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EDUCATION ON RENEWABLE ENERGY: PERCEPTIONS OF FUTURE LIFE AND EARTH SCIENCES TEACHERS IN MOROCCO

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ABSTRACT

Introduction: All countries should aim to transform their education systems to make them sustainable and resilient in the face of climate change. To achieve this, teachers and educational support staff must all be able to fully implement green education. **Objectives:** The objective of this article is to assess the perceptions of future Life and Earth Sciences (LES) teachers at the Regional Centers for Education and Training (CRMEFs) in Morocco regarding the energy transition. **Methodology**: Future teachers were invited to complete an online questionnaire, consisting mainly of open-ended questions, via a personalised electronic link .**Results:** Analysis of 145 questionnaires distributed to the target population shows that most of the prospective teachers surveyed are familiar with the concepts of energy transition and renewable energy. However, the application of these concepts in the classroom appears to depend on their academic knowledge, pedagogical training, and practices within schools. **Conclusion**: Our study, therefore, leads us to examine how pre-service teachers' understanding of the concept of energy transition is put into practice and how learning is structured, particularly in light of changes to the Life and Earth Sciences (LES) curriculum in Morocco.
Keywords: *Representation, Life and Earth Sciences (LES), future teachers, energy transition, Morocco.*

1. INTRODUCTION

The third pillar of action of the Partnership for Green Education aims to adapt teacher training and the capacities of education systems to climate change by taking a comprehensive approach, from policy formulation and planning to financing and implementation (UNESCO, 2025). It seeks to help education systems address climate change by implementing measures that build climate resilience, decarbonize education systems, and ensure adequate training for teachers and policymakers. In a world where environmental challenges are becoming increasingly pressing, students are emerging as key players in the energy transition. By incorporating knowledge of renewable energy into their education, they develop not only a better understanding of sustainable energy solutions but also a commitment to taking action for a more environmentally friendly future. Through innovative initiatives and community projects, these ambitious young people highlight the importance of education focused on renewable energy for bringing about meaningful and sustainable change (Misael, 2025). These teaching methods align with those teachers are now encouraged developing more broadly within the framework of citizenship education (fostering critical thinking, teaching responsible behaviour, promoting student participation and engagement, etc.). However, when it comes to Education for Sustainable Development (ESD), teachers often feel ill-equipped and find it difficult to move beyond the confines of the school setting and their specific subject areas, which does not foster the desired change or the transition to new behaviours (Hugon et al. 2019). Training on renewable energy is vital for preparing younger generations to address climate challenges. School curricula are increasingly incorporating content to convey knowledge about solutions such as solar, wind, hydroelectric, biomass, and geothermal energy. This enables students to gain a clear understanding of the global energy landscape and to explore available sustainable alternatives (Misael, 2025). In educational theory, a schema is defined as a functional explanatory system, unique to each student, which integrates knowledge, opinions, and value systems. Within the framework of critical civic education, the goal is not to deconstruct this representation (and in particular to challenge students' value systems) but to help it evolve by questioning opinions that contradict established scientific knowledge or by providing the missing knowledge needed to take all dimensions of the problem into account (Damien Grenier, 2024). The research question we propose to address is as follows: What are the perceptions of future Life and Earth Sciences (LES) teachers regarding the topic of energy transition, and how do these perceptions evolve following the training program?

2. MATERIELS AND METHODES

2.1 Participants

This research is based on a descriptive and analytical survey. A questionnaire was administered to a sample of 145 prospective Life and Earth Sciences (LES) teachers from the class of 2025-2026, who were undergoing initial training for secondary education at the Regional Centers for Education and Training (CRMEFs) in Morocco and who held various bachelor's degrees (Life Sciences, Earth Sciences), Professional Bachelor's degrees in teaching, and holders of other degrees such as Master's or Doctoral degrees.

2.2. Data collection instrument

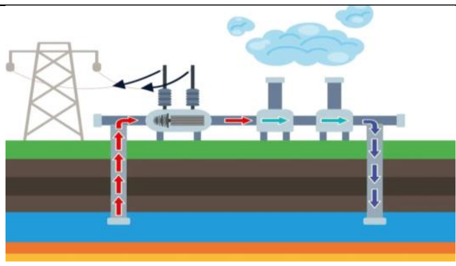
Future Life and Earth Sciences (LES) teachers were invited to complete an online questionnaire, consisting mainly of open-ended questions, via a personalized electronic link. The questionnaires were administered from April 1 to 14, 2026. The first two questions focused on defining the concept of energy transition to help us gather insights into their understanding of this concept. The first was an open-ended question: "What words or images come to mind when I mention energy transition?" and the second sought a more comprehensive definition: "How would you define the concept of energy transition more precisely?" The following questions consisted of a selection of seven (07) pictures (**Figure 1**). Participants were first asked to choose the image that they felt best illustrated the energy transition and to explain why, and then to choose and justify the picture that they felt illustrated it the least. Here, we drew on the study conducted by Carole Voisin and al. (2023), which we adapted for the purpose of analyzing the representations of future teachers. We selected various pictures likely to highlight the prevalence of a particular dimension in the representations of future teachers, or potential obstacles. Furthermore, according to one of the methodologies proposed by Barthes and Alpe (2013), it seems worthwhile to compare the representations analyzed in this way with the a priori constructed framework.

The concept of energy was introduced relatively late (in the mid-19th century) in several branches of physics and is sometimes expressed in different units (joules, calories, kilowatt-hours, metric tons of oil equivalent). It is a complex and debated concept that, moreover, has multiple connections and interdependencies with the economic, environmental, political, and health sectors, to name just a few (Abdul and al., 2019).

Picture 1

Picture 2

Picture 3



Picture 4

Picture 5

Picture 6

Picture 7

Figure 1: Pictures included in the questionnaire to illustrate the energy transition.

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For example, we selected the first picture to balance renewable energy production with the potential impacts on natural heritage and ecosystems, as exemplified by the Noor Ouarzazate complex, the first solar project developed as part of Morocco's energy strategy, which aims to increase the share of renewable energy in the national electricity mix to over 52% by 2030 (IRES, 2020). The second picture aimed to highlight the second-largest source of renewable electricity generation after hydropower: wind power, which has experienced significant growth due to the need to reduce carbon emissions. For the third picture, we sought to explore the idea that hydroelectric dams are infrastructure designed for the production of hydroelectric power. The fourth picture shows that the Earth's heat is a valuable natural resource. For several centuries, humans have harnessed this energy for heating. Today, geothermal energy is emerging as a sustainable solution to climate challenges. The fifth picture indicates that biomass energy could be a solution, provided it is obtained in a clean and renewable manner. The sixth picture illustrates the diversity of renewable energy sources, which are derived from natural sources (solar energy, wind energy, bioenergy, etc.). The final picture addressed the following question: Can nuclear energy be considered a renewable energy source ?

We emphasized that we were more interested in the reasons and explanations behind their choices than in the choices themselves, as the pictures could be interpreted in various ways. The questionnaire included a few other questions (analysis of provided pictures, relationship to sustainable development, etc.). We analyzed the data using word clouds (to gain insight into the range of perceptions held by future teachers).

2.3. Scope

In this study, only students in the Life and Earth Sciences (LES) program enrolled in the CRMEFs were included in the sample. The survey is limited to the Life and Earth Sciences (LES) departments of the CRMEFs (4 out of 12): Marrakech–Safi; Rabat–Salé–Kénitra; Casablanca–Settat; and Souss–Massa.

2.4 Analyse statistiques

Descriptive statistics (frequencies and percentages) were used to characterize the sociodemographic profile of respondents and their answers to the questionnaire. Open-ended responses to the first two questions were processed using word cloud analysis to identify the most salient terms associated with the concept of energy transition. For the three multi-component questions summarized in Table 2 (Q1, Q2, Q3), each answer was coded as "complete" when it cited all components expected by the a priori analytical framework (three components for Q1 and Q2; two for Q3), or "partial" otherwise. To compare the proportion of complete answers across the three questions, a chi-square (χ^2) test of homogeneity was performed, followed by pairwise post-hoc comparisons corrected for multiple testing using the Bonferroni method (adjusted $\alpha = 0.05/3 = 0.0167$). A p-value below the adjusted threshold was considered statistically significant.

3. RESULTS

Response rates to the questionnaires varied by CRMEF (**Table 1**):

Table 1: Data Collected.

CRMEF Region	Marrakech–Safi	Rabat-Sale–Kenitra	Casablanca-Settat	Souss-Massa	Total
Headcount	46	33	38	28	145
%	31.7	22.8	26.2	19.3	100.0

We find that the majority of prospective Life and Earth Sciences (LES) teachers surveyed (65.5%) are women, compared with 34.5% who are men (**Figure 2**).

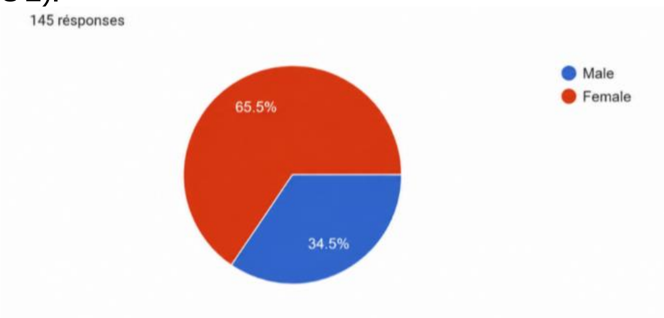

Figure 2: Gender of prospective teachers surveyed.

For the current training cycle at the CRMEFs, **Figure 3** shows that it is divided primarily between the middle school track (71.7%) and the high school track (28.3%).

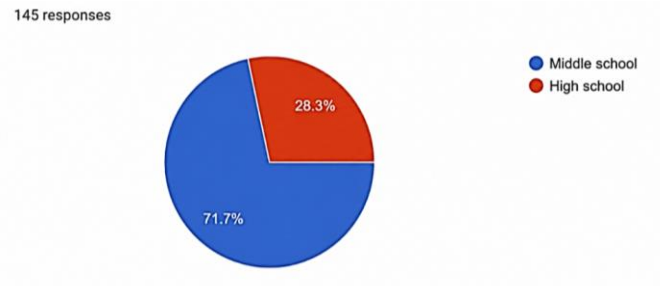

Figure 3: Training track of surveyed prospective teachers.

The majority of respondents (62.8%) hold a bachelor's degree, followed by those with a master's degree (34.5%). It appears that those with a doctorate and a DEUG (1.4%) represent a minority of the sample (**Figure 4**).

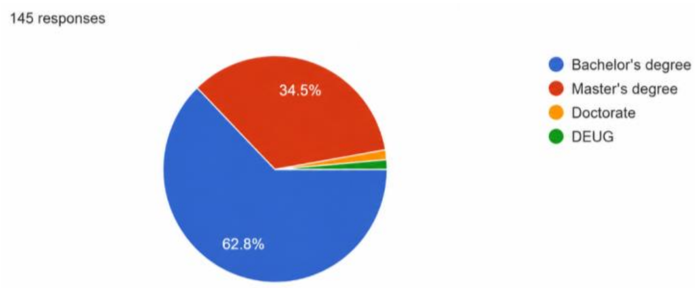

Figure 4: Highest degree held by the prospective teachers surveyed.

Question 1: What words come to mind when I mention the energy transition?

When the concept of the energy transition is mentioned, the word that comes to mind for future Life and Earth Sciences (SVT) teachers is "solar energy" (64.1%), followed by "wind energy" (15.9%) and "hydropower" (5.5%) (**Figure 5**).

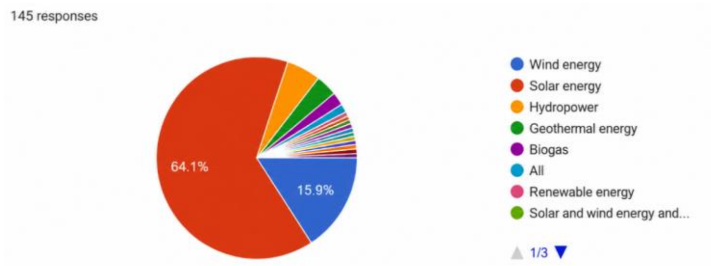

Figure 5: Selection of terms that best or least illustrate the energy transition.

Try to choose one photo (from among the 7 pictures) that you think best illustrates the energy transition.

Of the 145 future Life and Earth Sciences (LES) teachers who answered this question, 52.4% chose picture N° 6, followed by picture N° 1 at 23.4%. Only 1.4% chose picturN° 7 .As for the remaining pictures, they were selected in moderate and comparable proportions (**Figure 6**).

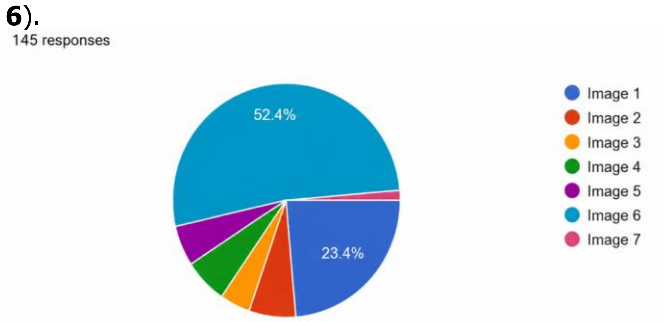

Figure 6: Selection of images that best illustrate the energy transition.

Reasons for the responses (selected responses)

Comments from future teachers, for example:

- ✓ Image No. 1: Solar energy is the most suitable energy source for Morocco thanks to its high levels of sunshine throughout the year, especially in desert regions. Unlike wind or hydroelectric power, it is available on a regular and sustainable basis, making Morocco a country well-suited for the development of solar energy.
- ✓ Image No. 2: It uses a natural, inexhaustible, and non-polluting source (wind), which reduces greenhouse gas emissions and protects the environment.
- ✓ Image No. 3: Solar energy best represents the energy transition because it is growing the fastest, its costs have fallen, and it symbolizes the decentralization of production.
- ✓ Image No. 4: Best represents the energy transition because it shows the use of geothermal energy, a renewable energy source. This technology generates electricity or heat by harnessing geothermal energy.
- ✓ Image No. 5: Waste-to-energy (biogas) makes energy more accessible to everyone. It transforms consumers into "producers" and offers a mature technological solution for quickly breaking free from energy dependence.
- ✓ Image No. 6 is the most comprehensive because it illustrates how these solutions complement each other. It shows wind turbines, solar panels, and vegetation. The energy transition does not rely on a single technology, but on a diversified energy mix that respects biodiversity to replace fossil fuels.
- ✓ Image No. 7: because it depicts a nuclear power plant (recognizable by its large cooling towers). Although nuclear power is a low-carbon energy source, it remains a subject of debate in the energy transition due to the management of radioactive waste and the associated risks.

Among the responses to this question from the 145 future Life and Earth Sciences (SVT) teachers, 62.8% chose Photo No. 7, followed by Photo No. 4 with a percentage of 9.7%. As for the remaining images, they were selected in moderate and comparable proportions (**Figure 7**).

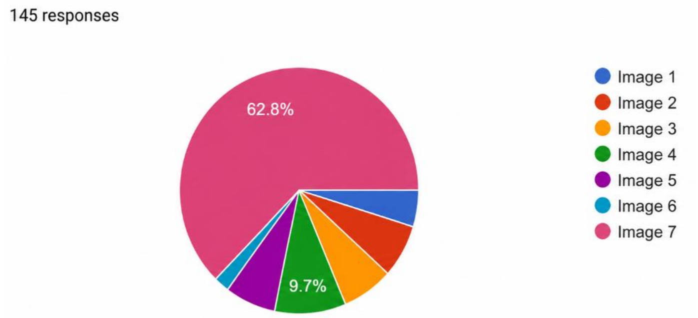

Figure 7: Selection of images least representative of the energy transition.

Justification of Responses

The majority of future Life and Earth Sciences (LES) teachers define the energy transition as the shift from one mode of energy production (non-renewable and primarily based on fossil fuels) to another (renewable, with particular reference to wind power). For example, some future teachers wrote:

- *picture No. 7 least represents the energy transition because it depicts nuclear energy, which is not a renewable energy source, unlike the other sources presented.*
- *picture No. 7: Because it poses risks related to radioactive waste and the use of non-renewable resources such as uranium.*
- *picture No. 7 depicts a nuclear power plant. Although this form of energy produces little CO_2, it poses problems related to radioactive waste and nuclear risks.*

Word clouds

The word clouds (Figure 2) were generated by analyzing the responses to the first two questions, which focused on defining the concept of the energy transition. The larger the word, the more frequently it appeared in the responses.

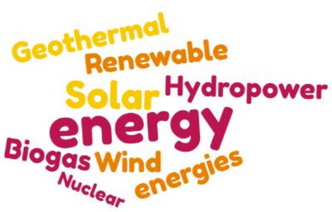

Figure 8: Word clouds related to the energy transition.

It is worth noting, however, that the word cloud focuses more on renewable energy sources, particularly solar energy. Furthermore, while the terms "nuclear," "wind," and "geothermal" were previously limited to solar and wind power, they have now diversified to include hydroelectric, tidal, biomass, and geothermal energy. To conclude this subsection, we can therefore say that the representations held by students in Life and Earth Sciences (LES) remain focused on the production aspect of the energy transition, but that these representations have become both more nuanced (the transition is less often defined as a black-and-white shift) and enriched in terms of the diversity of production methods, as well as economic and environmental impacts.

Table 2 presents a summary of the analysis of the responses from each prospective teacher surveyed, explained in greater detail in the following sections, to compare their conceptions, personal commitments, and reported learning activities.

Question	Theme	Complete answer, n (%)	Partial answer, n (%)	χ^2 (vs. other question)	df	p	Significance (Bonferroni, α=0.0167)
Q1	Q1. Why is the energy transition essential? (combined items: combat global warming / reduce dependence on fossil fuels / ensure energy security)	130 (89.65%)	15 (10.35%)	-	-	-	-
Q2	What are the main actions involved in the energy transition? (combined items: develop renewable energy / reduce energy consumption / promote energy efficiency)	118 (81.37%)	27 (18.63%)	-	-	-	-
Q3	What is the difference between the energy transition and the ecological transition? (energy sector only vs. broader scope incl. biodiversity, water, soil, circular economy)	140 (96.55%)	5 (3.45%)	-	-	-	-
Global test (Q1 vs Q2 vs Q3)	Homogeneity of the 3 proportions	-	-	**17.36**	2	**< 0.001**	Yes
Q1 vs Q2 (post-hoc)		-	-	4.01	1	0.045	No
Q1 vs Q3 (post-hoc)		-	-	5.37	1	0.020	No
Q2 vs Q3 (post-hoc)		-	-	17.00	1	< 0.001	**Yes**

Distribution of complete vs. partial answers for questions Q1, Q2, and Q3 (n = 145 per question), with results of the chi-square test of homogeneity. A "complete" answer refers to a response citing all expected components (3 for Q1 and Q2; 2 for Q3); a "partial" answer refers to a response citing only some of them. The global test compares the homogeneity of the three proportions of complete answers. Pairwise post-hoc comparisons were corrected using the Bonferroni method for 3 comparisons (adjusted threshold: α = 0.05/3 = 0.0167). Only the Q2 vs Q3 gap remains statistically significant after correction.

4. DISCUSSION

Reducing the effects of climate change therefore requires a shift in the energy model. The International Energy Agency has established a roadmap (IEA, 2023) to bring net greenhouse gas emissions to zero by 2050 in order to limit global warming to 1.5°C above pre-industrial levels by 2100. This roadmap calls for the accelerated electrification of the global energy system and a massive deployment of so-called renewable energy sources, which would account for 90% of electricity generation. However, as Fressoz (2024) points out, a massive substitution of one energy source for another has never occurred to date. On a global scale, throughout history, humanity has simply accumulated new energy sources without reducing its consumption of wood, coal, or oil. The shift away from fossil fuels toward renewable sources therefore presents an unprecedented challenge (Damien Grenier et al., 2024). Since 2009, Morocco has been committed to renewable energy, a topic not yet addressed in school curricula. Yet students are future citizens who will be called upon to secure their own livelihoods while effectively contributing to the development of society. The concept of energy transition takes on different forms depending on the country where it is implemented (with its own balance between environmental, economic, and social dimensions). The energy transition is sometimes presented as a component of the "ecological transition," which encompasses other topics such as the preservation of ecosystems and water resources. It should be noted that an energy transition takes place over decades, given the significant inertia of the energy system (which has been undergoing a continuous energy transition for nearly two centuries). Education plays a vital role in transforming society's perception of renewable energy. Through innovative school curricula and educational initiatives, students can begin to understand various energy solutions such as solar, wind, and hydroelectric power, as well as other sustainable alternatives. For example, secondary schools are incorporating modules on the ecological transition, enabling students not only to learn about issues related to corporate social responsibility but also to discover the environmental implications of their daily choices. By investing in education on these topics, we contribute not only to the well-being of future generations but also to the sustainability of our planet (Misael, 2025).

Around the world, numerous educational initiatives aim to incorporate carbon footprints into school curricula. Whether through research projects, visits to renewable energy production sites, or hands-on workshops, these initiatives enable students to measure, analyze, and understand the environmental impacts of their daily choices. For example, some schools have successfully reduced their carbon footprint by adopting eco-friendly practices, such as reducing car travel or optimizing energy use (Justine Fabre, 2025).

The analyses presented (word clouds, analysis of image selection, and responses to questions) appear largely consistent and reveal the persistent overemphasis on the production dimension in the representations of future Life and Earth Sciences (LES) teachers. This leads us to hypothesize that the core of these representations revolves primarily around this dimension. However, regarding peripheral elements, we note some enrichment of these representations concerning the diversification of renewable energy production methods, with particular mention of economic and environmental impacts. When compared with the multi-referential map, certain omissions can be identified, such as environmental and economic aspects. These analyses, however, have some limitations and potential biases. A comparative statistical analysis of the responses summarized in Table 2 further nuances this picture. A chi-square test of homogeneity comparing the proportions of complete versus partial answers across the three questions revealed a significant overall difference ($\chi^2 = 17.36$, df = 2, $p < 0.001$). Pairwise post-hoc comparisons, corrected for multiple testing using the Bonferroni method (adjusted $\alpha = 0.0167$), showed that this difference was primarily driven by the gap between Q2 and Q3 ($\chi^2 = 17.00$, $p < 0.001$): future teachers were significantly more likely to give a fully complete answer when distinguishing the energy transition from the ecological transition (96.55%) than when identifying the full range of concrete actions involved in the energy transition (81.37%). The differences between Q1 and Q2, and between Q1 and Q3, did not remain statistically significant once corrected for multiple comparisons. These results suggest that future LES teachers hold a comparatively solid declarative understanding of the energy transition, knowing what it is and how it differs from related concepts, but a less consolidated operational understanding of the concrete levers through which it is implemented. This distinction reinforces the broader observation that representations remain centered on the production dimension, and highlights the operational, action-oriented dimension as a specific target for reinforcement in pre-service training programs

For teachers, Education for Sustainable Development often corresponds to a project aimed at standardization through "best practices" and "best actions" (Lange, 2012), without encouraging students to question these assumptions. It would therefore be necessary to provide teachers with the means to change their perceptions of this form of education and to empower them to take action in the classroom and within the school, particularly through experiential activities (Lange, 2014).

5. CONCLUSION

Education is a crucial factor in transforming perceptions of renewable energy. Through innovative school curricula and awareness campaigns, young people are becoming aware of environmental challenges and the solutions available to them. Starting in middle school, students learn about various sources of clean energy, such as solar, wind, hydroelectric, biomass, and geothermal, thereby fostering a broader understanding of the global energy landscape.

In conclusion, analyses of word clouds, similarities, and image choices allow us to make the following observations. First, when compared to the multi-referential map, we note that the representations of future life and earth science teachers focus primarily on energy production and, to a lesser extent, on environmental impacts (limited resources, CO_2 emissions) and consumption. The results of this study open up several promising avenues for research. First and foremost, longitudinal studies tracking future teachers in their professional practice would make it possible to assess the extent to which the observed representations persist and actually influence their teaching of concepts related to the energy transition in Life and Earth Sciences (LES).

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