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## **The Effectiveness of ICTE in Teaching Life and Earth Sciences at the Middle School Level: A Quasi-Experimental Study in Moroccan Secondary Education**

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### **Abstract**

This interventional study assesses the impact of Information and Communication Technologies for Education (ICTE) on learning outcomes, motivation, and participation of students in Life and Earth Sciences (LES) at the middle school level. Methodologically, identical content was taught using two approaches: a traditional lecture-based method and a technology-enhanced approach incorporating videos, animations, and simulations. Data were collected through questionnaires administered to third-year students and LES teachers, and analyzed using descriptive statistics. Results demonstrate a **remarkable effectiveness of ICTE** across all evaluated pedagogical dimensions. Students report **enhanced understanding of complex biological phenomena**, easier content **retention**, and **greater active participation**. Teachers observe a **clear improvement in academic performance** and acknowledge the essential role of ICTE in **making abstract scientific concepts visible and accessible**, something unachievable through traditional instruction alone. These findings confirm that ICTE serves as a **powerful pedagogical lever** for transforming the quality of science education.

Nevertheless, **structural barriers** remain, including inadequate equipment, lack of internet access, and insufficient

teacher training, calling for a **proactive educational policy** focused on digital infrastructure and continuous professional development.

**Keywords:** ICTE – Life and Earth Sciences – learning outcomes – motivation – participation – interventional research – middle school.

### **Introduction**

In the digital age, Information and Communication Technologies for Education (ICTE) occupy a preeminent place in the transformation of educational systems worldwide. Their integration aims to modernize pedagogical practices, diversify didactic resources, and foster learning that is more active, collaborative, and resolutely learner-centered (UNESCO, 2023).

In Morocco, successive educational reforms strongly encourage the strategic use of digital technology to enhance the quality of teaching and to develop the essential skills of the twenty-first century. Within this institutional framework, teachers are actively encouraged to make use of various digital tools, such as video capsules, interactive animations, simulations, and educational platforms, to enrich their daily practice.

The teaching of Life and Earth Sciences (LES) is particularly well suited to the integration of ICTE. Indeed, this discipline frequently requires the conceptualization of microscopic biological phenomena or geological processes unfolding over immense time scales. The use of digital technology makes it possible to visualize these complex mechanisms, facilitate their modeling, and significantly improve their comprehension, thereby making learning more concrete, vivid, and meaningful for students.

However, the actual effectiveness of ICTE in the school context remains contingent upon several determining variables, notably teachers' level of techno-pedagogical competence, the relevance and quality of access to digital resources, and the logistical and didactic conditions of their implementation. The mere presence of technology in the classroom cannot therefore guarantee an automatic and systematic improvement in student achievement.

In this perspective, the present interventional study aims to rigorously examine the impact of ICTE integration on students' understanding of scientific concepts, their level of motivation, and their degree of participation in Life and Earth Sciences at the middle school level. It seeks to precisely evaluate the pedagogical effectiveness of ICTE while identifying its major contributions and systemic limitations in the field.

ICTE today occupy an important place in pedagogical practice owing to the possibilities they offer for enriching learning situations and fostering student involvement. Their integration is often presented as a means of improving the quality of learning and strengthening learner motivation. However, the effectiveness of these technologies remains contingent on the conditions of their implementation and pedagogical use. It therefore seems relevant to examine their actual contribution to the teaching-learning process.

## Methodology

This research adopts a quantitative approach with descriptive and comparative aims in order to study the impact of ICTE integration on student learning.

The study was conducted with a sample of 42 third-year middle school students (3AC, equivalent to Grade 9). To assess the effect of ICTE integration, learners were exposed to two teaching modalities covering the same content: a first presentation of the lesson using a traditional approach without ICTE, followed by a second presentation incorporating digital tools and technological aids.

Data collection relies primarily on a questionnaire administered to the learners. This instrument aims to gather their perceptions regarding content comprehension, motivation, classroom participation, and their appraisal of the two teaching modalities (with and without ICTE). The responses obtained make it possible to identify any differences observed in students' attitudes and learning.

In addition, a questionnaire intended for teachers was also developed. Its purpose is to gather their views on the use of ICTE in pedagogical practice, the benefits they offer for teaching and learning, and the difficulties likely to limit their integration in the classroom.

The collected data were analyzed using descriptive statistical methods (frequencies, percentages, and means) in order to compare the results obtained and to assess the contribution of ICTE to improving student learning and motivation.

## Sample

- Target population: third-year middle school students (3AC) and teachers.
- Student sample: 42 students.
- Data collection instrument: two questionnaires (one for students and one for teachers).

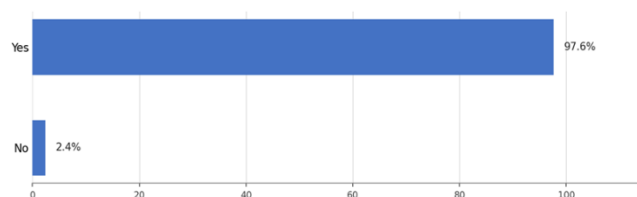
## Data Collection Tools

- Student questionnaire.
- Teacher questionnaire.
- Descriptive analysis of the responses collected.

## Results Analysis and Interpretation

### 1. Analysis and Presentation of the Student Questionnaire

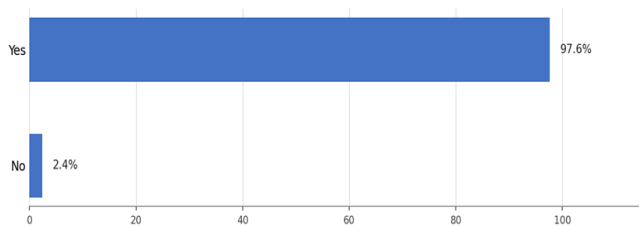
- Did the images and videos help you understand the lesson?



**Figure 1:** Contribution of visual materials to comprehension

(97.6% Yes) The near-unanimity of positive responses confirms the effectiveness of iconographic and audiovisual materials as vectors of comprehension. This result aligns with multimedia learning theory, according to which the combination of image and sound optimizes the cognitive processing of information.

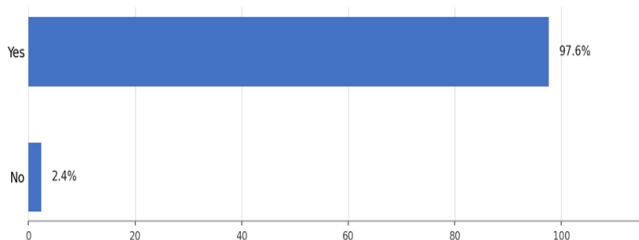
- Did ICTE make it easier for you to memorize the lesson?



**Figure 2:** Retention of the lesson content with ICTE

(97.6% Yes) This result constitutes one of the most significant indicators of the study. It attests to the facilitating effect of ICTE on memory processes, consistent with Paivio's dual-coding theory (Paivio, 1971), according to which the combined verbal and visual processing enhances the encoding and long-term retention of information.

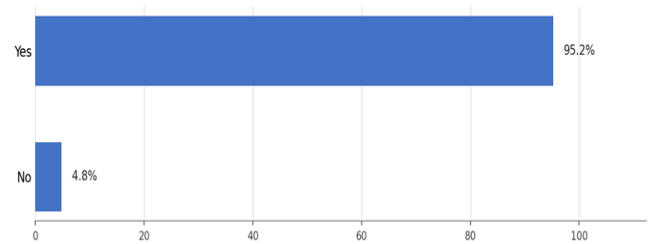
- Do ICTE motivate you to learn?



**Figure 3:** Student motivation with ICTE

(97.6% Yes) This particularly high rate reflects a strong and nearly unanimous motivational impact of ICTE. Digital tools appear to act as extrinsic stimuli that trigger and sustain the desire to learn, thereby fostering a climate conducive to cognitive engagement.

- Did you participate more during the lesson?

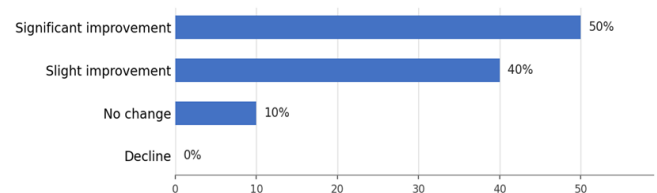


**Figure 4:** Student participation in class

(95.2% Yes) Nearly all learners reported being more active during the session incorporating ICTE. This result highlights the mobilizing effect of digital tools on students' behavioral engagement, transforming a passive stance into effective, voluntary participation.

## 2. Analysis and Presentation of the Teacher Questionnaire

- Have you noticed changes in your students' academic performance since integrating ICTE into your LES teaching?



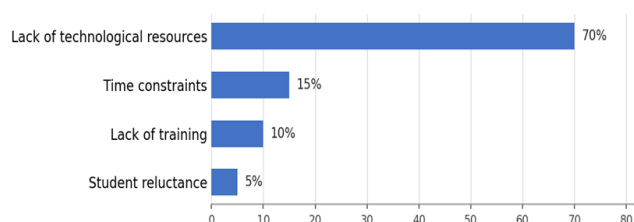
**Figure 5:** Perceived impact on students

Data: Significant improvement: 50% / Slight improvement: 40% / No change: 10% / Decline: 0%

Ninety percent of teachers observed an improvement in their students' performance since the integration of ICTE, half of whom reported a significant improvement. No teacher reported a decline.

This result is particularly significant. It confirms the pedagogical added value of ICTE in LES teaching, as perceived by practitioners. The perceived improvement, even partial, reinforces the legitimacy of investment in educational technology.

- What obstacles do you encounter in integrating ICTE into your LES teaching?



**Figure 6:** Obstacles to ICTE integration

Data: Lack of technological resources: 70% / Time constraints: 15% / Lack of training: 10% / Student reluctance: 5%

The lack of adequate technological resources is by far the main obstacle identified (70%). Time constraints and lack of training represent secondary obstacles, while student resistance is marginal (5%). Teachers do not identify their own resistance or that of their students as major barriers. The problem is above all structural and institutional: it is the lack of infrastructure that hinders pedagogical integration, not a deficit of will or motivation among the actors involved.

### 3. Discussion

On the cognitive level, the comprehension and retention rate of approximately 97%, corroborated by the observations of 90% of teachers, can be interpreted through the lens of Chevallard's (1985) theory of didactic transposition. By diversifying the modes of representation of knowledge, ICTE would facilitate its appropriation by learners. This interpretation can also be related to the notion of epistemological obstacle developed by Bachelard (1938), insofar as digital materials may help overcome certain difficulties in conceptualization.

On the motivational level, the engagement rate of nearly 98% confirms the role of ICTE in strengthening learner involvement. This dynamic is consistent with Brousseau's (1998) theory of didactic situations, according to which the devolution of the problem to the learner fosters their responsibility in constructing their own knowledge.

These results nevertheless remain conditioned by significant structural constraints, with 70% of teachers reporting a shortage of technological resources. This limitation is likely to compromise the conditions for implementing ICTE-based learning situations and underscores the importance of an institutional environment conducive to their sustainable integration.

### Strengthen the technological equipment of schools

Given the shortage of technological resources reported by 70% of teachers, it is imperative that educational institutions invest in adequate digital infrastructure, a sine qua non condition for the efficient and equitable integration of ICTE.

Implement ongoing training for teachers; In order to capitalize on the positive effects of ICTE on student learning and motivation, specialized pedagogical training programs should be developed to enable teachers to fully master digital tools and optimize their didactic use.

### Conclusion

This research confirms that ICTE constitute an effective pedagogical lever for teaching LES at the middle school level. Their integration substantially improves the comprehension of complex phenomena, strengthens motivation, and fosters active learner participation, with effects unanimously recognized by both the students and teachers surveyed.

However, their full potential remains contingent on structural conditions that are still insufficient, including inadequate equipment, lack of internet access, and insufficient training. Removing these obstacles constitutes an unavoidable institutional priority in order to make ICTE a genuine tool for transforming science pedagogy in the service of twenty-first-century learners.

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