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Perceptions of secondary life and earth sciences teachers on ecology education at middle and high school levels

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Abstract The objective of this study is to explore and analyze the perceptions and opinions of teachers in the Secondary Education Cycle (Middle and High School levels) relating to the teaching of ecology. It also aims to raise the difficulties and obstacles that stand in the way of teaching this subject. In this end, a questionnaire-based survey was adopted in undertaking the study and collecting the relevant data. The participants in this study are one hundred and forty-six teachers in this cycle. The results obtained reveal that, although the school textbook is mainly intended for students, it is commonly used by teachers as a reference in course preparation (59.31%), although the majority (97.26%) consider it insufficient. A significant proportion of respondents indicate that they do not conduct practical work (46.58%) and believe that the time allocated to teaching ecology is insufficient (58.90%). Moreover, a significant proportion of teachers (61.64%) report experiencing difficulties in their students' learning of ecology. Similarly, a notable proportion (24.66%) also reports personal cognitive obstacles related to the mastery of this subject. The ecological field trip is considered essential by the majority of teachers (87.59%), however, only a few of them organize it with their students (23.40%). Furthermore, a large number of teachers (81.38%) report not having an ecological field trip guidebook. This study has allowed us to identify several shortcomings in our educational system regarding the teaching of ecology at the secondary level. It is therefore necessary to review training programmes in order to improve teachers' theoretical and practical skills; to develop strategies aimed at further stimulating student engagement in learning (practical work and ecological field trips) and to create a guidebook clearly outlining the activities to be carried out by students during the ecological field trip.

Keywords: perception, teaching of ecology, teachers, educational system

1. Introduction

Ecology, according to Haeckel's definition (1866), is the science that studies the interactions between organisms and their environment as a whole. It focuses on the relationships between living organisms and their environment and is considered a complex and functional system. As a science of biological systems, it also encompasses the study of interactions between different organisms within ecosystems (Duvigneaud, 1974).

Ecology holds a central position in the Life and Earth Sciences curriculum of Moroccan secondary education, both at the middle school and qualification cycles. This disciplinary component focuses on the relationships between living organisms and their biotope, the ecological factors influencing these interactions, and the flow of matter and energy and natural balances. It also addresses issues related to water, including its exploitation, pollution, and conservation, as well as the need to protect natural balances, emphasizing the link between health and the environment (Official Instructions and Programmes for the Teaching of Life and Earth Sciences in College (1) and High School (2), 2007).

In order to achieve the educational objectives associated with ecology, field trips play a crucial role in enhancing students' learning experience. These excursions not only complement the lessons learned in class but also allow students to apply the knowledge acquired at school in real-world contexts. Moreover, they provide students with an opportunity to experience life outside the classroom, offering them a direct connection with the scientific concepts being studied. In other words, "They give meaning to learning by placing students in direct contact with the scientific concepts being studied" (Jacquet, 2021).This not only addresses educational objectives but also fosters a sense of responsibility among students regarding current and future ecological challenges. The inclusion of these themes in educational programs reflects a commitment to cultivating a generation that is aware of environmental challenges and equipped to act in favor of ecosystem preservation.

However, several studies have demonstrated that students face challenges in floristic and faunal classifications—an essential aspect of understanding ecosystems and biodiversity—as well as in learning other topics, such as immunity and

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geology (Kaid Rassou et al., 2017; Maskour et al., 2019; Haiki et al., 2020). Furthermore, another study on the impact of ecological field trips among secondary school students revealed that they face difficulties in assimilating the ecological concepts covered in class (Haddad, 2024). Given these student challenges, it is essential to investigate how teachers perceive and address these issues in their teaching of ecology.

Teachers, as key figures in the transmission of knowledge, face various challenges, the most significant of which is the lack of foundational training in the subject matter (Maskour et al., 2019). This training deficit can have a notable impact on their classroom practice and affect the quality of the instruction provided. This challenge underscores the importance of addressing the issue, which is why we undertook this study with Life and Earth Sciences teachers. The primary objective of our research is to explore and gain a deeper understanding of their perceptions regarding the teaching of ecology, as well as to identify the challenges and problems they encounter that may hinder the effective transmission of knowledge in the classroom.

2. Materials and methods

This section is devoted to the introduction of the research design and the description of the participants, data collection tool and data analysis process.

In this study, we have opted for a descriptive analytical approach. To this end, we conducted a survey with a group of teachers.

2.1. Participants

For the participants, we chose teachers from both middle and high school education levels. A sample of 146 teachers was invited to participate voluntarily by completing our questionnaire.

2.2. Data collection tools

We chose to use a questionnaire as the primary data collection tool. This choice is justified by its ability to facilitate the comparison of teachers' responses to various aspects related to the teaching of ecology.

The questions structuring the questionnaire were based on our research team discussions and on previous works in the field (kaid rassou et al., 2017, Aidoun et al., 2016). Some specialists analyzed the coherence and relevance of the questions to the research objectives.

The questionnaire consists of 31 questions addressing various items to collect the maximum amount of information. These items are as follows:

1. General information for identifying teachers (academy, delegation, and years of experience) (Q1 to Q3).
2. The educational materials used by teachers (Q4–Q7)
3. Availability of teaching resources (Q8–Q12)
4. Teachers' perceptions of ecology teaching (Q13–Q20)
5. Teachers' perceptions of students' affinity with ecology (Q21–Q25)
6. The ecological field trip and the guidebook (Q26–Q31)

2.3. Data processing technique

Statistical analysis was performed via SPSS software version 25. The results are presented as percentages. The chi-square test was used to determine whether the differences between the observed and expected frequencies in the categorical data were statistically significant.

3. Results and Discussion

3.1. Information about the surveyed teachers

In this section, we present data concerning the academies, the delegations, and the seniority of the surveyed teachers (Tables 1, 2, and 3).

The majority of teachers participating in this study belong to the Tangiers-Tetouan-Al-Hoceima Regional Academy (62.33%). The remaining academies are represented by percentages of less than 10% each (Table 1).

With respect to the delegations (Table 2), the majority of the respondents (47.9%) are from the Tangier-Asilah delegation, whereas 6.2% are from Al Hoceima. The remaining 45.9% corresponds to other delegations from the various academies presented in Table 1.

This distribution in favor of the northwestern region of Morocco is attributed to the fact that the questionnaire was primarily distributed in the Tangier-Tétouan-Al Hoceima region, which is the area of my work as a teacher.

The seniority of the teachers participating in this study (Table 3) offers a valuable perspective on their level of expertise within the field of education. The descriptive analysis of our sample revealed a diversity of profiles. Nearly 60% of the

participants had less than 10 years of experience, approximately 30% had between 10 and 20 years of experience, and only 13% had over 20 years of expertise.

Table 1 Academies of origin of the survey participants.

Q1- Academy (N=146)	Number	Percentage
Tangier-Tetouan Al Hoceima.	91	62,3
Fes-Meknes.	13	8,9
Casablanca Settat	12	8,2
Souss Massa	7	4,8
Beni Mellal - Khenifra	6	4,1
Marrakech-Safi	6	4,1
Oriental – Oujda	4	2,7
Rabat-Salé- Kenitra	3	2,1
Daraa Tafilalet	2	1,4
Guelmim - Oued Noun	1	0,7
Laayoune-Boujdour-Sakia ElHamra	1	0,7
Total	146	100%

Table 2 Delegations of the teachers participating in the study.

Q2-Delegation (N=146)	Number	Percentage
Tangier- Asilah	70	47,9
AlHoceima	9	6,2
others	67	45,9

Table 3 Seniority of the teachers participating in the study.

Q1- Seniority (N=146)	Headcount	Percentage
Less than 10 years	86	58,9
Between 10 and 20 years	41	28,1
More than 20 years	19	13,0

3.2. Educational and teaching materials used by teachers

3.2.1. Educational materials used by teachers

To identify the bibliographic resources used in preparing a biology lesson, we structured four questions for the respondents. The results are presented in Figure 1 (a, b, c and d).

Question Q4 (Figure 1.a: Bibliographic resources used), a multiple-choice question, identified three primary bibliographic resources employed by secondary education teachers for preparing biology lessons: the internet (36.36%), textbooks (33.99%), and reference books (26.88%).

These results suggest that the use of the internet plays a significant role in the resources utilized by teachers. The same results were reported in a study on the teaching of geology in Morocco (kaid rassou et al., 2017). Currently, the internet serves as a crucial technological tool, offering an extensive array of multimedia resources and educational materials that are accessible to educators (Damaskou, 2011). However, the integration of this tool for educational purposes does not seem to have elicited widespread engagement from the majority of educators within the Moroccan educational system, despite its recognized role in the modernization and general enhancement of teaching practices. Comparable results have been reported by other researchers in Benin (Daye et al., 2015).

The response rate to question Q5 (Figure 1-b: manual used) was 44.20%. Among the 86 teachers who use the manual as a bibliographic resource, 66 (76.74%) responded to this question, with the majority (83.33%) using the Fi Rihab SVT manual.

The textbook is also used as a bibliographic reference in course preparation by teachers, even though this educational resource is designed primarily for students, not for teachers (IGEN, 1998). However, Figure 1-c shows the results of Q6 (Is the textbook sufficient to prepare a lesson?), reveals that 97.26% of the teachers believe that the textbook is insufficient for adequately preparing a science lesson, which seems contradictory. From Figure 1-d (Q7: Why is the textbook insufficient?), it appears that the major issue is the insufficiency of its content (47.77%), followed by the poor quality of its illustrations (tables, figures, photos, diagrams, etc.) at 44.13%. The presence of errors and the lack of references were represented by lower percentages. Teachers surveyed in another study regarding geology curricula also expressed their dissatisfaction with the textbook (Kaid Rassou et al., 2017). These results clearly indicate that it would be highly beneficial to adopt and develop an appropriate textbook with curricula tailored to secondary education.

Proper course preparation requires diversifying the teacher's resources (Gueudet & Trouche, 2010). The teacher must create their own teaching tools, such as lesson plans or instructional materials, by drawing on their knowledge, experience, training, readings, and available resources (Leroyer, 2013).

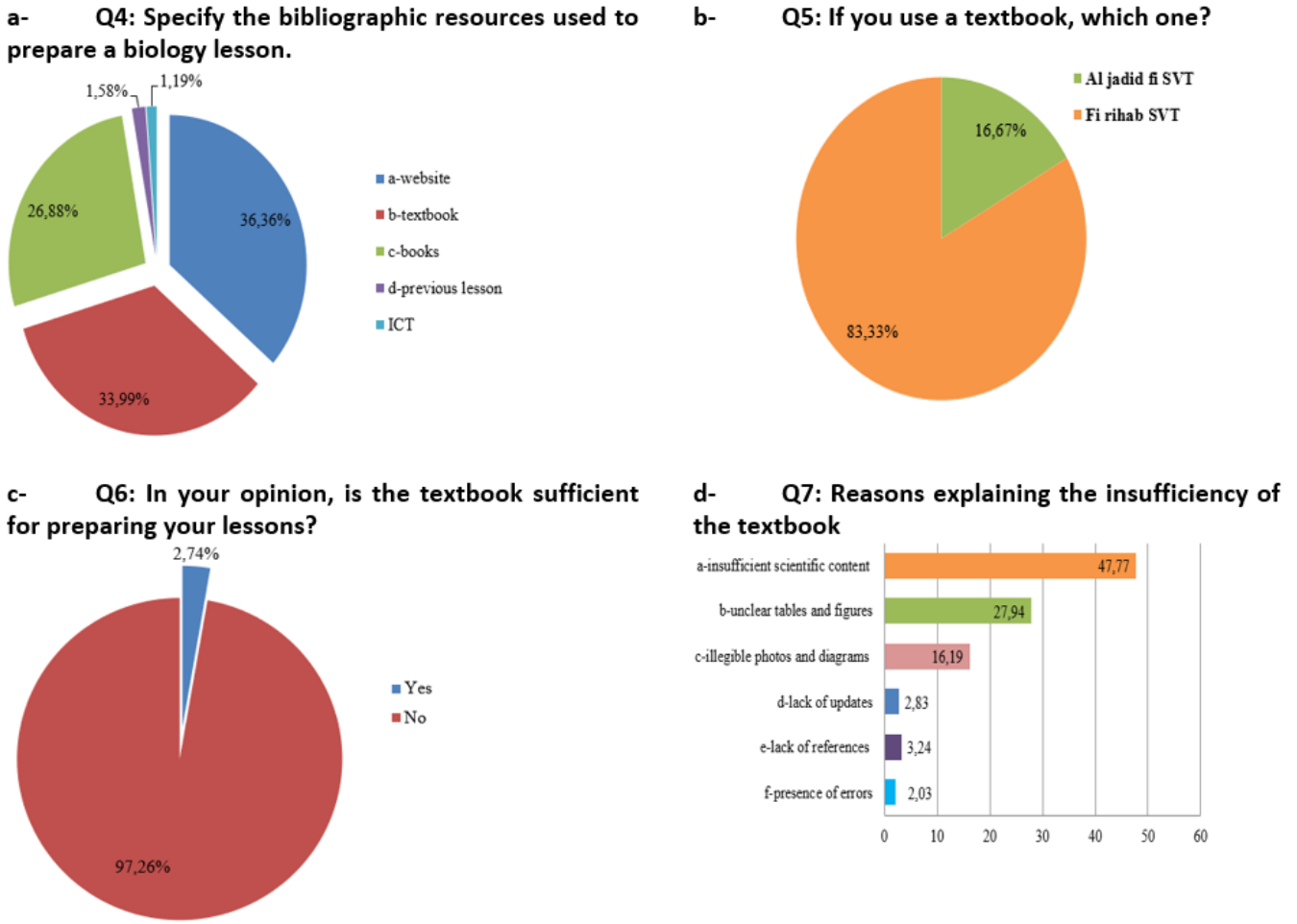

Figure 1 Educational materials used by teachers to prepare a biology lesson (a: Q1, b: Q2, c: Q3 and d: Q4).

3.2.2. Teaching materials used by teachers

To identify the teaching materials used during the presentation of a Life and Earth Sciences lesson, we designed five questions for the respondents. The results are shown in Figure 2 (a, b, c, d, and e).

Regarding the instructional materials used by life and earth sciences teachers (Q8, Figure 2.a), the projector is the most commonly used (27,9%), followed by the whiteboard (25,25%). The use of projectors appears to enhance the comprehensibility of knowledge for students by integrating information and communication technologies (ICTs) to enhance the quality of information (Anoumou, 2006).

Experimentation is used by only 19.64% of teachers, which may negatively impact practical sessions, a component of the official instructions and programs for life and earth sciences education. Indeed, experimental activities, also referred to as practical work, play a crucial role in education. They provide an ideal setting for learning the experimental approach, which involves introducing students to the use of tools in life and earth sciences, thereby stimulating their motivation (Wialle, 1999).

Moreover, in Morocco, the official instructions, textbooks, and those responsible for curriculum development emphasize the importance of experimental practice in the teaching of experimental sciences (The National Charter for Education and Training, 1999).

In contrast, the results obtained in our study regarding the availability of a practical laboratory room (Q9, Figure 2.b) show that one-third of the Life and Earth Sciences participating in this study work in institutions that do not have a practical laboratory room. This hinders the selection of experimental materials as teaching resources in life and earth sciences education. Furthermore, 53.42% of the teachers did not conduct practical work (Q10, Figure 2.c: Do you conduct practical sessions?). Similarly, the majority of teachers who conduct these practical sessions (72.22%) state that this activity accounts for only 25% of the planned practical work (Q11, Figure 2.d: Estimate the approximate percentage of practical work conducted?). This is due to other obstacles aside from the availability of a practical laboratory room (Q12, Figure 2.e: If you do not conduct practical work, specify the reasons.). These include a lack of scientific equipment (50.92%), overcrowded classrooms (30.67%), and insufficient time (18.40%). These results corroborate those of Turki (2012). The lack of hands-on activities and concrete observations may be the cause of various difficulties related to the teaching and learning of certain concepts in ecology.

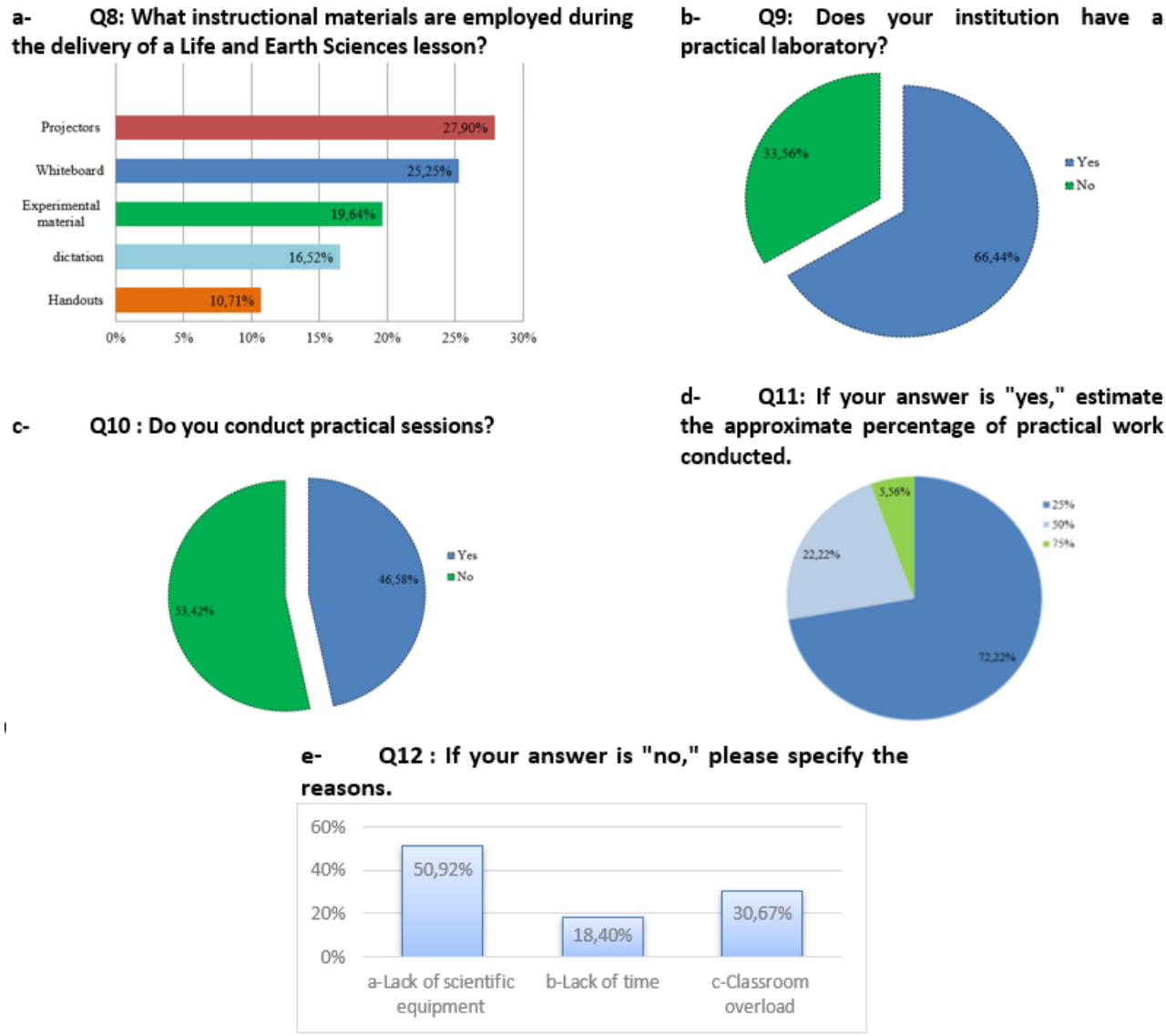

Figure 2 Teaching materials utilized by educators for lesson presentation (a: Q8, b: Q9, c: Q10, d: Q11 and e: Q12).

To examine the relationship between the availability of a practical laboratory room and the conduct of practical sessions, the results are presented below (Table 4).

Table 4 Relationship between the availability of a practical laboratory room and the conduct of experimentation.

		Do you conduct practical sessions?		Total	CHI2	P value
		No (53,42%)	yes (46,58%)			
Does your institution have a practical laboratory room?	No	44,9%	20,6%	33,6%		
	yes	55,1%	79,4%	66,4%	9,61	0,002

Table 4 clearly shows that nearly 80% of teachers who conduct practical sessions with their students work in institutions that have a practical laboratory room. In contrast, nearly half of the teachers who do not conduct these experimental activities work in institutions that do not have a practical laboratory room. This result is statistically significant (Chi2 = 9.61; p = 0.002) and indicates that the presence of a dedicated laboratory room represents a significant challenge for improving the teaching of ecology at the middle and secondary education levels.

3.3. Teaching of ecology by Life and Earth Sciences teachers in middle and secondary education

3.3.1. Evaluation of pedagogical practices in the teaching of ecology

In this section, the results obtained regarding the teaching of ecology are presented. Five questions from our questionnaire were specifically designed to address this area, thereby clarifying various aspects related to the instruction of this topic.

We surveyed the teachers about their academic background to determine whether they had received training in ecology. The results are presented in Figure 3.

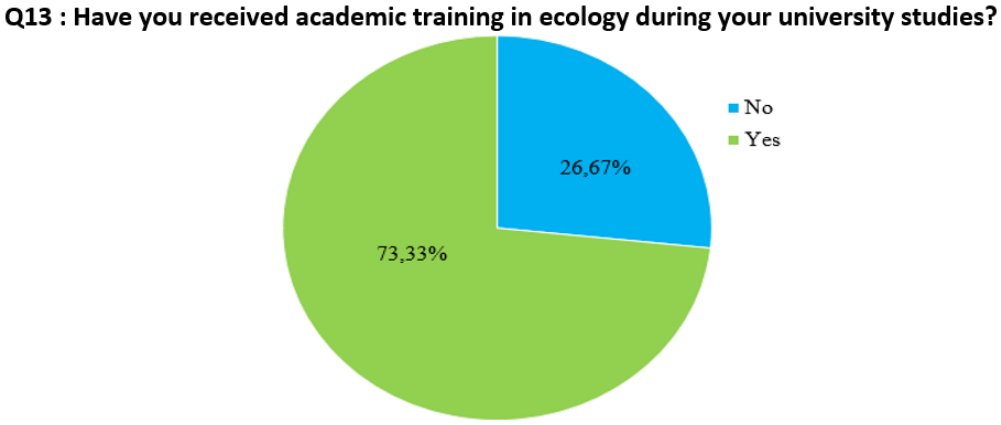

Figure 3 Evaluation of academic training in ecology among the surveyed teachers.

On the basis of the results regarding academic training in ecology (Q13, Figure 3), approximately one quarter (26.67%) of the surveyed teachers did not receive any academic training in ecology during their initial education. In a study addressing plant classification, the percentage of teachers who did not receive training during their university studies was greater (53%) (Maskour et al., 2019).

The absence of specific training in ecology among teachers may have a negative impact on their motivation and skills, which could, in turn, affect their effectiveness when teaching this topic.

We then surveyed the participants to determine whether they had taught ecology. The responses to these questions are presented in Table 5.

The results (Table 5) indicate that the majority of teachers (93.15%) are involved in teaching this subject, with only a minority not participating (6.85%). This result is statistically significant (Chi2 = 108.740; $p < 0.001$) according to the chi-square test.

Table 5 Teaching of ecology by the surveyed teachers.

Q2 : Do you currently teach or have you ever taught the topic of ecology? (N=146)	Headcount	Percentage	Chi2	P value
No	10	6,85	108,740	<0,001
Yes	136	93,15		

To determine whether the time allocated to this topic is appropriate for its content, we posed question 15. The results obtained are presented in Table 6.

Table 6 Teachers' opinions on the time allocated to ecology.

Q3 : Do you think the time allocated to the topic of ecology is sufficient? (N=146)	headcount	Percentage	Theoretical headcount	Chi2 (p value)
No, insufficient	86	58,90	73	4,630
Yes, sufficient	60	41,10	73	(0,031)

The results (Table 6) show that more than half of the surveyed teachers (58.90%) reported that the time allocated to teaching this topic was insufficient. This percentage is statistically significant (Chi2 = 4.630; $p = 0.031$). This leads us to reconsider the time allocated to this topic.

Given the crucial role of ecological field trips and the importance of practical work in teaching this topic, we surveyed the teachers on these aspects.

Their responses are illustrated in the following figures (Figure 4, a and b).

A field trip is a planned excursion of a group of students outside the school premises, for a specified duration, with the aim of developing practical skills and enriching learning beyond the classroom context (Colombet, 2012). The responses obtained to question Q16 (Figure 4.a: Necessity of the ecological field trip) revealed that the majority of the teachers affirmed the essential nature of the ecological field trip (87.59%). Indeed, field trips provide opportunities and environments conducive to the acquisition of knowledge (MIN.E.S.E.B., 2001). They incorporate pedagogical and didactic activities via innovative approaches and appropriate tools to achieve established educational objectives (French Ministry of National Education, 2005).

Observation and experimentation are essential tools for fostering research and hands-on engagement and stimulating students' curiosity and motivation. These activities lead to increased interest and a better understanding when students are confronted with concrete situations where they can interact directly (Najoui et al., 2017). In contrast, the results presented in

Figure 4.b regarding question Q17 (Conducting practical work in ecology) show that 53.79% of the teachers who participated in this study did not conduct practical work in ecology. This may have a negative impact on the assimilation of ecological concepts by students. Similar results were reported in a study addressing the teaching of geology in Morocco (Kaid Rassou et al., 2017).

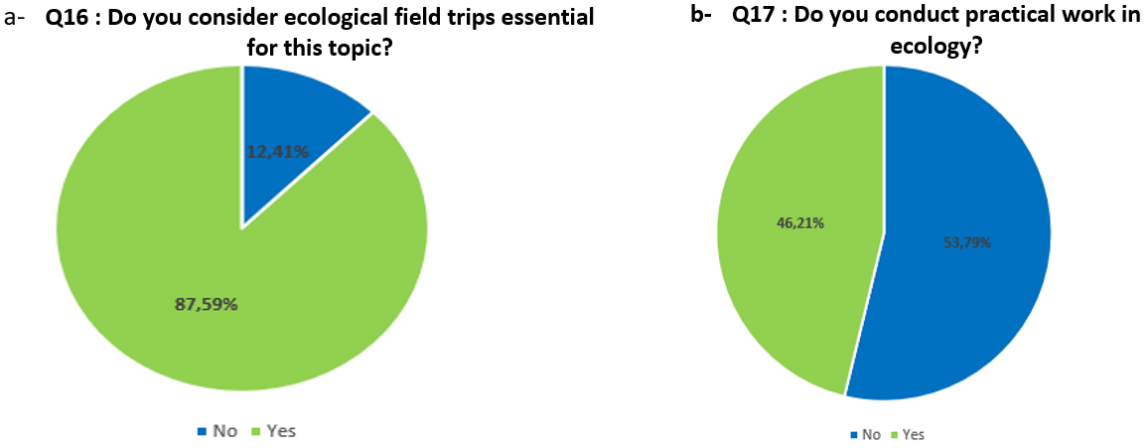

Figure 4 Teachers' opinions on the necessity of ecological field trips and practical work in ecology (a: Q16 and b: Q17).

3.3.2. Challenges encountered by teachers in ecology and the proposed solutions to address them

In this section, we attempt to identify the challenges faced by teachers in teaching ecology by exploring the nature of these obstacles. The results obtained are presented in Figure 5 (a and b).

Regarding the response to question Q18 (Figure 5.a: difficulties related to ecology), nearly a quarter of the teachers who participated in this study experienced difficulties related to ecology. It appears that the lack of up-to-date scientific references is the major issue encountered by the surveyed teachers (Q19, Figure 5.b: nature of the difficulties encountered). The complexity of the concepts and the insufficient foundational training in ecology represent a cognitive barrier for half of the surveyed teachers. Another study on teaching geology revealed that teachers also face various types of knowledge-related difficulties in teaching this discipline (Kaid Rassou et al., 2017).

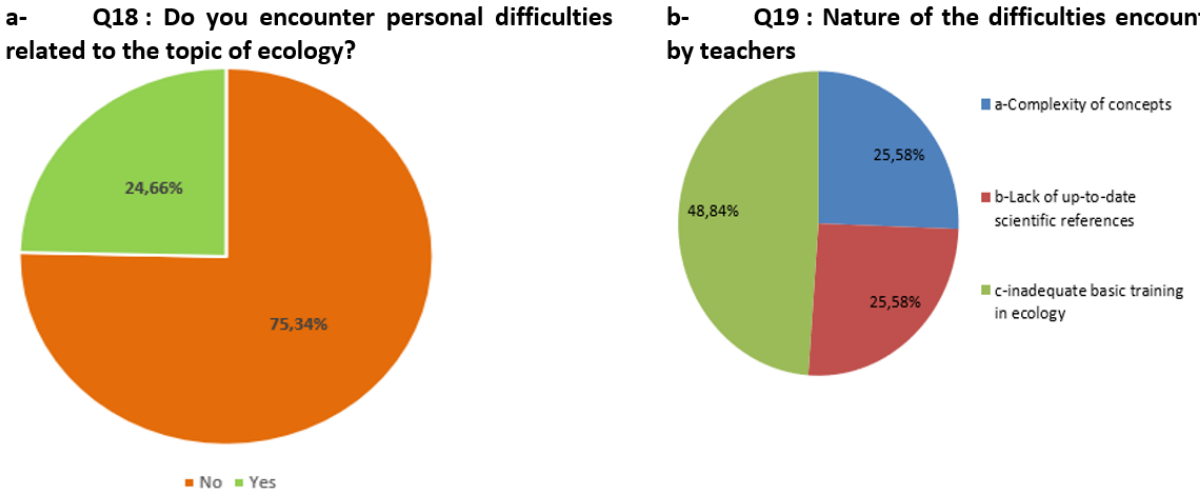

Figure 5 Evaluation of the difficulties encountered by teachers and their nature (a: Q18 and b: Q19).

These results suggest that obstacles that may hinder effective learning are present not only among students but also among their teachers, which can negatively affect the didactic interaction between the teacher and the learner.

We also asked the participants to propose solutions that could help overcome the difficulties encountered in ecology (Table 7).

Table 7 Solutions proposed by teachers to overcome the difficulties encountered.

Q4 : If you encounter difficulties in ecology, what solutions would you propose to overcome them? (N=126)	Headcount	Multiresponse percentage	Percentage (valid)
a- Equip school libraries with up-to-date ecological references.	58	60,4	46,03
b- continuous professional development in ecology	68	70,8	53,97

The results presented in Table 7 show that the surveyed teachers highlighted "continuous professional development in ecology" (53.97%) as a solution to help them overcome the difficulties encountered in this area, followed by "equipping school libraries with up-to-date ecological references," which also represented a significant percentage (46.03%). Comparable results were observed in another study conducted among teachers of plant classification, where nearly 75% of the surveyed teachers identified the need for continuous professional development to overcome the challenges encountered in teaching this topic (Maskour et al., 2019). Indeed, continuous professional development is considered a tool that enables teachers to enhance their skills, improve their qualifications, and increase their effectiveness to adapt to current technological and organizational developments (Elhalimi, 2020). It primarily contributes to the success of learning (Altet, 1994).

To verify the relationship between the number of hours allocated to ecology in the Life and Earth Sciences curriculum for secondary education (Collégial and Qualifiant) and the difficulties encountered by teachers, we examined the interactions between the two corresponding questions (Table 8).

Table 8 Relationships between the difficulties encountered by teachers and the number of hours allocated to ecology.

		Do you encounter personal difficulties related to the topic of ecology?			CHI2	P
		No (75,34%)	Yes (24,66%)	Total		
Do you find the number of hours allocated to the topic of ecology sufficient?	No, insufficient.	50,0%	86,1%	58,9%	14,6	0,001
	Yes, sufficient.	50,0%	13,9%	41,1%		

The results presented in Table 8 indicate that the majority of teachers who reported experiencing difficulties consider the allocated time for this topic to be insufficient (86.1%). This result is statistically significant according to the chi-square test (Chi2 = 14.6; p = 0.001). The insufficient allocated time for this topic may make teaching more challenging for these teachers and consequently impact the quality of instruction; in such cases, teachers might focus solely on basic concepts without addressing more advanced topics, which could also limit students' understanding.

3.4. Teachers' Perceptions of Students' Interest in Ecology in Secondary Education (Collégial and Qualifiant)

The student, as a learner, is at the center of the educational process in ecology. Through classroom lessons, he is introduced to and interacts with complex concepts such as sustainable development, biocenosis, biotope, climate change, and biodiversity. This theoretical knowledge is often complemented by practical activities, such as projects or field studies, aimed at enhancing students' engagement and fostering a deeper understanding of ecological issues.

In this context, we structured several questions for teachers regarding the students and their relationships with ecology (Table 9).

Table 9 Students' motivation to study the topic of ecology.

Q21 : Do you consider that students are motivated to study the topic of ecology? (N=146)	Observed headcount	Percentage	Chi2 (p value)
I don’t know	19	13,01	119,85(<0,001)
No	16	10,96	
Yes	111	76,03	

The response to the first question in this section (Q21, Table 9) indicates that teachers report that students are motivated to study the topic of ecology. This is highly advantageous and suggests that students are predisposed to understanding the topic of ecology. In another study focusing on secondary-level floristics, 60% of respondents reported that their students are demotivated to study this topic, which negatively impacts their ability to assimilate the lessons (Maskour et al., 2019).

With respect to teachers' perceptions of students' motivation to participate in an ecological field trip, the results obtained are presented below (Figure 6).

The responses to question Q22 (Figure 6.a: Students' motivation to participate in a field trip) revealed that 76% of the teachers believe that students are motivated to take part in an ecological field trip. These results are consistent with those reported in a Moroccan study on plant classification (Maskour et al., 2019).

In the same context, the majority of teachers who participated in this study and conducted the ecological field trip (75%) confirmed that most students were disciplined and actively participated in the execution of the field trip (Figure 6.b). This finding demonstrates that learners value learning outside the classroom. Indeed, in the same study previously cited (Maskour et al., 2019), teachers emphasized that methods promoting student engagement and active participation, such as field trips and practical work, are particularly appreciated by students and prove to be effective for the learning process.

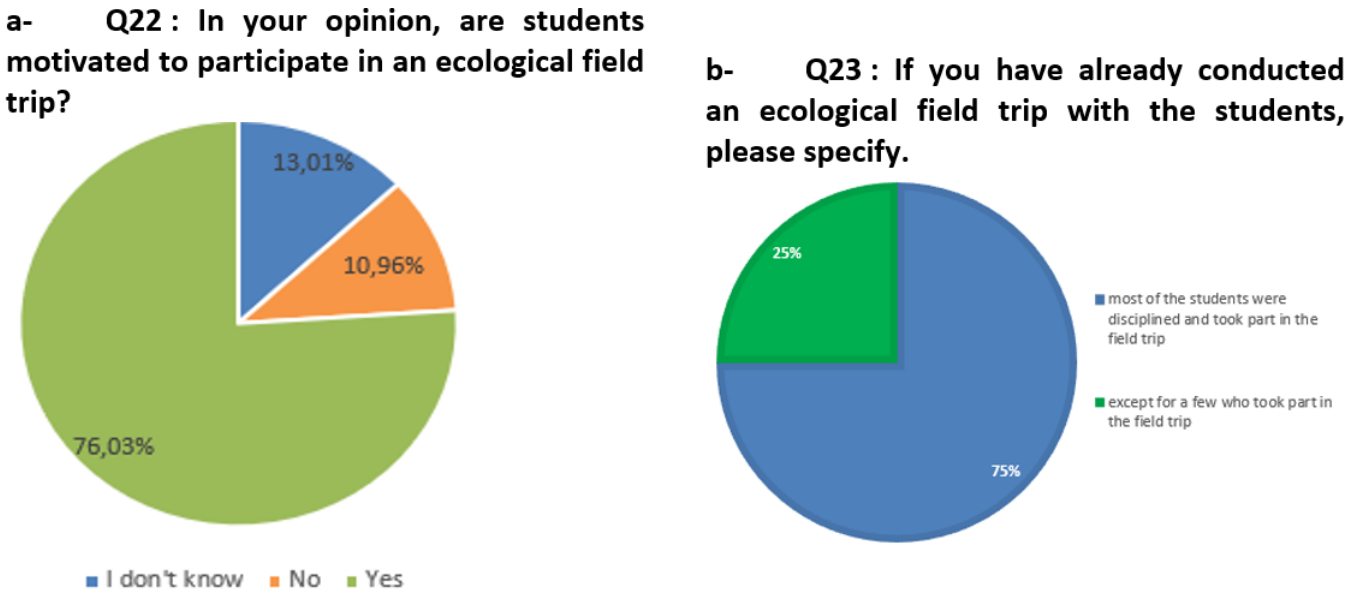

Figure 6 Teachers' perceptions of students' motivation to participate in a field trip (a: Q22 and b: Q23).

However, students may face learning barriers in regard to certain ecological concepts. To verify this hypothesis, we present the following results to assess the presence or absence of difficulties among learners (Table 10).

Table 10 Teachers' perceptions of the difficulties encountered by students in ecology.

Q5 : Do you believe that students encounter particular difficulties in learning ecology? (N=146)	Observed headcount	Percentage	Chi 2 (p value)
No	56	38,36	90,00(0,006)
Yes	90	61,64	

Table 10 shows that 61.64% of the teachers confirmed that students encountered particular difficulties in learning ecology. This result is statistically significant (Chi2=90; p=0.006) according to the chi-square test for a single sample. This situation is not unique to ecology; a study conducted with secondary school students regarding the difficulties encountered in learning physical sciences revealed similar results: 79% of students experienced difficulties during the acquisition of scientific concepts (Nasser et al., 2017). Tamraoui et al. (2017) also reported similar difficulties among students in a study on the learning of geology concepts in Morocco.

The following question in our questionnaire aims to determine the main causes of the difficulties encountered by students. The responses to this question are presented in Table 11.

Table 11 Reasons mentioned by respondents explaining the difficulties encountered by students.

Q6 : If your answer is "yes," what is the main cause? (N=126)	Observed headcount	Multiresponse percentage	Percentage (valid)
a- Complexity of ecological phenomena	47	53,4	34,8
b- Difficult concepts	29	33,0	21,5
c- Too much data to memorize	59	67,0	43,7

Table 11 shows that teachers consider information overload (43.7%) and the complexity of phenomena (34.8%) as the main causes of learning difficulties for their students in ecology. The complexity of the concepts ranks last, with a percentage of 21.5%. In another study conducted in Belgium, students faced similar challenges in learning certain chemistry concepts (Willame et al., 2015). These findings highlight the need for a thorough revision of the ecology curricula in lower and upper secondary education to address identified shortcomings.

To assess the impact of insufficient instructional time on students' understanding, we obtained the results presented in Table 12.

On the basis of the results presented in Table 12, the chi-square test reveals no significant difference (Chi2 = 2.49; p = 0.115) between the responses of teachers who consider the allocated instructional time insufficient and those who do not. Indeed, 66.3% of teachers who report that the allocated time is insufficient assert that students encounter difficulties. Similarly, 53.3% of those who consider the allocated instructional time sufficient share this opinion. These findings suggest that the difficulties encountered by students may be attributable to factors other than the instructional time dedicated to the topic of ecology.

To determine the relationship between the difficulties encountered by the surveyed teachers and those faced by students, we performed the cross-tabulation presented in Table 13.

Table 12 Relationships between instructional time allocated to ecology and students' difficulties.

		Do you find the instructional time allocated to the topic of ecology sufficient?			CHI2		P value
		No (58,90%)	Yes (41,10%)	Total			
Do you believe that students encounter specific challenges in learning ecology?	No	33,7%		46,7%	39,0%	2,49	0,115
	Yes	66,3%		53,3%	61,0%		

Table 13 Relationships between the difficulties encountered by teachers and those faced by students.

		Do you encounter personal difficulties related to the topic of ecology?			CHI2	P
		No (75,34%)	Yes (24,66%)	Total		
Do you believe that students face specific challenges in learning ecology?	No	47,3%	13,9%	39,0%	12,7	0,001
	Yes	52,7%	86,1%	61,0%		

The results presented above indicate that 86.1% of the teachers who faced difficulties related to the topic of ecology also asserted that students encountered challenges in learning ecology. This result is statistically significant according to the chi-square test ($Chi^2 = 12.7$; $p = 0.001$). Teachers experiencing difficulties with ecology may face challenges in conveying complex concepts effectively. This, in turn, may contribute to students' difficulties, particularly when insufficient instructional time is available to provide detailed explanations.

This highlights the need to identify rapid and effective solutions to assist teachers in addressing their challenges. The implementation of continuous professional development programs has emerged as a particularly suitable strategy.

3.5. Organization of ecological field trips and provision of a comprehensive guidebook

3.5.1. Organization of ecological field trips

As highlighted earlier, ecological field trips play a significant role in enhancing students' comprehension and assimilation of studied concepts. This section of the study investigates the challenges associated with organizing such trips, their execution, and their impact on students' understanding. The corresponding results are presented in Table 14.

Table 14 Implementation of ecological field trips by the teachers who participated in the study.

Q7 : Have you conducted an ecological field trip with your students?	Headcount	Percentage	Chi2	P value
No	108	76,60	116,562	<0,001
Yes	33	23,40		

The data presented in this table indicate that only 23.40% of the surveyed teachers conducted an ecological field trip with their students. This result is consistent with findings from other studies on ecology and geology, where more than 75% of teachers reported not organizing field trips with their students (Maskour et al., 2019; Kaid Rassou et al., 2017). This may hinder the proper assimilation of ecological concepts among students, as ecological field trips provide environments conducive to knowledge acquisition (MIN.E.S.E.B., 2001).

We asked teachers to identify the reasons why they did not conduct ecological field trips. The results are presented in Table 15.

Table 15 Reasons cited by teachers for not conducting ecological field trips.

Q8 : If your answer is "no," please specify the reasons.	Headcount	Percentage	Response percentages
a- Lack of time	33	28,9%	14,0%
b- Lack of practical training	29	25,4%	12,3%
c- Fear of potential student accidents	79	69,3%	33,6%
d- Administrative and logistical issues (permissions and transportation)	94	82,5%	40,0%

The results indicate that administrative and logistical challenges represent the primary barrier to conducting ecological field trips, cited by more than 80% of the participants and accounting for 40% of the total responses. These challenges hinder the ability of biology and geology teachers to organize such activities with their students. These challenges encompass issues related to obtaining permissions, managing transportation, and overall organizing field trips. Furthermore, the fear of student accidents (cited by 69.3% of teachers, accounting for 33.6% of the responses) appears to be a significant barrier to the implementation of ecological field trips. This issue could be mitigated through training in risk management, enhanced insurance coverage, and the establishment of clear safety protocols. A lack of time was selected by 28.9% of the teachers, accounting for 14% of the total responses. This suggests that, despite the challenges of busy schedules, other factors may play a more significant role in the decision not to organize these field trips. Finally, a lack of practical training was selected by 25.4% of the teachers (12.3% of the total responses). While it does not appear to be the primary cause, a quarter

of the teachers feel that they lack the practical skills necessary to organize ecological field trips. This highlights the need for additional training, specifically focused on field trips, to increase teachers' confidence in managing such activities.

These observations are consistent with the work of Sanchez et al. (2005), who demonstrated that teachers organizing field trips encounter difficulties in implementing onsite scientific investigation activities. Similarly, Maskour et al. (2019) reported similar findings.

To understand the aspects addressed during the organization of an ecological field trip and assess their impact on student learning, we formulated questions Q28 and Q29, the responses to which are illustrated in Figure 7 (a and b).

Figure 7.a (Q28: What aspects are studied during the field trip?) This clearly indicates that the majority of the participating teachers (76%) who organized ecological field trips with their students focused on the study of animal and plant ecology in the field. However, 22% of these teachers reported studying only plant ecology, whereas 2% focused solely on animal ecology. This can be attributed to the lack of foundational training in the teachers' educational background, which may result in limited competence, as postulated by Maskour et al. (2019). Such deficiencies could negatively affect students' understanding of certain ecological aspects during field trips.

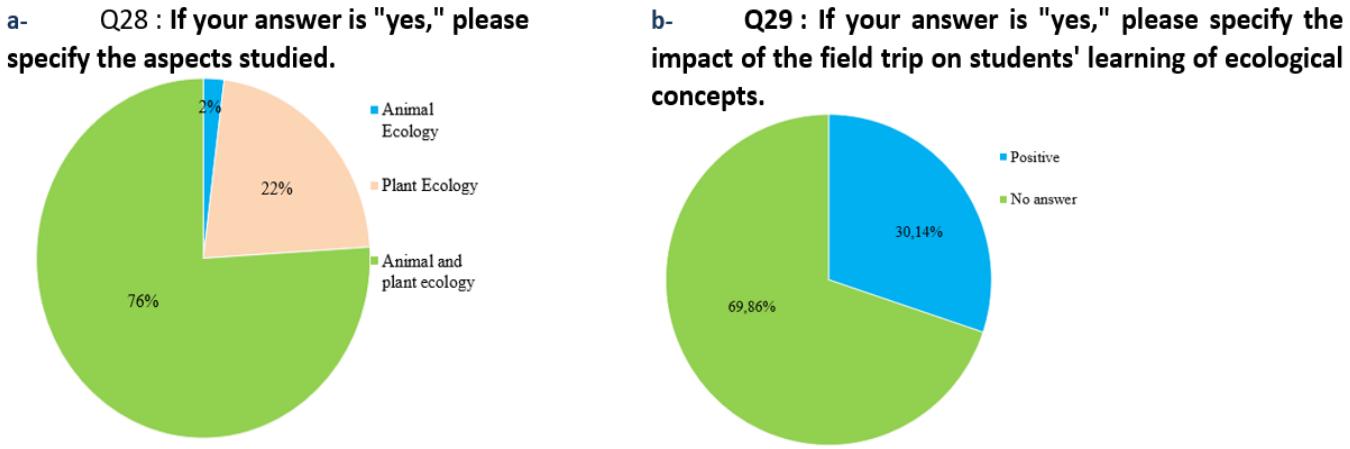

Figure 7 Aspects studied during the ecological field trip and their impact on students' learning (a: Q28 and b: Q29).

Regarding the impact of the field trip on students' learning (Q29, Figure 7.b), only 30.1% of the surveyed teachers responded to this question, all of whom affirmed that the ecological field trip has a positive effect on students' understanding of ecological concepts.

Indeed, the ecological field trip plays a crucial role in the acquisition of skills and knowledge targeted by education, providing students with a practical and immersive experience that complements classroom learning (French Ministry of National Education, 2005).

3.5.2. *Availability of an ecological field trip guidebook for the surveyed teachers*

An ecological field trip guidebook provides teachers with valuable resources and practical recommendations, contributing to the success of the field trip. We surveyed the participants regarding their access to such a guidebook during the execution of the field trip and its perceived usefulness (Figure 8 (a and b).

The results revealed that the majority of teachers who participated in this study (81.38%) did not have an ecological field trip guidebook (Q30, Figure 8.a). In fact, the absence of a well-structured ecological field trip guidebook can limit the educational effectiveness of field activities because of less rigorous planning and inadequate preparation, thereby reducing the quality of trips and their impact on students' learning. Furthermore, the majority of teachers (85.59%) confirmed the usefulness of the guidebook during the field trip, recognizing its importance in structuring and coordinating the activities planned onsite (Q31, Figure 8.b).

On the basis of these results, it is crucial to prepare a well-structured ecological field trip guidebook that outlines the various stages of the trip, with the aim of enhancing the effectiveness of this activity in students' learning.

To determine whether the availability of a field trip guidebook facilitates the execution of this activity, we examined this interdependence (Table 16).

The results presented in Table 16 indicate that 81.4% of the teachers who did not have access to the guidebook did not conduct the ecological field trip with their students. Only 18.6% of the respondents who did not have the guidebook conducted the field trip, whereas 42.9% of those who had the guidebook did and carried out the ecological field trip. This result is statistically significant according to the chi-square test (Chi2 = 7; p = 0.007). These findings highlight the crucial role of the guidebook in the success of the ecological field trip, suggesting the need to develop a more detailed guidebook to optimize its use.

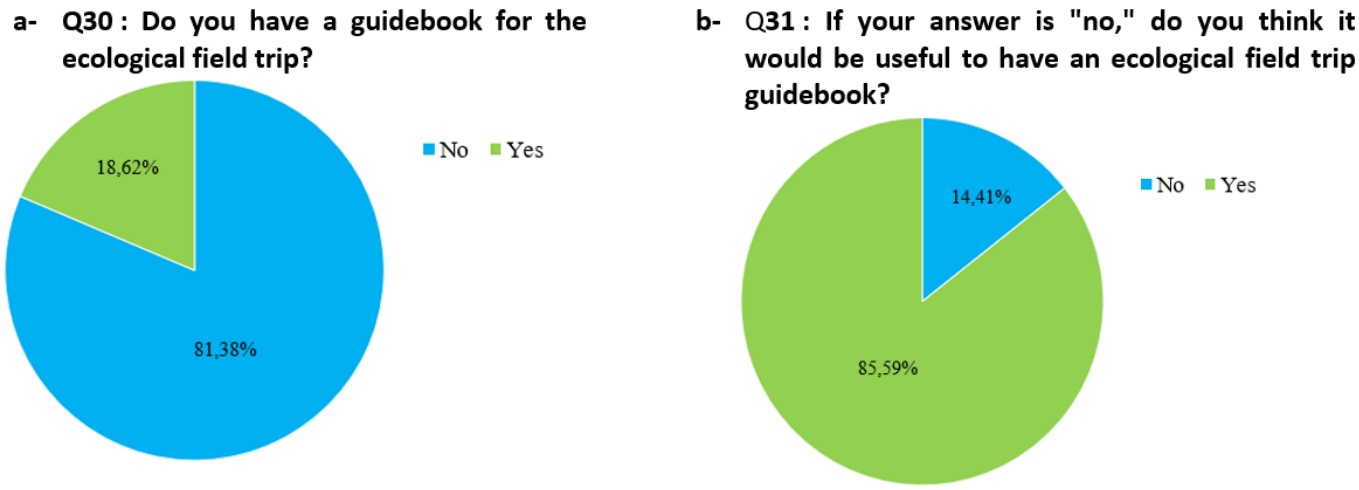

Figure 8 Availability of an ecological field trip guidebook and teachers' opinions on its usefulness (a: Q30 and b: Q31).

Table 16 Relationships between the availability of a guidebook and the execution of the ecological field trip.

		Do you have a guidebook for the ecological field trip?		Total	CHI2	P value
		No (81,38%)	Yes (18,62%)			
Have you conducted an ecological field trip with your students?	No	81,4%	57,1%	76,6%	7,37	0,007
	Yes	18,6%	42,9%	23,4%		

4. Conclusions

The teaching of ecology is a key component of the Moroccan curriculum, requiring special attention to ensure the effective transmission of knowledge. The role of teachers is critical in this process, as they are the primary conveyors of scientific information, and their ability to integrate appropriate pedagogical approaches is essential for the success of this instruction.

In this study, several constraints and difficulties were identified, which may pose obstacles to the teaching and learning of ecology. These challenges can hinder the effective transmission of knowledge in this field. It is therefore crucial to raise awareness among all stakeholders involved in curriculum development while underscoring the importance of continuous professional development for teachers. Such training would facilitate the acquisition of the necessary skills to implement active and hands-on pedagogical methods; additionally, the development of a guidebook for the ecological field trip appears to have a positive impact on this learning process. Furthermore, encouraging the exchange of experiences and innovative practices among various educational stakeholders in secondary education would contribute to creating a stimulating learning environment conducive to both teacher motivation and student success.

Ethical considerations

The teachers were informed about an ongoing study on the education of ecology at the middle and high school levels, emphasizing that participation in this study was voluntary and that their responses would be published anonymously. To ensure confidentiality and anonymity, the questionnaire used in this study was distributed online without requesting any personal information from the teachers, except for the work region and seniority. The purpose of the study is clearly described at the beginning of the questionnaire.

Conflict of interest

The authors declare that they have no conflicts of interest.

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