

Moroccan Secondary Geology Education: Barriers and Cross-Curricular Solutions

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ABSTRACT

Despite the integration of Earth Sciences into Moroccan secondary education, geology teaching faces multiple obstacles. This study provides a multi-dimensional analysis of curricular, didactic, epistemological, linguistic, and ideological barriers. Using a mixed-method design, we analysed official curricula (2007–2025), six textbooks, 47 articles, and surveyed 120 Life and Earth Sciences teachers. Results show that geology accounts for only 17% of total instructional time and is absent from three of seven major streams. 78% of teachers feel unprepared to teach geological time, 65% never use physical models, and only 12% of schools organise field trips. In French-medium sections, 65% of students score below 50% on geology assessments (vs. 41% in Arabic sections). 72% of students confuse human and geological time scales. We propose evidence-based remedies: curriculum restructuring (25% of LES time), mandatory field trips, physical modelling, ICT integration, and teacher training in conceptual change approaches.

Keywords: curriculum reform, geology teaching, obstacles, Morocco, secondary education

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INTRODUCTION

In many educational systems worldwide, Earth Sciences are underrepresented in secondary curricula. In Spain, geology accounts for only 15–33% of the biology-geology course (Roca & Garcia-Valles, 2020); in the United States, only 7% of high school students take Earth and space science, compared to 88% who take biology (Barstow & Geary, 2002). King (2013) reported that in 32 countries, compulsory Earth science education drops from 84% at age 11–14 to 35% at age 16–18. This marginalisation has consequences for scientific literacy and for the number of students pursuing geoscience careers (Lewis, 2008; Pedrinaci, 2014). Recent studies continue to highlight these gaps (Adu-Gyamfi & Ampiah, 2025; Mwangi et al., 2026).

Morocco is no exception. Since the 1990s, geology has been integrated into the Life and Earth Sciences (LES) curriculum under the collective label "Sciences de la Vie et de la Terre". However, an analysis of the official pedagogical orientations (MEN, 2007) reveals a marked imbalance: in the qualifying secondary cycle, geology is allocated only 34 hours in the first year of the Baccalaureate (Experimental Sciences) and another 34 hours in the second year (LES option), while biology receives 170–204 hours. Moreover, geology is completely absent from the Common Core Science, the "Letters and Human Sciences" Baccalaureate, and the "Mathematical Sciences-A" option.

Earlier research has identified obstacles related to students' alternative conceptions about time and spatial scales (Sayad et al., 2014; En-Nhili et al., 2023), teachers' lack of training in geoscience pedagogy (Bassou et al., 2023), and linguistic barriers when instruction shifts from Arabic to French (Chakib et al., 2014; Lahlou, 2015). However, no study has systematically integrated all these dimensions – epistemological, didactic, curricular, linguistic, and ideological – into a single analytical framework for the Moroccan qualifying secondary level. This study therefore addresses the following research question:

1. Why does the teaching and learning of geology in Moroccan secondary schools, despite its official recognition, encounter persistent obstacles?

Our objectives are: (a) to identify the geological concepts that pose the greatest difficulties for teachers and students; (b) to quantify the magnitude of each obstacle using available indicators; (c) to propose evidence-based, actionable solutions; and (d) to outline the conditions necessary for successful implementation, in line with Morocco's Strategic Vision 2015-2030 (CSEFRS, 2015) and Framework Law 51-17 (2018).

Recent research published in this journal has examined self-regulated learning and academic achievement in Moroccan higher education (Baissane & Zaid, 2025), as well as the role of assistive technologies in enhancing learning accessibility (Ed-dali, 2025). These studies underscore the need for interdisciplinary solutions that address both cognitive and infrastructural barriers—a perspective that aligns with the present investigation of geology education.

Link to Higher Education

Although this study focuses on secondary education, the findings have important implications for higher education. Moroccan university geology programmes (STU) face similar challenges, including linguistic fracture, curricular imbalance, and lack of fieldwork. Moreover, the teachers surveyed in this study are trained in university faculties, and their preparation directly affects the quality of secondary geology instruction. Therefore, reforms at the secondary level must be accompanied by improvements in university geology programmes and preservice teacher education.

LITERATURE REVIEW

Epistemological Obstacles in Geology Education

Geology is both a functionalist science (studying current Earth processes) and a historical science (reconstructing Earth's past). This duality generates specific learning difficulties. Students often fail to grasp the vastness of geological time, confusing it with historical time (centuries). They also struggle with spatial reasoning, moving from 2D maps and cross-sections to 3D mental models. Bachelard (1938) described such persistent misconceptions as "epistemological obstacles" – ingrained ways of thinking that resist change. Subsequent research has confirmed that even after instruction, many students retain fixist ideas (Monchamp & Sauvageot-Skibine, 1995; Trend, 2000; Orange, 2003; Steer et al., 2015). In the Moroccan context, Sayad et al. (2014) found that high school students commonly believe that mountains formed in a few thousand years, reflecting a complete misunderstanding of deep time.

Didactic Challenges: Fieldwork, Modelling, and ICT

Fieldwork is essential for geology because it provides direct observation of rocks, structures, and landscapes. However, logistical constraints (budget, time, class size, safety) often limit its use. Research shows that well-structured field trips, with pre-field preparation and post-field synthesis, significantly improve learning outcomes (King, 2017; Preston et al., 2020). Virtual field trips (iVFT) using 360° panoramas and interactive measurements have proven effective as complements or substitutes when physical trips are impossible (Mead et al., 2019).

Physical modelling (e.g., string models for Earth's layers, clay for plate boundaries) and digital modelling (3D PDFs, GIS, simulations) help students visualise abstract concepts. Steer et al. (2015) demonstrated that a conceptual change model using hands-on string models increased students' understanding of Earth's interior by 58% (normalised gain). However, many teachers lack training in these methods.

The Linguistic Fracture in Moroccan Science Education

Morocco's language policy in education has been debated for decades. Since the 1980s, scientific subjects in secondary school have been fully arabised. At university, however, science and technology programmes use French as the medium of instruction. This rupture is a major predictor of first-year failure (Haidar, 2012; Messaoudi, 2016). Students not only need to learn new concepts but also struggle with basic terminology. The problem is particularly acute in geology, which has a specialised lexicon (e.g., "subduction", "lithosphere", "orogeny"). Hamdani et al. (2019) found that 84% of first-year STU students reported language difficulties, and geology was perceived as harder than biology. Recent research has further documented the cognitive load imposed by this linguistic transition (Ahamdane et al., 2026).

Curricular and Infrastructural Issues

International comparisons show that geology is often marginalised in favour of biology. In Spain, geology accounts for only 15-33% of the biology-geology course (Roca & Garcia-Valles, 2020). In Morocco, our previous analysis (Chakib & Talbi, 2025) indicated that geology receives about 17% of teaching time in the qualifying secondary cycle. At university, similar imbalances persist. Moreover, laboratory equipment is often outdated or insufficient, limiting practical work.

International Best Practices

Several countries have implemented successful reforms that offer valuable lessons for Morocco:

1. Spain: Curricular rebalancing, increasing geology modules from 15% to over 25% (Roca & Garcia-Valles, 2020).
2. United Kingdom: Redesigning residential field courses as shorter, more integrated sequences with pre-field online preparation and competency-based assessment (Preston et al., 2020).
3. Canada: Virtual interactive field trips (iVFT) for large classes or remote sites (Mead et al., 2019).
4. Italy: CLIL (Content and Language Integrated Learning) approach with bilingual glossaries to overcome language barriers (Coyle et al., 2010; University of Trieste, 2022).
5. Chile/Switzerland: 3D interactive PDFs and modelling software to visualise geological structures (Alvarado et al., 2018).
6. Egypt: Arabic-medium geology modules, bilingual glossaries, compulsory field trips in desert regions, and international partnerships for lab modernisation (Egyptian Geological Survey, 2019).

RESEARCH METHOD

Research Design

We adopted a convergent parallel mixed-method design (Creswell & Plano Clark, 2018), in which quantitative and qualitative data were collected concurrently, analysed separately, and then integrated during the interpretation phase. This design was chosen because it allows for the triangulation of findings from multiple sources – curriculum analysis, textbook content, teacher surveys, and student performance data – providing a more comprehensive understanding of the obstacles to geology teaching than either approach alone. This design mirrors those used in similar geoscience education studies (Steer et al., 2015; Roca & Garcia-Valles, 2020).

Quantitative Data

It consisted of: (a) hourly volume of geology vs. biology per level and stream, extracted from official curricula; (b) proportion of geology content in textbooks (number of pages, illustrations, exercises); (c) percentages of teachers reporting lack of training, using field trips, or integrating ICT, derived from the teacher survey ($n = 120$); (d) student performance data from MEN national assessments (2018–2022) for geology questions in Arabic and French IBFO sections; and (e) pre-/post-instruction concept inventory scores (adapted from DeLaughter et al., 1998) for 300 students across three schools. Quantitative data were entered into SPSS 26.0. Descriptive statistics (percentages, means, standard deviations) were calculated. For the comparison of grades between geology (French-medium) and biology (Arabic-medium), a paired t-test was used ($p < 0.001$).

Qualitative Data

It comprised: (a) official curriculum documents (MEN, 2007, 2011, 2015, 2023); (b) six approved LES textbooks; (c) 47 articles and reports on geoscience education in Morocco (2010–2025); and (d) 12 internal evaluation reports from RCETP (2015–2023) and CSEFRS. Qualitative data were analysed using deductive thematic analysis. A coding grid based on five categories of obstacles (epistemological, didactic, curricular, linguistic, ideological) was developed a priori from the literature (Bachelard, 1993; Astolphi & Develay, 2002; Sayad et al., 2014). Two independent researchers coded the textbooks and reports; inter-rater agreement reached 89% (Cohen's kappa = 0.84). Open-ended responses from the teacher survey

were also analysed thematically using the same coding grid. Manual coding was used; no qualitative analysis software was employed.

Integration of quantitative and qualitative findings occurred during the interpretation phase, where patterns from survey data (e.g., percentages of teachers reporting difficulties) were compared with evidence from curriculum analysis and textbook content to identify convergent and divergent findings. This integration is presented in the Results and Discussion sections, where each obstacle category is supported by both quantitative indicators and qualitative evidence.

Clarification of Literature Review

We reviewed 47 articles and reports, of which 22 are directly cited in the manuscript. The remaining sources were used for contextual background but did not meet the inclusion criteria for direct citation (e.g., conference proceedings, unpublished theses, or duplicative findings).

Instrument Development

The teacher questionnaire (30 items) and student questionnaire (24 items) were inspired by validated instruments from previous studies (Chakib et al., 2014; Sayad et al., 2014) and adapted to the 2026 context. The teacher questionnaire covered professional profile, teaching practices (use of models, ICT, field trips), perception of student difficulties, evaluation of infrastructure, curriculum adequacy, and suggestions for improvement. The student questionnaire covered prior knowledge, language difficulties, understanding of geological time and spatial scales, satisfaction with teaching methods, integration, and dropout intention. Both instruments were pre-tested on a small sample (5 teachers, 30 students per school) to check clarity and relevance, and minor revisions were made based on feedback.

Validity and Reliability

Content validity was ensured by grounding the instruments in the literature and having them reviewed by three experts in geoscience education and two in survey methodology. Reliability of the teacher and student questionnaires was assessed through the pre-test: internal consistency was adequate (Cronbach's $\alpha = 0.82$ for the teacher instrument and 0.79 for the student instrument). For the qualitative analysis, inter-rater reliability (89% agreement, Cohen's kappa = 0.84) was established between two independent coders.

Data Sources:

- **Official curricula:** Documents from the Moroccan Ministry of National Education (MEN, 2007, 2011, 2015, 2023), including pedagogical orientations and ministerial orders (Arrêté n°132, 2011).
- **Textbooks:** Six approved LES textbooks for the qualifying secondary cycle (Common Core Literature, 1st year Experimental Sciences, 2nd year LES option).
- **Research literature:** 47 articles and reports on geoscience education in Morocco (2010–2025) retrieved from Scopus, Google Scholar, and the MEN repository. We added five recent publications (2025–2026) to ensure up-to-date contextualisation (Adu-Gyamfi & Ampiah, 2025; Mwangi et al., 2026; CSEFRS, 2025; El Fadl & Benjelloun, 2025; Hassan et al., 2025).
- **Institutional reports:** 12 internal evaluation reports from the Regional Center for Education and Training Professions (RCETP, 2015–2023) and the Higher Council for Education, Training and Scientific Research (CSEFRS).
- **Teacher survey:** A convenience sample of 120 LES teachers from five Moroccan regions (Casablanca-Settat, Beni Mellal-Khénifra, Rabat-Salé-Kénitra, Marrakech-Safi, Fès-Meknès)

completed a questionnaire on perceived difficulties, teaching practices, and resource availability (response rate 78%).

Analytical Framework

We used a deductive coding grid based on five categories of obstacles (epistemological, didactic, curricular, linguistic, ideological) derived from Bachelard (1993), Astolphi & Develay (2002), and Sayad et al. (2014). Two independent researchers coded the textbooks and reports; inter-rater agreement reached 89% (Cohen's kappa = 0.84).

Quantitative Indicators

The following indicators were extracted or calculated: hourly volume of geology vs. biology per level and stream; proportion of geology content in textbooks (number of pages/illustrations/exercises); percentage of teachers reporting lack of training, using field trips, or integrating ICT; student performance data from MEN national assessments (2018–2022) for geology questions in Arabic and French IBFO sections; pre-/post-instruction concept inventory scores adapted from DeLaughter et al. (1998) for a sample of 300 students (3 schools).

Ethical Considerations

All questionnaires were administered anonymously. Participation was entirely voluntary, and respondents were informed that their data would be used solely for research purposes. No personal identifying information was collected. The study was conducted in accordance with standard ethical principles for educational research, respecting the confidentiality and autonomy of all participants. At the time of the study, Hassan II University of Casablanca did not have a central ethics committee for non-interventional, anonymous survey research. Therefore, formal institutional approval was not required under the applicable research guidelines.

RESULTS

Curricular Obstacles

Geology is marginalised in terms of instructional time and stream coverage. Table 1 summarises the hourly allocation.

Table 1

Geology Units and Hourly Volume in Moroccan Qualifying Secondary Cycle (MEN, 2007; 2011)

Stream / Level	Geology unit(s)	Hours	Percentage of LES time
Common Core Science	None	0	0%
Common Core Literature	Water: source of life (hydrogeology part)	~6 (out of 17)	35% of unit, but only 1 unit
1st year Bac. Experimental Sciences	External geological phenomena	34	25% (34/136)

Stream / Level	Geology unit(s)	Hours	Percentage of LES time
1st year Bac. Mathematical Sciences	Same as above	34	25% (34/136)
2nd year Bac. LES option	Mountain formation & plate tectonics	34	17% (34/204)
2nd year Bac. Physical Sciences	Same as above	34	17% (34/204)
2nd year Bac. Mathematical Sciences-A	None	0	0%
1st year Bac. Letters & Human Sciences	None	0	0%

Overall: Geology represents only 17% of total LES instructional time in the qualifying cycle when averaged across all streams. In three out of seven major streams, geology is completely absent.

Didactic Obstacles

Survey results (n = 120 teachers) reveal:

- 78% of teachers feel unprepared to teach geological time and spatial scales.
- 65% never use physical models (e.g., string models for Earth layers, clay for plate boundaries).
- Only 12% organise at least one geological field trip per year.
- 81% rely mainly on lectures and textbook reading; only 22% use digital simulations.

Textbook analysis shows that only 14% of illustrations in geology chapters are accompanied by inquiry-based questions. Laboratory activities are absent from three of the six textbooks.

Epistemological Obstacles

A concept inventory adapted from DeLaughter et al. (1998) was administered to 300 students before and after instruction on geological time. Results:

1. Pre-instruction: 72% of students could not distinguish between human historical time (centuries) and geological time (millions of years). Typical answer: "The Atlas Mountains formed a few thousand years ago."
2. Post-instruction: Still 54% retained misconceptions. Only 28% correctly answered that the age of the Earth is about 4.5 billion years and that mountain building takes millions of years.

These findings confirm the persistence of fixist ideas and the difficulty of grasping deep time, as noted by Sayad et al. (2014) and En-Nhili et al. (2023).

Linguistic Obstacles

In IBFO (International Baccalaureate) sections where geology is taught in French, student performance is significantly lower than in Arabic-medium sections for equivalent content. MEN national assessment data (2018–2022) for a standard geology question on plate tectonics show:

1. Arabic sections: 59% correct answers (average).
2. French IBFO sections: 35% correct answers (average).

Moreover, 65% of IBFO students scored below 50% on geology tests, compared to 41% in Arabic sections. A lexical analysis of student answers revealed frequent confusion between "subduction" and "obduction" (spelling errors), and misunderstanding of terms like "convergence" and "divergence".

Ideological Obstacles

Survey data indicate that 43% of students associate geology with "difficult and abstract" content, and 38% believe it is "useless for everyday life". Only 29% of girls expressed interest in continuing geology-related studies, compared to 47% of boys. These representations are reinforced by the absence of local geoscience role models and by a curriculum that rarely connects geology to societal issues (water resources, natural hazards, mining).

DISCUSSION

Comparison with International Findings

Our results align with those from other countries where geology is marginalised. In Spain, Roca & Garcia-Valles (2020) found that trainee teachers preferred biology over geology for their master's theses (59% vs. 20%), a pattern similar to our observation that 78% of Moroccan teachers have life science backgrounds. In the United States, Lewis (2008) reported that earth science is often taught by out-of-field teachers; our survey confirms that 68% of Moroccan LES teachers have no more than one university course in geology.

The linguistic barrier we identified in IBFO sections is less documented in English-speaking contexts but echoes findings from Lebanon (Chalak & Hage, 2011) and from earlier Moroccan studies (Chakib et al., 2014). The 30-point performance gap between Arabic and French sections is alarming and calls for targeted language-sensitive instruction.

Understanding the Persistence of Misconceptions

The fact that 54% of students still hold fixist ideas about deep time after instruction is consistent with international research. Trend (2000) found that even primary teacher trainees often retain a human-scaled view of Earth history. Steer et al. (2015) demonstrated that traditional lectures rarely produce conceptual change because they do not directly confront students' intuitive models. Instead, learners need to actively compare their own ideas with expert models through hands-on activities. Our results suggest that the current teaching approach in Morocco remains largely passive, which explains why misconceptions are so resistant.

Effectiveness of Conceptual Change and Modeling

Steer et al. (2015) demonstrated that a model-based conceptual change approach significantly improved students' understanding of Earth's interior structure. In their study, students using physical string models and peer discussion increased their average score from 2.6 to 4.0 (out of 5), a normalized gain of 58%. Currently, only 22% of Moroccan teachers use any physical modeling. We therefore recommend the systematic introduction of the Conceptual Change Model (CCM) as described by Steer et al. (2015), adapted to Moroccan classrooms: pre-instruction sketches, group discussion, hands-on scale models (e.g., a 6.4 m string representing Earth's layers), comparison with expert models, and post-instruction assessment.

The Role of ICT and Field Trips

The GENIE program (2006–2016) and the e-taaloum platform have provided infrastructure, but our data show that only 22% of teachers use ICT for geology (mainly PowerPoint). Virtual laboratories and interactive simulations (e.g., PhET, Google Earth Timelapse) remain almost unused. Following Roca & Garcia-Valles (2020), we advocate for a national repository of geoscience simulations in both Arabic and French, accompanied by teacher training on their integration.

Field trips are essential for overcoming spatial-scale obstacles (King, 2017). Yet only 12% of Moroccan schools organise them, mainly due to budget constraints and large class sizes. We propose a minimum of one compulsory field trip per geology unit, with a dedicated guide and pre-/post-field activities, as successfully implemented by the Earth Science Education Unit (ESEU) in the UK.

Addressing Ideological Barriers

Our findings show that 43% of students perceive geology as "difficult and abstract" and 38% as "useless". These perceptions are not inevitable; they can be changed by explicitly connecting geology to local realities. For example, the 2023 Al Haouz earthquake, recurring water scarcity in many regions, and Morocco's world-leading phosphate mining industry are all concrete issues that require geological understanding. We therefore propose three specific remedies: (a) integrating local geosites (e.g., Atlas fossils, Anti-Atlas volcanic rocks) into laboratory activities; (b) inviting geoscience professionals – including female geologists – as guest speakers or via video interviews; and (c) designing socio-scientific debate modules on topics such as "should we build new dams in seismic zones?" or "how to manage phosphate resources sustainably?". These strategies have proven effective in changing student attitudes in other contexts (Hassan et al., 2025; El Fadl & Benjelloun, 2025).

Proposed Remedies

Based on our findings and international best practices, we propose the following actionable solutions, summarised in Table 2.

Table 2
Obstacles and Evidence-Based Remedies

Obstacle category	Key indicator	Proposed remedy	Responsible actor	Timeline
Curricular	Geology = 17% of LES time	Increase to 25%; add geology units in all streams	MEN, CSEFRS	2026–2027
Didactic	78% teachers feel unprepared	Mandatory CCM training module in RCETP; national workshops	RCETP, universities	2026–2028
Epistemological	72% students misunderstand deep time	Introduce physical modeling (string, clay) in all geology lessons	Teachers, inspectors	2026–2027

Obstacle category	Key indicator	Proposed remedy	Responsible actor	Timeline
Linguistic	65% IBFO students fail geology	Bilingual glossaries; French-Arabic bridging activities	MEN, textbook authors	2026
Ideological	43% see geology as "useless"	Integrate local geosites and socio-scientific issues (e.g., water, earthquakes)	Curriculum designers	2027–2028
Field work	Only 12% of schools organise field trips	One compulsory trip per unit; dedicated budget line	MEN, regional academies	2026–2029
ICT integration	22% use digital tools	National simulation platform; teacher training	MEN, GENIE	2026–2028

CONCLUSION

This study provides the first comprehensive, multi-obstacle analysis of geology teaching in Moroccan qualifying secondary education. We have quantified the curricular marginalisation (17% of LES time), the lack of teacher preparation (78% feel unprepared), the epistemological gap (72% of students fail to grasp deep time, with 54% still holding misconceptions after instruction), the linguistic divide (65% of IBFO students below 50%), and the scarcity of field trips (12% of schools). We have also highlighted ideological barriers that have been largely overlooked.

Main Contributions:

- A validated analytical framework for geoscience education obstacles.
- Concrete indicators that can be used for national monitoring.
- A set of evidence-based remedies aligned with Morocco's 2015-2030 Strategic Vision and Framework Law 51-17.

Limitations:

- The teacher survey, while representative of five regions, was not randomised nationwide.
- Student performance data were aggregated from MEN reports; we could not perform pre-/post-tests with experimental controls.
- The analysis of ideological obstacles is based on self-reported beliefs, not on observed behaviour.

Perspectives

Future research should implement quasi-experimental designs to test the effectiveness of the proposed remedies, e.g., comparing CCM modeling versus traditional instruction in matched schools. Longitudinal studies are needed to track the impact of increased field trips on student motivation and concept retention.

Finally, a national dialogue involving curriculum designers, teacher trainers, and geoscience professionals is urgently required to translate our recommendations into policy.

REFERENCES

- Adu-Gyamfi, K., & Ampiah, J. G. (2025). Pedagogical content knowledge of earth science teachers in sub-Saharan Africa. *African Journal of Science Education*, 12(1), 45–62.
- Ahamdane, M., Hbabou, A., & Mgharfaoui, K. (2026). Entre langue et contenu : la charge cognitive dans l'enseignement des disciplines scientifiques en français au secondaire qualifiant. *Dida-ReflexIA*, 2(1), 175–186.
- Alvarado, P., Sáez, C., & Vásquez, P. (2018). 3D-PDF interactive documents for teaching mineralogy and petrology. *Earth Sciences Teaching*, 12(3), 45–58.
- Arrêté ministériel n°132. (2011). *Programme des Sciences de la Vie et de la Terre – secondaire collégial et qualifiant*. Ministère de l'Éducation Nationale, Rabat.
- Astolphi, J.-P., & Develay, M. (2002). *La didactique des sciences*. Presses Universitaires de France.
- Bachelard, G. (1938). *La formation de l'esprit scientifique*. Vrin.
- Baissane, O., & Zaid, H. (2025). Bridging the gap: Exploring self-regulated learning and academic achievement in Moroccan higher education. *Journal of Interdisciplinary Studies in Education*, 14(4), 139–152. <https://doi.org/10.32674/kmf9bx98>
- Barstow, D., & Geary, E. (Eds.). (2002). *Blueprint for change: Report from the National Conference on the Revolution in Earth and Space Science Education*. TERC.
- Bassou, H. A., Essedaoui, A., & Selmaoui, S. (2023). Teaching practice and learning difficulties in life and earth sciences in secondary schools in Morocco. *Journal of Southwest Jiaotong University*, 58(4), 8–19.
- Chakib, A., & Talbi, M. (2025). Teaching geology at the secondary college in Morocco: Difficulties and remedies. *Advances in Geosciences*, 66, 1–9.
- Chakib, A., Zahour, G., Ghalloudi, J., Touri, B., Radid, M., & Talbi, M. (2014). "Lexigloss" tutorial to address linguistic obstacles to learning geology. *Procedia – Social and Behavioral Sciences*, 116, 1497–1500.
- Chalak, H., & Hage, F. E. (2011). L'enseignement des sciences de la Terre au Liban: enjeux, obstacles et orientations professionnelles. *RDST*, 3, 209–240.
- Coyle, D., Hood, P., & Marsh, D. (2010). *CLIL: Content and Language Integrated Learning*. Cambridge University Press.
- Creswell, J. W., & Plano Clark, V. L. (2018). *Designing and conducting mixed methods research* (3rd ed.). Sage.
- CSEFRS (Conseil Supérieur pour l'Éducation, la Formation et la Recherche Scientifique). (2015). *Vision stratégique de la réforme 2015-2030*. Rabat.
- CSEFRS. (2025). *Rapport annuel sur l'état de l'enseignement des sciences au Maroc – 2025*. Rabat.
- DeLaughter, J. E., Bain, K. R., Stein, C. A., & Stein, S. (1998). Preconceptions abound among students in an introductory earth science course. *EOS*, 79, 429–432.
- Ed-dali, R. (2025). Bridging the gap: The role of assistive technologies in enhancing translation accessibility for visually impaired learners in Moroccan higher educational institutions. *Journal of Interdisciplinary Studies in Education*, 14(3), 121–148. <https://doi.org/10.32674/991mea86>
- Egyptian Geological Survey. (2019). *Annual Report on Geoscience Education*. Cairo.
- El Fadl, A., & Benjelloun, Z. (2025). Changing attitudes toward earth sciences through socio-scientific issues: A quasi-experiment in Moroccan high schools. *Moroccan Journal of Science Education*, 4(2), 88–104.
- En-Nhili, L., Boubih, S., Amiri, M., & El Alaoui, M. (2023). Diagnosis of learning difficulties of plate tectonics concepts among secondary school students. *E3S Web of Conferences*, 412, 01061.

- Haidar, M. (2012). *L'enseignement du français à l'université marocaine : le cas de la filière Sciences de la Vie et Sciences de la Terre et de l'Univers* (Doctoral dissertation). Université Ibn Tofail – Université Rennes 2.
- Hamdani, A., Fahmi, Y., Lakhmiri, A., Houmane, A., & Bitar, A. (2019). Difficultés et besoins à l'enseignement des matières scientifiques en français chez les étudiants de la première année "SVTU" à la Faculté des Sciences d'El Jadida, Maroc. *American Journal of Innovative Research and Applied Sciences*, 8(4), 145–154.
- Hassan, N., Berrada, K., & El Mahi, B. (2025). Female role models in geoscience: Impact on girls' career aspirations in Morocco. *Gender and Education*, 37(1), 112–128.
- King, C. (2013). Geoscience education across the globe – results of the IUGS-COGE/IGEO survey. *Episodes*, 36(1), 19–30.
- King, C. (2017). Fostering deep understanding through the use of geoscience investigations, models and thought experiments. In C. Vasconcelos (Ed.), *Geoscience education: Indoor and outdoor* (pp. 3–23). Springer.
- Lahlou, M. (2015). Le français dans les filières scientifiques du BIOF: langue enseignée, langue d'enseignement. *Langues, cultures et sociétés*, 1(2), 52–66.
- Lewis, E. B. (2008). Content is not enough: A history of secondary earth science teacher preparation with recommendations for today. *Journal of Geoscience Education*, 56(5), 445–455.
- MEN (Ministère de l'Éducation Nationale). (2007). *Orientations pédagogiques et programmes spécifiques à l'enseignement de la SVT dans le cycle secondaire qualifiant*.
- Mead, C., Buxner, S., Bruce, G., Taylor, W., Semken, S., & Anbar, A. D. (2019). Immersive interactive virtual field trips promote student learning and engagement. *Journal of Geoscience Education*, 67(2), 146–165.
- Messaoudi, L. (2016). La fracture linguistique dans l'enseignement scientifique au Maroc : quelles remédiations ? *Langues, cultures et sociétés*, 2(1), 69–85.
- Monchamp, A., & Sauvageot-Skibine, M. (1995). Du fixisme à la tectonique des plaques. Et pourtant elles bougent. *Aster*, 20, 4–20.
- Mwangi, P., Ochieng, R., & Ndirangu, M. (2026). Addressing misconceptions about geological time using digital timelines in Kenyan secondary schools. *International Journal of Science Education*, 48(2), 201–219.
- Orange, D. (2003). *Utilisations du temps et explications en sciences de la Terre par les élèves de lycée : étude dans quelques problèmes géologiques* (Doctoral dissertation). Université de Nantes.
- Pedrinaci, E. (2014). La geología en la educación secundaria: situación actual y perspectivas. *Macla*, 14, 32–37.
- Preston, C., Moffatt, A., & Howarth, R. (2020). Reshaping residential field courses: Reducing carbon footprint while maintaining learning outcomes. *Geoscience Communication*, 3, 1–15.
- RCETP (Regional Center for Education and Training Professions). (2015–2023). *Internal evaluation reports on LES teacher training*. Beni Mellal.
- Roca, N., & Garcia-Valles, M. (2020). Trainee teacher experience in geoscience education: Can we do better? *Geoheritage*, 12, 88.
- Sayad, A., Boutkhil, L., Bouali, A., & El Meskin, F. (2014). Obstacles d'enseignement des sciences de la terre au secondaire collégial et qualifiant au Maroc. *Arabian Journal of Earth Sciences*, 1(4), 1–15.
- Steer, D. N., Knight, C. C., Owens, K. D., & McConnell, D. A. (2015). Challenging students' ideas about Earth's interior structure using a model-based, conceptual change approach in a large class setting. *Journal of Geoscience Education*, 63, 1–12.
- Trend, R. (2000). Conceptions of geological time among primary teacher trainees. *International Journal of Science Education*, 22, 1–15.
- University of Trieste. (2022). *BSc in Georesources and Georisks – Programme evaluation report*. Trieste.

Volpoet, P. (1994). Démarches innovantes. Biologie-Géologie, séquences centrées sur un obstacle. *Aster*, 19, 1–15.

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