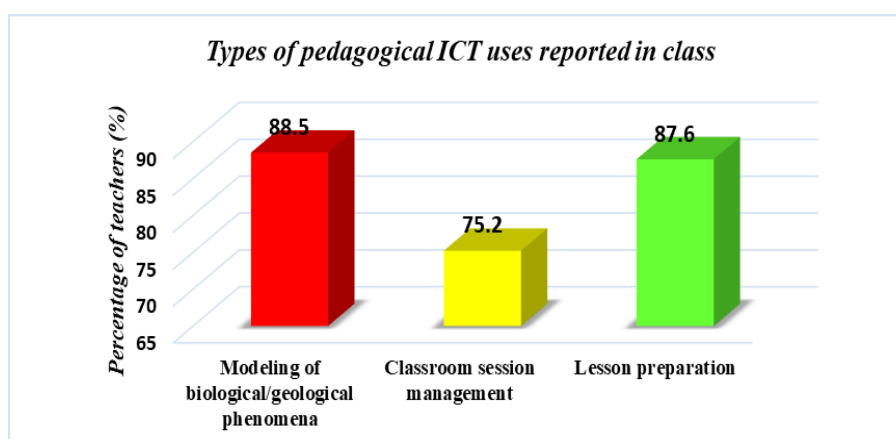


Figure 7: Types of pedagogical ICT uses reported in class.

3.5 Constraints on ICT Use

The main constraints reported by teachers who do not use ICT are lack of computer equipment (71.4%) and lack of training in this area (28.6%). Across the whole sample, the constraints most widely reported (multiple responses permitted) are the absence of devices and equipment in most schools (73.5%), the length of the school curriculum, which limits available time (47.8%), and classroom overcrowding (38.1%) (Table 2, Figure 8).

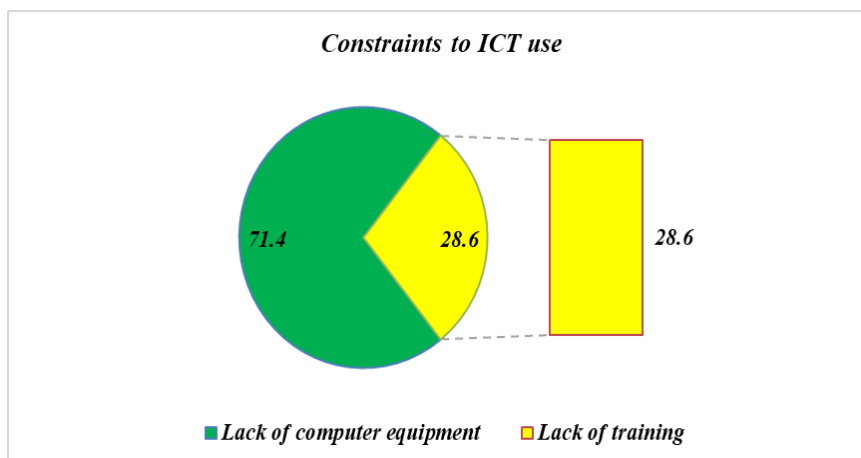


Figure 8: Main constraints to classroom ICT use.

Table 2: Main constraints on classroom ICT use.

Constraint	Percentage
Absence or insufficiency of computer equipment	73.5%
Length of the school curriculum	47.8%
Classroom overcrowding	38.1%

3.6 Teachers' Proposals

Asked about the conditions needed to improve their use of ICT, teachers primarily propose strengthening schools' computer equipment (88.5% of responses), establishing regular continuing-education sessions (67.3%), and encouraging the production of LES-specific digital resources (46%) (Figure 9).

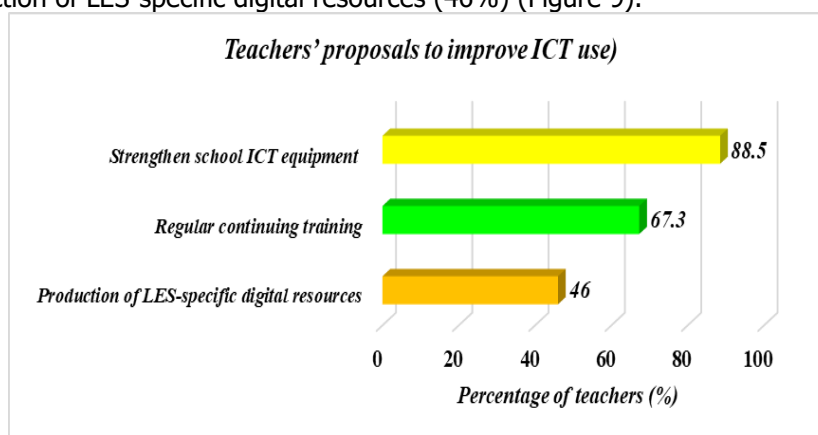


Figure 9: Teachers' proposals to improve ICT use.

4. DISCUSSION

The results obtained confirm, in the specific context of the Drâa-Tafilalet region, findings already reported by several studies conducted in other Moroccan academies. Maouni et al. (2014), in a survey of 131 LES teachers from the AREF of Tanger-Tétouan, found that most teachers and students possess basic computer tools with Internet access, but that mastery of specialized software (image processing, EXAO, animation production) remains weak, and that self-training constitutes, there too, the main pathway for acquiring digital competencies, with more than 90% of surveyed teachers and learners reporting having trained themselves. Similarly, El Ouidadi et al. (2011), in their study on the attitudes and needs of Moroccan teachers regarding ICTE within the Fès-Boulemane academy, report persistent slowness in the integration of ICT into school practices despite existing institutional schemes. El Bachari et al. (2010) confirm this finding

in the Marrakech academy, noting that multimedia rooms resulting from the GENIE program are often underused due to outdated equipment and insufficient staff training.

Our study highlights a paradoxical situation: relatively satisfactory personal equipment among teachers (98.2% own a personal computer) contrasts with a persistent deficit in institutional equipment, which echoes the observations of Maouni et al. (2014) that LES classrooms or laboratories frequently have a video projector and a computer, but rarely a scanner, printer, or interactive whiteboard, although these are needed for optimal use of digital resources in the natural sciences. More recent work conducted specifically on the discipline confirms and refines these findings. Nafidi et al. (2018), in a national survey covering several Moroccan academies, reach a conclusion convergent with ours: genuine pedagogical integration of ICT into LES learning and assessment activities does not yet exist, and most of teachers' digital skills capital remains acquired through self-training, regardless of the academy of practice. This result suggests that the predominance of self-training observed in our sample (55% of trained teachers) is not a regional singularity but reflects a structural characteristic of the national continuing-education system. Likewise, El Madhi et al. (2014) identify, in their study on the constraints associated with ICT integration in LES, a triad of obstacles: insufficient equipment, lack of training, and classroom overcrowding, that almost exactly matches the constraints reported in our own sample (lack of equipment: 73.5%; length of curriculum: 47.8%; classroom overcrowding: 38.1%), reinforcing the external robustness of our results despite the regional scope of our survey.

International Perspective

This convergence of results, obtained in different academies, at different periods, and with varying sample sizes, suggests that the obstacles to ICT integration in LES are less a matter of regional specificities than of structural limitations common to the entire Moroccan education system. This reading is also consistent with the international literature on the topic. Pelgrum (2001), in a comparative survey conducted in more than twenty countries, identified lack of time, insufficient teacher training, and equipment shortage as the most universally reported barriers to ICT integration in schools, while Cuban (2001) showed, in the North American context (although better equipped in infrastructure) that massive investment in computer equipment did not translate into a proportional transformation of actual pedagogical practices.

More recent international evidence reinforces this reading. A systematic review by Akram et al. (2022) confirms that infrastructural, attitudinal, and training-related barriers continue to constrain technology integration across very diverse education systems. König et al. (2022), in a scoping review of empirical studies on ICT integration in teachers' lesson plans, likewise stress that equipment availability alone is a poor predictor of actual classroom use, which instead depends heavily on teacher beliefs and institutional support. Using the PLS-SEM approach with 685 in-service teachers in China, Peng et al. (2023) showed that attitudes, self-efficacy, digital competence, and digital-tool use jointly determine ICT integration, with digital competence and tool use acting as mediators, a pattern consistent with a broader meta-analytic finding that teachers' technology-integration self-efficacy is closely linked to their technological-pedagogical-content knowledge (TPACK) (Zeng et al., 2022), compatible with the gap we observe between high personal equipment ownership and limited institutional integration in Drâa-Tafilalet. In a cross-national European study covering seven countries and using the validated ICAP Technology Scale (Antonietti et al., 2023), Maričić et al. (2024) and Anđić et al. (2025) found that teaching experience and socio-economic context significantly moderate the quality of technology integration, lending further support to our recommendation that seniority-based comparisons deserve dedicated inferential testing once disaggregated data become available. In the specific case of science teaching, Ibrahim et al. (2024), surveying Albanian science teachers, similarly reported that ICT use remains limited by inadequate infrastructure, restricted access to technology, and insufficient teacher training, a pattern of constraints that closely matches the one observed in our own sample. Finally, Deroncele-Acosta et al. (2023) and Caratiquit and Javier (2025) both emphasize that institutional/school support and teachers' techno-efficacy, rather than equipment alone, are decisive mediators of effective digital-technology adoption, a conclusion that directly supports our recommendation for structured, school-embedded continuing-education schemes rather than equipment-only policies. The Moroccan case, and more specifically that of the Drâa-Tafilalet region, thus appears as a contextualized illustration of a problem shared by many education systems, where equipment policy alone, without structured pedagogical support, is not sufficient to ensure effective appropriation of digital tools by teachers.

Differences by Teaching Cycle and Seniority: an Open Question

A natural extension of this study would be to compare ICT equipment, training, and constraints between the lower-secondary (collège) and upper-secondary (lycée) cycles, and across seniority groups, using a chi-square test of independence. Conceptually, such comparisons are justified: lycée teachers more frequently carry out laboratory-based practical work and may face different equipment constraints than collège teachers, and less senior teachers, who constitute the majority of our sample, may rely more heavily on self-training due to having had fewer opportunities to

access institutional continuing-education cycles. As specified in section 2.4, this comparison requires the respondent-level dataset and is presented as a recommended next analytical step rather than a completed result.

Methodological Limitations

Several methodological limitations must be considered when interpreting these results. First, the self-reported nature of the data may introduce social desirability bias, particularly regarding the real frequency of ICT use, since responses reflect perceptions rather than direct observation of classroom practice. Second, the sample, although stratified by province, remains regional and exploratory, and does not allow strict statistical generalisation at the national level. Third, instrument validation was not subjected to confirmatory factor analysis to verify convergent and discriminant validity. Fourth, the linguistic dimension of ICT use was not measured through dedicated items. Finally, the cross-sectional design does not allow for the tracking of changes over time or for causal inference. As detailed in section 2.4, the dataset available for this study consisted of aggregated percentages rather than respondent-level records, which precluded chi-square comparisons by teaching cycle and seniority. Future work should report cross-tabulated frequencies, the χ^2 statistic with degrees of freedom and p-value, and Cramér's V for these comparisons.

5. CONCLUSION

This study provided an overview of ICT integration in LES teaching within the AREF Drâa-Tafilelet. Empirically, three main findings emerge: (i) very high personal computer equipment ownership among teachers (98.2%) combined with frequent Internet use (73.5% daily use); (ii) pedagogical integration of ICT declared by a large majority of teachers (92.9%), mainly for lesson preparation and modeling of biological and geological phenomena, but underpinned by largely informal training, with self-training accounting for 55% of reported training modalities; (iii) persistent structural constraints, foremost among them insufficient institutional equipment (73.5%), the length of school curricula (47.8%), and classroom overcrowding (38.1%). Placed in the specific regional context of Drâa-Tafilelet, an academy characterized by mountainous terrain, the geographical dispersion of schools, and accessibility constraints typical of rural and remote areas of southeastern Morocco, these results reveal a telling paradox: teachers' individual commitment to appropriating digital tools contrasts with a persistent deficit in institutional support. The convergence of this finding with results obtained in other Moroccan academies (El Madhi et al., 2014; Maouni et al., 2014; Nafidi et al., 2018) suggests that this situation reflects a structural characteristic of the Moroccan education system as a whole.

The findings above point to four major, actionable recommendations for strengthening ICT integration in LES teaching in the Drâa-Tafilelet region:

- Structured continuing education: replace reliance on self-training with a regular, mandatory continuing-education plan centred on the didactic use of LES-specific ICT tools, formally integrated into teachers' weekly timetables.
- Equitable equipment provision: generalise essential computer equipment to all schools, with particular attention to rural and mountainous areas.
- Peer support and resource development: strengthen cooperation between schools and encourage the production of LES-specific digital resources adapted to the regional geological context.
- Complementary studies at a broader scale, combining direct classroom observation, confirmatory factor analysis, and, as a priority next step, chi-square tests of independence with Cramér's V effect sizes, comparing ICT equipment, training modality, and constraints by teaching cycle and professional seniority group, once the respondent-level dataset is consolidated.

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