Pedagogical innovation and the development of 21st century skills and sustainable development in the teaching and learning of life and earth sciences in Morocco.

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Abstract. The world of education in the 21st century is undergoing transformations that affect teaching methods and learning styles. The Moroccan education system is at the heart of this movement, demonstrating its will and institutional commitment through the pedagogical integration of information and communication technologies (ICT) into the teaching-learning process. However, a number of studies have shown that this integration into learning and assessment activities in life and earth sciences (LES) remains very weak, if not absent, in qualifying secondary and college education. To pedagogically innovate teaching practice in LES, our research comes to help teachers and innovative designers conceive digital resources to develop 21st century skills in LES. To meet the objective of our research, a questionnaire was drawn up and sent to 200 teachers in the various regional education and training academies of the Kingdom of Morocco. Analysis of the results showed that teachers' awareness of these skills in general, and those specific to LES in particular, was moderate and that in-service and pre-service teacher training, the design of multi-level and multi-type digital resources, and curriculum reform are very important elements in reinforcing 21st century skills in the digital teaching-learning of LES.

Keywords. 21st century skills, digital teaching resources, educational innovation, ICT, Life and earth sciences, sustainable development skills.

1 Introduction

The teaching of sciences in general, and life and earth sciences (LES) in particular, as well as their didactics, are of great importance and provide a strong epistemological foundation for the sociological and human sciences [1]. LES and their teaching in Moroccan secondary schools, according to the Moroccan curriculum, aim to develop scientific knowledge, methodological and empirical skills and values [2], [3]. However, the results of performance in science according to international assessments (TIMSS (Trends in Mathematics and Science Study) and PISA (Programme for international Student Assessment)) have shown that the level of Moroccan learners is low compared with learners in other countries [4], and that 69% of them do not have the required skills in science [5]. This context has prompted education decision-makers to take an interest in the issue of information and communication technologies (ICT) [6] and student skills, which are central to the roadmap 2022-2026's discourse on the learning crisis and the need to reverse the trend, and on the necessary efficiency of the Moroccan education system by contributing to innovative teaching-learning practices.

Several research studies have shown that improving teaching is essentially based on the development of so-called 21st century skills, notably collaborative skills, creativity, communication, and above all critical thinking, and the best way to foster these in learners [7], [8]. Other previous studies investigating the skills sought by potential employers, indicated that communication skills were among the most popular soft skills. This shows that there is a need to make learners aware of the importance of communication skills for careers [9] Hence the need to show learners the importance of communication skills for career [8] as well as other skills including socio-emotional aspects, [10]. Studies have also shown how new technologies can help develop some of these skills, such as animated video media, which can improve learners' learning outcomes and help their critical thinking in science learning [10]. 21st century skills are the key to solving economic, social, and global challenges and to engaging effectively in these spheres, so we must use these skills to change the future of our education system [12], including science education.

Given that a number of 21st century skills are already declared in the LES curriculum, and given their importance as shown by research, we turned to LES teachers (200 teachers) from the various regional education and training academies (RETA) in Morocco, with a view to addressing secondary school learners too, given that the 21st century is shaping up to be the century of change in all areas. Indeed, these fields have not changed except for didactics. As a result, teaching is faced with a new challenge: to develop new skills in the era of socio-economic globalization, known as 21st century skills. Our research focuses on the use of digital teaching resources to develop these skills in the teaching and learning of LES in Morocco, focusing on the following areas:

- What 21st century skills need to be developed in LES?

- How can the design of digital teaching resources help to develop these skills in learners?

This leads us to formulate this study question as follows: **How can we design the use of digital teaching resources in LES to develop 21st century skills ?**

To answer this question, our research highlighted the concept of use of digital pedagogical resources aimed at the development of 21st-century skills in the teaching-learning of LES in Morocco through:

＊Highlighting the degree of awareness of LES teachers in Morocco towards 21st century skills.

＊Exposing the relationship between digital pedagogical resources and 21st century skills in teaching learning LES.

In this way, our research can contribute to the reform of the Moroccan life and earth sciences curriculum to be carried out in the coming years. Indeed, PISA results concerning the level of learners in science are low, perhaps because the international science curriculum is essentially based on the development of 21st century skills in learners. This explains the choice of our topic concerning these skills in teaching and learning LES in Morocco, and how digital pedagogical resources could contribute to skills development in learners.

Our article is presented in five different parts. Beginning with a general introduction, before presenting the methodology adopted for data collection. The results obtained from our research are analyzed and discussed, and recommendations are deduced before concluding.

2 Methodology

In Morocco, the Ministry's desire to create a climate conducive to the use of ICT in classroom practices is manifested by the GENIE program, which, in addition to the axes dedicated to infrastructure and training, has added the acquisition of quality digital educational resources adapted to the Moroccan cultural and school context. Although the results of numerous research studies show that the pedagogical use of these technologies is still low, our research is aimed at improving the role of ICT in LES teaching and learning and helping to develop 21st century skills in learners.

Based on the theoretical framework, we carried out exploratory research using a questionnaire for data collection, which was drawn up and put online via Google Forms. We opted for the questionnaire because of the lack of time to travel and to save time and energy, and also to enable us to diversify the type of questions (multiple choice questions, short answer questions, tick box questions, multiple choice grid questions...).

2.1 Data collection

The questions proposed in our questionnaire, whose answers are presented as results in this article are shown in Table 1.

Table 1. Questions in the questionnaire distributed to respondents.

Q1	Which of the skills listed below do you consider to be those of the 21st century?
The teachers in our sample were presented with a list of some twenty competencies that are based on the consensus of reference frameworks from well-known international organizations: UNESCO, OECD, and the European Union.	Meta-competence (the ability to learn) Critical thinking Problem solving Creativity/ Innovation Cooperation Communication Systems thinking / Foresight / Strategic action (Sustainability competency) Connectivity and foresight Teamwork Skills related to: Information /Technology/Media Flexibility Initiative Sociability ...
Q2	From the 21st century competencies listed below; please select the ones you consider important for LES:
The teachers in our sample were presented with a list of 21st century competencies based on consensus reference frameworks from well-known international organizations: UNESCO, OECD, and the	Critical thinking Problem solving Collaboration Communication Creativity

| European Union. They were asked the following question:	Technological skills Sustainable and strategic skills ....
Q3	Could reinforcing 21st-century skills help the teaching and learning of LES?
Q4 The teachers surveyed were offered a list of types of digital teaching resources, and asked to specify which types of digital resources can help develop these LES skills in learners?	What kinds of digital resources can help learners develop these LES skills?
Q5 Respondents were asked to rank the 21st century skills assessment methods developed with the help of digital teaching resources.	▪ Short- and medium-term projects (Communication/Collaboration...), including. ▪ Computerized collaborative problem-solving test; ▪ Technology support (collection and analysis of assessment data on learner learning); ▪ Informal and experiential learning activities; ▪ School cycle final evaluations (Final product); ▪ Other.

Q: Question

After collecting the data, we used SPSS software to analyze them.

2.2 Data analysis

2.2.1 Sample characteristics

The characteristics of our research sample population are presented in figure 1, and a correlation is established between the degree of teachers' awareness of 21st century LES skills and certain population variables.

Fig.**1.** Sample characteristics
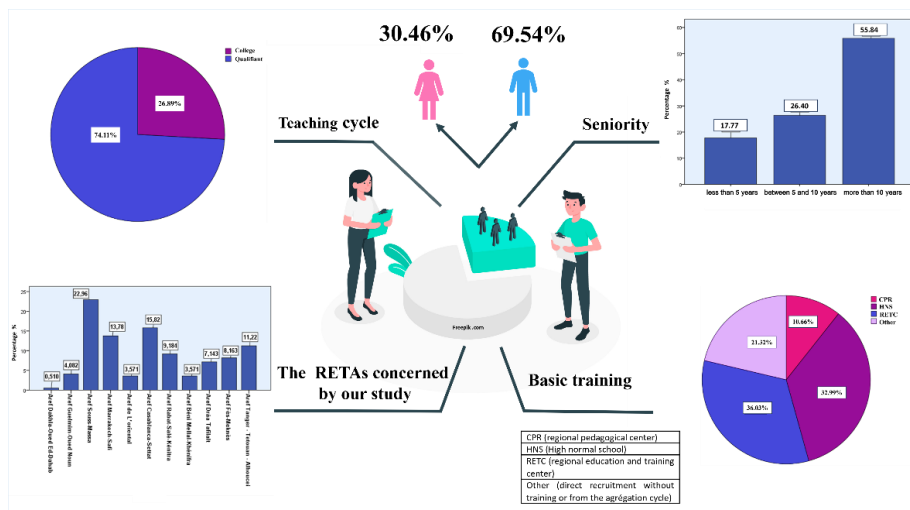
Source. Our own design

2.2.2 21st century skills

For question 1, almost half the respondents (48.73%) were moderately aware of the nature of 21st century skills, 28.43% of respondents showed a high degree of awareness, while 22.84% had a low degree of awareness. These results clearly show that, although some 21st century skills are explicitly declared in the LES curriculum, a large proportion of teachers are unaware of them (Figure 2).

Note 1: Teachers' level of awareness of 21st century skills in general were estimated from the teachers' responses as follows: one response with:

✓ Fewer than 5 valid competencies: low level of awareness
✓ A number of valid skills between 6 and 12: average level of awareness
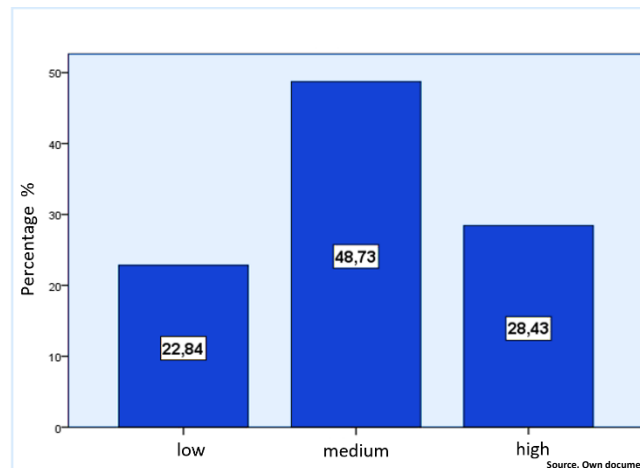✓ A number of valid skills above 12: high level of awarenes

Fig. 2. Teachers' awareness of 21st century skills

2.3.1 Important 21[st]century LES skills

For question 2 (Q2), according to the results, 46.19% of the teachers surveyed have an average degree of awareness of 21st century skills relating to LES, 14.21% have a high degree of awareness, while 39.59% have a low degree of awareness. These results clearly show that a large proportion of teachers are unaware of the skills specific to teaching and learning LES (Figure 3).

Analysis of the results revealed a weak correlation between the degree of teachers' awareness of 21st century LES skills and teaching seniority (0.091, i.e. correlated at 9%, obviously far from 100%), meaning that teaching seniority has no influence on the degree of teachers' awareness of 21st century LES skills. The same reasoning applies to the other variables (basic training, in-service training in 21st century skills).
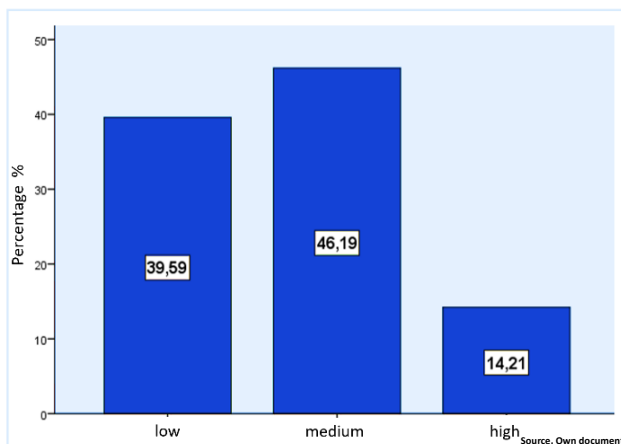

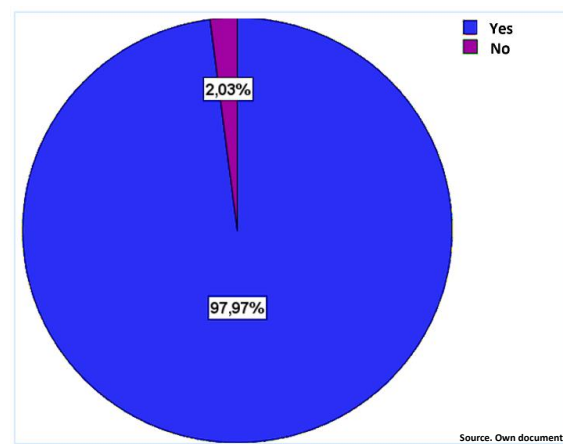**Fig. 3.** Teachers' level of awareness of 21st century LES skills

Fig. 4. 21st century skills and the teaching-learning of LES

For question 3 (Q3), almost all respondents answered yes, with a percentage of 97.97%, while just 2.03% answered no, which shows that reinforcing this type of skill can only benefit the teaching-learning of LES (Figure 4).

2.3.2 Digital teaching resources and the development of 21st century skills in LES

The teachers surveyed reported that interactive and creative digital resources (DR) contribute the most to the development of 21st century LES skills, with 36.17% and 31.81% respectively, followed by content DR (14.16%) and collaborative DR (13.94%), while only 3.92% favored other types of DR that could play this role. This shows that teachers have a new conception of the type of DR suitable for developing this type of skill in learners, after having long relied on content DR (Figure 5).
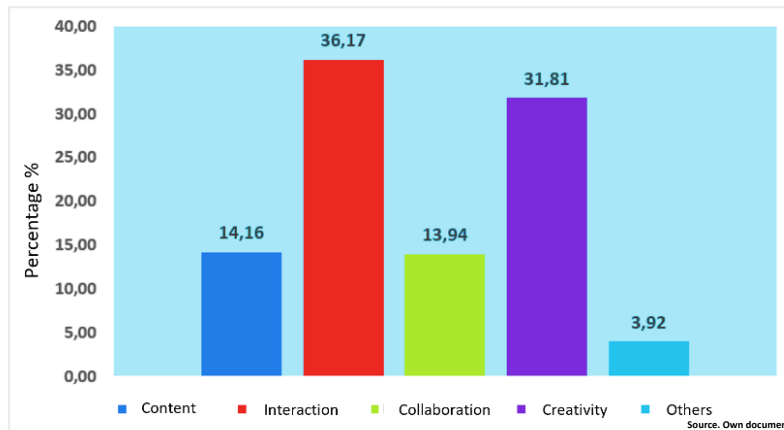
Fig. 5. Types of digital resources and development of LES (21st) skills in learners

2.3.3 *Assessing 21st century skills*

Concerning the evaluation of this type of skill (Q5), the teachers surveyed expressed the importance of each modality (Figure 6), specifying that short- and medium-term projects came first (Communication/Collaboration...), with 27%; then they attributed the same degree of importance (21%) to computerized problem-solving tests to be carried out in collaboration, as well as the support of technology (the collection and analysis of evaluation data on learners' learning). Furthermore, informal, and experimental learning activities (19%) could enable assessment of the acquisition of these skills. On the other hand, 10% of teachers chose the assessment at the end of the school cycle (Final Product), proving that teachers encourage the project approach and the reflection of assessment in LES.
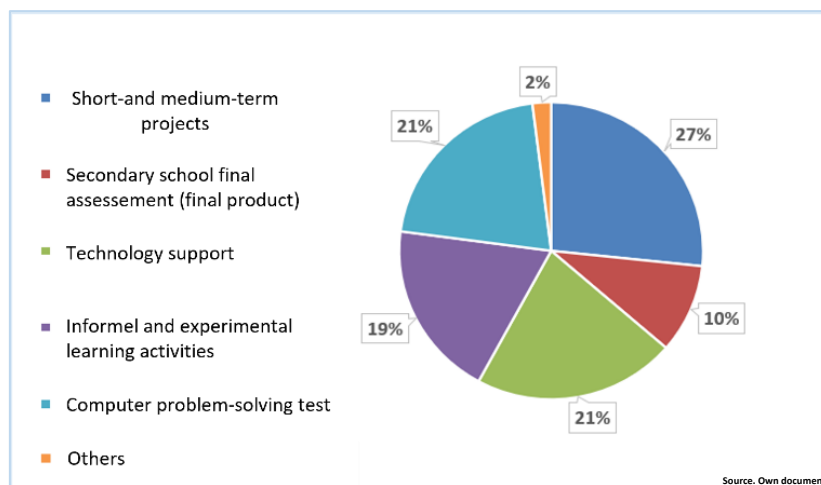

Fig. 6. Assessing 21st century skills

3 Discussion

With regard to teachers' awareness of 21st century skills, analysis of the results revealed that almost half the respondents were moderately aware of the nature of these skills. However, a large number were unaware of LES specific skills, even though they are explicitly mentioned in the White Paper and the discipline's official instructions. According to our results, teachers' experience and training have no impact on their degree of awareness of these skills, showing their need to training (ongoing, basic).

There was also a consensus among the teachers surveyed that reinforcing 21st century skills could be beneficial to the teaching-learning of LES. Indeed, the technology potential can only help them to develop this type of skill and innovate their classroom practices through the use of a panoply of DR types [11], due to the wealth of pedagogical opportunities induced by the integration of ICT into teaching practice in LES [13].

Our research has also shown that teachers are in favor of rethinking the evaluation of LES, by rethinking the technological means that can be mobilized and envisaged to measure the degree of progress and acquisition of a skill, since it is acquired on a time scale, leading to a project-based pedagogical approach.

4 Recommendations

In line with the objectives of our research and based on the results obtained, we would like to make a few recommendations aimed at helping teachers to improve the design and/or choice of digital resources aimed at developing 21st century skills and innovating in the teaching and learning of LES:

- o The need to review training engineering at training center level and integrate a module on 21st century skills, given that RETC have introduced the ICT module in basic training, but not yet a module on these skills. Basic training would thus enable future teachers not only to be equipped technically, but also pedagogically, to enable pedagogical innovation and thus the development of these skills in LES classroom practices.
- o The need for ongoing training for teachers, which would enable them to strengthen their skills and knowledge concerning the development of digital educational resources and specifically those aimed at developing 21st century skills, and also ranging from analysis to evaluation following a guide that would also enable non-designers to make the best choice of official digital educational resources (ODER).
- o Development of multi-level digital teaching resources aimed at reinforcing these skills in learners by helping teacher designers and innovators to produce suitable innovative digital devices following a blueprint, and form a bank of ODER for LES teachers with the languages of instruction adopted.
- o School life is a very important pillar for the development of 21st century skills via health and environment clubs (developing strategic and sustainability skills through environmental clubs...).
- o Curriculum reform is needed to make it universally competitive, and to give more space to the development of these skills in the hourly volume of learning acts, since some skills are already included in the LES curriculum: problem-solving, creativity, critical thinking, communication, technological and strategic skills. However, the level of learners in science proven by the PISA test remains far from expectations.
- o Use of digital learning environments and devices (Moodle, Oppia, Lalilo, Tacit...) to develop 21st century skills in learners and put in place indicators to measure the degree of acquisition of these skills
- o Assessment must certainly foster the acquisition and appropriation of 21st century skills by learners, hence the need to rethink the assessment system and build a 21st century assessment structure based on short- and medium-term projects, using computerized, collaborative problem-solving tests.

5 CONCLUSION

Teaching in the age of the 21st century means teaching in the age of ICT, which are undoubtedly playing an essential role in the field of education, which is undergoing transformations affecting teaching methods and modes of learning. Our Moroccan system is at the heart of this movement. It has embarked on a major change in its curricula and the organization of education, with a view to developing in a highly competitive world.

Our research began with the question: "**How can we design the use of digital teaching resources in LES to develop 21stcentury skills?**" The results showed that, although some 21stcentury skills are officially declared, LES teachers' awareness of skills in general and those specific to LES is average.

On the other hand, a large proportion of LES teachers integrate official resources into their teaching sequences, which is a good reason to think about designing ODER based on the skills to be developed by learners.

When it comes to the 21st century skills to be developed in LES (critical thinking, problem-solving, creativity, communication, technological and strategic skills, etc.), what remains to be done is to operationalize the development of these skills, from scripting to assessment, which can only be in favor of learning to teach LES.

In our next research project, we'll be analyzing the LES curriculum from the point of view of 21st century skills (programs, ministerial notes, ODER) and we'll opt for an analysis of ODER according to an evaluation grid to see to what extent the LES digital supports on the Ministry portal take into account the development of these skills, and then produce a guide for the design and use of ODER according to a well-defined master plan. We'll also try to get sustainability skills underway, given that protecting our planet and the environment in which we live has become indispensable, and it's also become crucial to integrate sustainability into our education and training systems, in order to give more value to our planet and act in favor of protecting it in a sustainable way.

References

[1] Y. Lhoste. Épistémologie & Didactique des SVT. : Langage, apprentissage, enseignement des sciences de la vie et de la Terre. Presses universitaires de Bordeaux, 2017, Études sur l'éducation - PR Martine Jaubert, 979-10-300-0074-0. ⟨hal-02555328⟩

[2] Ministère de l'Éducation Nationale et Formation des Cadres et de Recherche Scientifique. *Cadre de référence des Science de la Vie et la Terre, cycle collégial*, 2009. Direction des curricula et la vie scolaire. Royaume du Maroc.

[3] Ministère de l'Éducation Nationale et Formation des Cadres et de Recherche Scientifique. *Cadre de référence des Science de la Vie et la Terre, cycle secondaire qualifiant*, 2009. Direction des curricula et la vie scolaire. Royaume du Maroc.

[4] G. N. Loubaki, P. Potvin, L. R. Hijazi, & J. Vàzquèz-Abad, (2015). Diagnostic des conceptions en sciences susceptibles d'expliquer les différences de performances à une évaluation internationale entre le Québec et le Maroc. *Comparative and International Education*, *44*(1).

[5] ministère de l'éducation nationale du préscolaire et des sports, Rapport National Maroc-PISA 2018 publié février 2023, Centre National de l'Evaluation et des Examens. Royaume du Maroc.

[6] Commission Spéciale Éducation et Formation. Charte nationale d'éducation et de formation (COSEF). (1999). Récupéré le 02 Avril 2023 du site: http://cdrom.cosef.ac.ma. Royaume du Maroc.

[7] Greenberg, A. D., & Nilssen, A. H. (2015). The role of education in building soft skills: putting into perspective the priorities and opportunities for teaching collaboration and other soft skills in education. *Wainhouse Research, SMART*.

[8] Pruneau, D., Kerry, J., Langis, J., & Léger, M. (2015). Améliorer les programmes canadiens de sciences et technologies au primaire par l'ajout de compétences du 21e siècle. *Canadian Journal of Education / Revue* Canadienne *de l'éducation*, *38*(3), 1–23. http://www.jstor.org/stable/canajeducrevucan.38.3.07

[9] Majid, S., Liming, Z., Tong, S., & Raihana, S. (2012). Importance of soft skills for education and career success. International Journal for Cross-Disciplinary Subjects in Education, 2(2), 1037-1042.

[10] Suryanti, H. H. S., & Supeni, S. (2019). A Problem Based Learning (PBL) Model in Developing Students' Soft Skills Aspect. *International Journal of Higher Education*, *8*(8), 62-69.

[11] Astuti, R., maslikhatun Nisak, N., Nadlif, A., & Zamzania, A. W. H. (2021, February). Animated video as a media for learning science in Elementary School. In *Journal of Physics: Conference Series* (**Vol. 1779**, No. 1, p. 012051). IOP Publishing.

[12] Saavedra, A. R., & Opfer, V. D. (2012). Teaching and learning 21st century skills: Lessons from the learning sciences. *A Global Cities Education Network Report. New York, Asia Society*, *10*.

[13] Nafidi, Y., Alami, A., Zaki, M., El Batri, B., Hassani, M. E., & Afkar, H. (2018). The integration of ICT in the teaching of life and earth sciences in Morocco: current situation and challenges to be met. European Scientific Journal, 14(10.19044).