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ACTIVIDADES CON BIOGRAFÍAS DE GEÓLOGAS: FOMENTANDO VOCACIONES CIENTÍFICAS EN UN CONTEXTO INCLUSIVO

ACTIVITIES WITH BIOGRAPHIES OF WOMEN GEOLOGISTS: FOSTERING SCIENTIFIC VOCATIONS IN AN INCLUSIVE CONTEXT

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Abstract

This paper presents an inclusive didactic proposal aimed at students in the third cycle of Primary Education and/or Compulsory Secondary Education. The importance of showing students, from their initial training, the historical role of

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women scientists and, specifically, the contribution of many women to the understanding and advancement of geology, is exposed. As a method to work on this proposal, the viewing of documentary videos, the reading of biographies of geologists, the discussion of cases and the inquiry by the students on data and images on a group of women scientists and their contributions to geology have been chosen. The selected biographies allow for classroom debate on many aspects to bring geology closer to students and encourage its study in an inclusive context. Finally, a cooperative work is proposed in the form of the realization of a set of posters that collect this information in an organized way and that can be used to carry out an exhibition in the school for Primary Education students. While for Secondary Education students the use of new technologies is proposed, using entries in sciences Blog or social networks controlled by the teacher to publicize the work of each student. This last phase of the work is a means to involve the entire center, both the rest of the students, as well as the teachers, managers, and family members, and even to transcend the local sphere and be able to reach people from anywhere in the world by using new technologies.

Keywords: *Coeducation, compulsory education, geology didactics, inclusive contexts, gender perspective, posters.*

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1. INTRODUCTION

The Royal Decree 157/2022, of 1 March, establishes the organization and minimum teaching requirements for Primary Education. (BOE 52, of 2 March 2022), in its Appendix III states that "Learning situations represent an effective tool for integrating the curricular elements of the different areas through meaningful and relevant tasks and activities to solve problems in a creative and cooperative way, reinforcing self-esteem, autonomy, reflection and responsibility" (p. 108). Moreover, it points out that "learning situations constitute a component that, aligned with the principles of Universal Design for Learning, allows learning to learn and lay the foundations for lifelong learning by promoting flexible and accessible pedagogical processes that adjust to the needs, characteristics and different learning paces of students" (p. 108). Thus, as stated by López (2022), learning situations will allow students to achieve the knowledge required for their educational level, as well as to develop the corresponding competences, including both key and specific competences.

When designing learning situations, teachers should bear in mind that they must be well-structured and oriented towards the achievement of the curricular competences. All of this without losing sight of the fact that they must also be a tool that allows all the diverse range of students to be able to have the same learning opportunities.

Within this context, the aim of this work is to develop a didactic proposal that includes a sequence of teaching-learning activities that, through learning situations, allows students to contextualize the information presented and work with different data coming from the reading of biographies of women geologists, developing tasks that will lead to the elaboration of a final product. This product will be the result (or should be) of the learning process, being this learning focused on aspects not only related to curricular contents, but also to social aspects and the education in values. Producing, therefore, final products by working with biographies of different women geologists will allow us to work not only on the contents related to the geology curriculum, it will also make visible and highlight

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the difficulties that these women (like so many others) had to face at the time when developing their scientific careers.

In view of the above, we consider it of great importance that the biographies and scientific-historical contexts of those men and women who have advanced our knowledge and who, ultimately, have made it possible to improve certain aspects of our lives through their discoveries, are tackled in the classroom. Given that in the bibliography of the last decade it is possible to find some proposals for the classroom that pursue the inclusion of female scientists (Álvarez Lires et al., 2003; Calvo, 2022; Creese and Creese, 1994; Fernández et al., 2006a, 2006b, among other publications), in this work we take a further step towards equality and we want to make visible in the classroom other realities that can also be useful for our students to have references that motivate them and can encourage their future dedication to science. In relation to the latter, we can see how our classrooms are becoming increasingly diverse and multicultural, with pupils having different religious beliefs, different countries of origin, cultures, cognitive and functional abilities, gender identities, etc.

We will contextualize the proposal in the following sections and present some activities that not only allow us to make visible the important role of women in the advancement of geology, but also, due to their personal characteristics, allow us to develop debates on other (in)equalities in our societies, either in the past or in the present. These activities should be taken as suggestions for teaching-learning sequences, but in no case are they intended to be a closed guide, and it will be up to each teacher to adjust the proposal to the reality of their classroom, completing or changing the aspects that they consider appropriate.

2. CONTEXTUALISATION OF THE LEARNING SITUATION:

2.1. THE ROLE OF WOMEN IN GEOLOGY

The progress of human societies has been and is directly related to scientific findings and technological development. Nowadays it is common to see women scientists involved in research, as well as leading scientific projects. Much less

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known and even underestimated is the historical role that many women have played in achieving this knowledge. There are currently many studies that attempt to make visible the contribution of women to social and scientific progress since the first societies were created (Álvarez Lires et al., 2003; Creese and Creese, 1994; Fernández et al., 2006a, 2006b; Magallón, 2004; Manassero Mas and Vázquez Alonso, 2002; Puertas Maroto, 2015). Even though there is still a long way to go, it is undeniable that the situation in some developed countries has improved and there are women in all positions on the research ladder (although there are fewer at the highest levels), the reality is that historically it was not only very complicated to dedicate oneself to science as a woman but also, those who managed to do so faced many men (relatives or work colleagues) having to present their results on their behalf as they were not accepted in scientific societies at the time (Burek and Higgs, 2007). This reality is not a minor issue, as it is not only a question of equality at work or at educational levels, but sometimes it has even had repercussions on women's quality of life and health. For example, the first studies on immunology or clinical trials with various drugs were only carried out with men of a certain age and their results were extrapolated to women and people of other ages. This way of handling data has historically led to errors in diagnoses and treatments by not considering the differences in reference values between women and men and even between individuals of different ages (Álvarez Lires et al., 2003; Puertas Maroto, 2015).

2.2. IMPORTANCE OF HISTORICAL REFERENCES

It is important to highlight the epistemological obstacles that exist in science and especially in geology, as there are deep-rooted social beliefs that can hinder scientific development (García Cruz, 1998); these obstacles perfectly define the existing relationship between science and society. Hence, the importance of including educational methodologies and rigorous scientific content, based on respect and gender equality for a good historical knowledge of the evolution of science. According to the basic ideas of Bachelard (1938) who emphasises the importance of offering a vision of science through the historical aspects that have

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influenced the construction of knowledge (constructivist methodology), we demonstrate the importance of historical knowledge about women researchers as well as how this will have an impact on our students.

Up until recent years, most didactic manuals, textbooks, or documentaries only presented scientific facts, more specifically for what concerns us in this work, geological knowledge. However, rarely did they include any reference to the historical figures (scientists, technicians, explorers, etc.) who had carried out the relevant research to arrive at these observations and scientific knowledge (Jiménez Jiménez, 2009). References to women geologists who had contributed their work and knowledge to the advancement of this science were much more unusual, if not non-existent (Alonso, 2002, 2003; Álvarez Lires and Soneira, 1992; Álvarez Lires et al., 2003; López-Navajas, 2014; Manassero Mas and Vázquez Pérez Rodríguez et al., 2009; Sahuquillo Balbuena et al., 1993; Solís-Espallargas, 2018). Even in the few documents in which references to the geologists appeared, it was by name and in no case were their biographies shown as a way of contextualising their scientific work. The lack of references and contextualisation of scientific (geological) findings is one of the multiple causes of the gradual but constant loss of students in the fields of science and engineering and, particularly, of the lack of female students interested in these fields (Bian et al., 2017; Sáinz, 2017). Some studies highlight gender differences in competitive situations such as geological olympiads and their possible causes (Calonge et al., 2021; Fesharaki et al., 2020). Over the last decade this trend is slowly changing and current textbooks present some examples of men and women who dedicated their lives to the advancement of scientific knowledge. Nonetheless, as is usually the case with everything related to visibilisation, geology is a step behind other sciences such as physics and chemistry and even biology, leaving aside a few exceptions, proposals for the inclusion of a gender approach have not been considered (Fernández et al., 2006a, 2006b). Different studies have shown that students are familiar with those scientists they have heard most about in the classroom and who appear in the media, for example, Albert Einstein or Marie Curie (BBVA Foundation, 2012), and several

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previous studies have highlighted the importance of including the history of science in the teaching of science, helping to humanize this field and show how it is undergoing continuous development, with great value as an option for the future (Moreno and Calvo, 2017; Solbes and Traver, 2001). However, this gender bias is again evident, as well as a bias related to the sciences in which they researched, being more common among physicists/chemists and followed distantly by biologists. The fact of dealing only with knowledge, but not with how, by whom and in what historical contexts this knowledge was constructed, gives pupils a biased, fictitious, and distant image of science. Finally, we can use the arguments presented by Fernández González (2000) for the inclusion of the history of science and its characters in the classroom: it is a way of providing scientific knowledge; it revolves around the human aspect of science; it promotes positive attitudes towards science; it can promote diversity of opinions and ideas through historical scientific debates; it conveys events, methods and scientific evolution itself in an orderly way; and it even helps in the organization of didactic proposals and units.

2.3. Methodological framework

The current educational model is immersed in the teaching-learning process through active methodologies, i.e., those methods, techniques and strategies used by the teacher to convert the teaching process into activities that encourage the active participation of students in their learning process (Labrador and Andreu, 2008).

Among all the methodologies that could be used in the learning situations we propose, we will focus on those that are based on learning through enquiry and cooperative work. Furthermore, in alignment with the indications of the LOMLOE (education law in force in Spain), we must not forget the importance of applying the principles and learning guidelines under the perspective of Universal Design for Learning (UDL; Alba Pator, 2018). Especially, considering that the proposal we are making has among its objectives to serve students with functional diversity and different abilities. According to García-Frank et al. (2020), this type of learning can be easily related to the Sustainable Development Goals, so that, for example, "SDG

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4: 'Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all', will be more easily achievable under the prism of the UDL, since if a didactic proposal is prepared in this perspective it will work in any context and for any person, regardless of their abilities and prior knowledge.

Focusing initially on exploratory and discovery learning, Inquiry-Based Learning (IBL) or Inquiry-Based Science Education (IBSE) in the international scope, we can say that it began to have relevance in the 1960s, but it really came to prominence in the 1990s with the publication of the National Science Education Standards in America (National Research Council, 1996). This teaching methodology has been recommended by national education reports in different countries. In Spain, the expert report ENCIENDE recommends "a rethinking of classroom methodologies towards proposals where enquiry and experimentation of a certain duration play a greater role" (Couso et al., 2011, p. 97).

On the other hand, the Ofsted survey report, which evaluates the strengths and weaknesses of science in primary and secondary schools, indicates that those schools with better results in science subjects and a higher degree of pupil engagement and motivation were those that used more practical methodologies focused on the development of research skills (Ofsted, 2011).

Regarding cooperative learning, there are numerous studies that validate the effectiveness of this type of learning over other more competitive or individualistic ones (Beltrán, 1993; Calvo, 1991). The fact of establishing these methodologies in the classroom is intended to improve the academic results of the students, improving their coexistence, with an improvement in the classroom climate, and not forgetting the special attention to diversity that working under this cooperative premise entails. This encourages respect among students, as well as the acceptance of different opinions and collaboration among peers, not only when it comes to students with specific educational support needs, but to all students in general (Alarcón, 2015; León del Barco, 2002).

As detailed in the section below, we propose a model of activities that allows coeducation, understood not only as teaching boys and girls in the same

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classroom, but also as a model used in the teaching-learning process of geology that places the geologists who have been involved in these findings at the center of the process, contextualizing their research in very different times and social realities in order to awaken a critical vision in our students, in addition to working in inclusive contexts to overcome other inequalities, given that it has been proven on numerous occasions that we can all be interested in and contribute our knowledge to science regardless of our functional or economic characteristics, etc. (García-Frank et al., 2020).

3. DIDACTIC PROPOSAL

3.1. OBJECTIVES OF THE PROPOSAL

The main objective of this work is to propose a learning situation that focuses on the use of biographies and historical-scientific contexts in which various female geologists have developed their work, to show students their importance in scientific advances and to provide female references for female students, awakening scientific vocations.

Social, historical, religious, cultural, etc. realities are introduced in a cross-cutting and complementary way to the teaching of geological aspects, which help to break down stereotypes. Thus, not only examples related to women are presented, but also to races, ideologies, economic and social levels, religions, sexual orientation, or functional and intellectual capacities. In summary, the aim is to provide a holistic view of the development of geology in close relation to the development of human societies. Moreover, students are used to the idea that each subject or field of knowledge is unique and unrelated to the others, partly because of rigid class structures in schools. However, this perception is clearly far from reality, since all knowledge is intimately related, and some influence, enrich or distort the others, so that each clearly has an impact on the others.

3.2. STAGES OF THE PROPOSAL AND RELATION TO THE LOMLOE COMPETENCES

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This proposal is related to the development of various competences, whether they are considered key competences for the educational stages in question or specific competences for the different subjects to which the proposal could be attached. The key competences indicated in the current legislation (LOMLOE) are shown in table 1.

KEY COMPETENCES	Acronyms
Competence in Linguistic Communication	CLC
Plurilingual Competence	PC
Competence in Mathematics, Science and Technology	CMST
Digital Competence	DC
Personal, Social and Learning to Learn Competence	CPSAA
Social and Civic Competences	SCC
Sense of Initiative and Entrepreneurship	SIE
Competence in Cultural Awareness and Expression	CAE

Table 1. List of key competences included in the exit profile specified by LOMLOE for the Secondary Education stages.

The proposal made in this work involves three consecutive phases, which at the same time have different objectives and involve different competences: work with the biographies selected by the teacher; investigative and cooperative work by the students; and finally, the exhibition of the results and their dissemination at school level or without a limit using blogs or social networks.

- First phase: Working with some of the selected biographies (the selected biographies are shown in tables 1 and 2 in the Appendix). The competences to be worked on in relation to the objectives of this phase are summarized in table 2 for Primary Education, while those related to Secondary Education are shown in table 3.

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Objective 1 is to show different fields of geology and their interrelations with other sciences and their social utility (geological risks, industrial and energetic uses of geological materials, knowledge of environmental and climatic changes, etc.).

Objective 2 is to show the personal circumstances of the protagonists of the biographies (by reading biographies or watching documentaries) and their struggle to dedicate themselves to what they loved, which was scientific research.

Objective 3 is to show other circumstances of the protagonists and to discuss the importance of giving opportunities to all human beings, regardless of their sex, religion, culture, race, functional conditions, and physical characteristics, in order to be able to dedicate themselves to science, with emphasis on those who, despite the difficulties, have managed to achieve this.

KEY COMPETENCES	SPECIFIC COMPETENCES	CONNECTION WITH THE DESCRIPTORS OF THE EXIT PROFILE
SIE; CMST; SCC; CLC; DC; CPSAA; CAE.	5. To identify the characteristics of the different elements or systems of the natural, social, and cultural environment, analyzing their organization and properties and establishing relationships between them, in order to recognize the value of the cultural and natural heritage, conserve it, improve it and take actions for its responsible use.	CMST1, CMST2, CMST4, CMST5, DC1, SCC4, CE1, CAE1
	6. To identify the causes and consequences of human intervention in the environment, from the social, economic, cultural, technological, and environmental points of view, to: improve the ability to face problems, seek solutions and act individually and cooperatively in their resolution, and to: put into practice sustainable lifestyles	CLC5, CMST2, CMST5, CPSAA4, SCC1, SCC3, SCC4, SIE1

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	that are consistent with respect, care and protection of people and the planet.	
	7. To observe, understand and interpret continuities and changes in the social and cultural environment, analyzing relationships of causality, simultaneity, and succession, in order to explain and evaluate the relationships between different elements and events.	CLC3, CMST4, CPSAA4, SCC1, SCC3, SIE2, CAE1.
	8. To recognize and value diversity and gender equality, showing empathy and respect for other cultures and reflecting on ethical issues, to contribute to the individual and collective well-being of a society in continuous transformation and to the achievement of the values of European integration.	PC3, CPSAA3, SCC1, SCC2, SCC3, CAE1

Table 2. List of competences to be worked on in the first phase for the area of Knowledge of the Natural, Social and Cultural Environment in Primary Education, with the development of the specific competences (according to the LOMLOE and RD 157/2022) and the connection with the descriptors of exit profiles.

KEY COMPETENCES	SPECIFIC COMPETENCES	CONNECTION WITH THE DESCRIPTORS OF THE EXIT PROFILE
CLC; SIE; SCC; DC; CPSAA.	2.3. To value the contribution of science to society and the work of people dedicated to it regardless of their ethnicity, gender, or culture, highlighting and recognizing the role of women scientists and understanding research as a collective and interdisciplinary task in constant evolution.	CLC3, CMST4, DC1, DC2, DC3, DC4, DC5, CPSAA4
	5. To analyze the effects of certain actions on the environment and health, based on the fundamentals of biological	CMST2, CMST5, DC4, CPSAA1, CPSAA2, SCC4,

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	and earth sciences, to promote and adopt habits that avoid or minimize negative environmental impacts, are compatible with sustainable development and allow for the maintenance and improvement of individual and collective health.	SIE1, SCC3
	6. To analyze the elements of a specific landscape valuing it as natural heritage and using knowledge of geology and earth sciences to explain its geological history, to propose actions aimed towards its protection and to identify possible natural hazards.	CMST5, DC1, SCC4, SIE1, CAE1

Table 3. List of key and specific competences (according to LOMLOE and RD 217/2022), along with the descriptors of the exit profile to be worked on for the area of Biology and Geology in Compulsory Secondary Education (ESO in Spanish) in the first phase.

- Second phase: students search for a different female geologist from the ones they have worked with in the classroom and obtain biographical and scientific data, images, etc. During this phase, the students, divided into groups, will work cooperatively to present the information to the teacher, who will make some initial suggestions that will allow them to choose the most important aspects to be included in the poster (Primary Education) or in a sequence of entries in the Department's Blog or social network created for this purpose by the teacher (Secondary Education). The competences to be worked on related to this phase in Primary Education are summarized in table 4, while those related to Secondary Education are shown in table 5.

KEY COMPETENCES	SPECIFIC COMPETENCES	CONNECTION WITH THE DESCRIPTORS OF THE EXIT PROFILE
CLC; DC; CPSAA;	1. To use digital devices and resources	CLC3, CMST4,

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CAE; CMST; SCC.	safely, responsibly, and efficiently, in order to search for information, communicate and work individually, in teams and in networks, and to rework and create digital content according to the digital needs of the educational context.	DC1, DC2, DC3, DC4, DC5, CAE4
	2. To raise and answer simple scientific questions, using different techniques, instruments and typical models of scientific thought, in order to interpret and explain facts and phenomena occurring in the natural, social and cultural environment.	CLC1, CLC2, CLC3, CMST2, CMST4, DC1, DC2, SCC4

Table 4. List of key and specific competences (according to LOMLOE and RD 157/2022), as well as their connection with the descriptors of the exit profile to be worked on in the second phase for the area of Knowledge of the Natural, Social and Cultural Environment in Primary Education.

KEY COMPETENCES	SPECIFIC COMPETENCES	CONNECTION WITH THE DESCRIPTORS OF THE EXIT PROFILE
CLC; DC; SIE; CPSAA; CAE; CMST.	1. To interpret and transmit scientific information and data, arguing about them and using different formats, to analyze concepts and processes in biological and geological sciences.	CLC1, CLC2, CLC5, CMST4, DC2, DC3, CAE4
	2. To identify, locate and select information, contrasting its veracity, organizing it, and critically evaluating it, to solve questions related to biological and geological sciences.	CLC3, CMST4, DC1, DC2, DC3, DC4, DC5, CPSAA4
	3. To plan and develop research projects, following the steps of scientific methodologies and cooperating, when necessary, to	CLC1, CLC2, CMST2, CMST3, CMST4, DC1, DC2,

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	investigate aspects related to geological and biological sciences.	CPSAA3, CE3
	4. To use computational reasoning and thinking, to critically analyze the answers and solutions and to reformulate the procedure, if necessary, to solve problems or explain everyday processes related to biology and geology.	STEM1, STEM2, CD5, CPSAA5, SIE1, SIE3, CAE4

Table 5. List of key and specific competences (according to LOMLOE and RD 217/2022), as well as their connection with the descriptors of the exit profile to be worked on in the second phase for the area of Biology and Geology in Compulsory Secondary Education (ESO).

- Third phase: the last phase would be the revision and correction by the teacher of the proposals and exhibition or publication open to the public in the format chosen by the class (culture and science week, women's day, science equality day, etc.). The competences to be worked on related to this phase in Primary Education are summarized in table 6, while those related to Secondary Education are shown in table 7.

KEY COMPETENCES	SPECIFIC COMPETENCES	CONNECTION WITH THE DESCRIPTORS OF THE EXIT PROFILE
CLC; CMST; DC; SCC.	2. To raise and give answers to simple scientific questions, using different techniques, instruments, and models of scientific thought, to interpret and explain facts and phenomena that occur in the national, social and cultural environment.	CLC1, CLC2, CLC3, CMST2, CMST4, DC1, DC2, SCC4

Table 6. List of key competences, specific competences, and descriptors of the exit profile (according to LOMLOE and RD 157/2022) to be worked on in the third

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phase for the area of Knowledge of the Natural, Social and Cultural Environment in Primary Education.

KEY COMPETENCES	SPECIFIC COMPETENCES	CONNECTION WITH THE DESCRIPTORS OF THE EXIT PROFILE
CLC; CMST; DC; CPSAA; CAE; SIE.	1. To interpret and transmit scientific information and data, arguing about them and using different formats, to analyze concepts and processes in biological and geological sciences.	CLC1, CLC2, CLC5, CMST4, DC2, DC3, CAE4
	3.5. To cooperate within a scientific project by assuming a specific role responsibly, using virtual spaces when necessary, respecting diversity and gender equality, and favoring inclusion.	CLC1, CLC2, CMST2, CMST3, CMST4, DC1, DC2, CPSAA3, SIE3

Table 7. List of key competences, specific competences, and descriptors of the exit profile (according to LOMLOE and RD 217/2022) to be worked on in the third phase for the area of Biology and Geology in Compulsory Secondary Education (ESO).

3.3. METHODOLOGY AND DIDACTIC RESOURCES

As already mentioned in previous sections, two different ways of proceeding are proposed in relation to their age group, depending on whether the students are in primary or secondary education. Thus, for primary school students, we propose an activity involving a cooperative search for biographies of female geologists and historical facts about their lives and the social context in which they carried out their scientific activity, in order to subsequently show the rest of the class and, if appropriate, the rest of the school, their work displayed on posters. For Secondary Education, on the other hand, an approach to the world of information and communication technologies (ICT) with a scientific use of ICT is proposed. While the first phase would be similar to that of Primary School, the results exhibition phase would be carried out through each pupil's entries in a Science blog at the

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school or in a Twitter thread or on a Facebook page created and managed for this purpose by the teacher, avoiding, of course, at all times sharing personal information of the pupils (neither data nor images in which they could be recognized).

Tables 1 and 2 in the Appendix summarize the aspects that we consider most relevant or interesting to work on in the classroom when we present each of the selected biographies. The distribution proposed in both tables responds to the geological topics that could be dealt with and the debates that could be held, so that, for example, metamorphism, which is a topic more related to the Secondary School curriculum, leads us to propose that the biography of Catherine Raisin should be proposed in Secondary School. However, this is only a suggestion, since if the teacher believes that any of the biographies can be used indistinctly in Primary School or Secondary School due to the characteristics of his/her classroom, he/she can adapt the contents without too much of a problem.

3.4. TIMETABLE PROPOSAL

In the context of a learning situation, an open proposal for a termly project is then set out, involving the completion of the project in one of the activities that schools usually carry out to celebrate the end of each term (Open Days, thematic exhibitions and visits from parents, end-of-term festivals, etc.).

3.4.1. Timetable in Primary Education

"Mondays of debate": The idea is to work for one or two hours on the four Mondays of a given month on the biographies selected by the teacher. The biographical aspects and contexts as well as the geological notions related to the biography selected for that day will be worked on. Different formats can be used: discussion groups, debates, teacher's exposition followed by directed questions and debate, etc.

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The second month of the trimestral project will be dedicated to the inquiry phase. Under the name "Mondays we investigate", four Mondays (1 hour each Monday) will be dedicated to cooperative work with the constant review of the teacher of the progress made. In these sessions the students will have to choose the female geologist about whom they want to do their work and will search on the Internet and in library books about her biography, the scientific-historical context in which she developed her activity and, finally, they will delve into the most interesting and understandable geological aspects at the level of Primary Education for their work.

The third month of the trimester will be dedicated to the phase of dissemination of the results, so that the communicative capacity will be evaluated. In the case of Primary School, the first two Mondays of this third month of the trimester, "selection Mondays", will be used to select the most important elements and at the same time to design the poster of each group. In this phase, depending on the knowledge of the students, a double step can be made, in which first some poster sketches are made on cardboard and finally they are transferred to digital posters, or start working directly with a program for the design of the posters. An example of this type of sequences carried out under the UDL prism can be found in García-Frank et al. (2020). Finally, on the third Monday and/or subsequent days, the posters will be exhibited in the corridors of the center and an open day can be dedicated so that teachers, students, and family members can visit the exhibition, where several students from the class should always be present to give information to the attendees and thus work on their communicative skills.

3.4.2. Timetable in Compulsory Secondary Education

In Secondary Education, the first two months could have a similar dynamic to the one described in subsection 2.4.1 for Primary Education. During the third month, "selection Mondays", will be dedicated to the students, under the supervision of the teacher, to select the most interesting material and the images and texts they want to use in the dissemination process. After these two Mondays, one day of the

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following week can be dedicated to publish the entries in the Science Blog and to make "dissemination notes" to give it visibility.

3.5. EVALUATION CRITERIA

Just like in any didactic proposal, it is important for the teacher to start from the knowledge that the students have, so a diagnostic evaluation or an evaluation of previous ideas should be carried out. In this case, it would be interesting to assess what the students know with some open-ended questions such as: Do you know any important scientist? Do you know what he/she discovered or what research he/she worked on? Do you know what a geologist does? Can you name one and tell their most important contributions to the advancement of knowledge? Do you think there were women geologists before the twentieth century? and any other question that allows us to know their initial level. We could also include some images of famous scientists and a list of names to match with these photographs, which would allow another type of approach to the knowledge of students, who often use more visual memory.

Once the activity is carried out, three evaluation phases are proposed to allow the continuous assessment of the teaching-learning process associated with this proposal:

- Evaluation rubric on the sources used by the students in their research for the work and on how they have worked cooperatively.

- Evaluation rubric on the selection of the most relevant information and the way in which the selected information and images are organized and displayed, either on a poster or in a blog post.

- Finally, a written test similar to the one used in the evaluation of previous ideas can be carried out with a different wording, but focusing on the same aspects, in order to assess the knowledge acquired by each student.

- Active intervention in class, for example, during debates, can be another way of evaluating the interest shown by students and their degree of maturity in the

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presentation of arguments and critical reflection on scientific facts and social events.

With no intention of proposing a closed evaluation instrument, a possible evaluation rubric is proposed, which should be adapted and validated by each teacher to the reality of his or her classroom. Table 8 shows the possible aspects to be evaluated in this rubric.

PHASE	ASSESSED ASPECT	DEGREE OF ACHIEVEMENT	Quantification values
Phase of evaluation 1	Use of information sources	Uses two or fewer references from unproven or unreliable sources	0
		Uses three or more references from unverified or unreliable sources	1
		Uses three or fewer references from verified/reliable sources.	3
		Uses four or more references from verified/reliable/official sources.	5
	Cooperative work	Does not participate or show interest	0
		Participates, but tries to make his or her vision of the work the only one that will be carried out.	1
		Does not actively participate, but fulfills his or her assigned workload	3
		Participates actively, accepting the proposals of the rest of the team and creating an enriching work environment.	5
Phase of evaluation 2	Organization and presentation of information	The information is displayed in a disorganized and inconsistent manner.	0
		The information is displayed with a certain order and cleanliness. There is a lack of coherence.	1
		The information is organized in an orderly, clean and coherent manner.	3
		The information is organized in an orderly, clean and coherent manner. Interactive and/or creative elements are included.	5

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Phase of evaluation 3	Acquisition of content related to the field of geology and the role of women in science.	Is not able to mention the names of more than two women scientists or their contributions to the field of geology.	0
		Can mention at least two female scientists and superficially explains their contributions to the field of geology.	1
		Can mention more than three female scientists and explain, in some detail, their contributions to the field of geology.	3
		Can mention more than three scientists and explain, in great detail, their contributions to the field of geology and how these contributions have contributed to the advancement of science.	5
Active intervention (discussions/exhibitions)		Does not participate spontaneously.	0
		Rarely participates and/or wants to impose his vision on the rest of the group without accepting their input or providing arguments.	1
		Participates actively, respecting the turns of speech and the contributions of the other students.	3
		Participates actively, respecting the turns of speech and the contributions of the rest of the students. Explains clearly and contributes data to his/her argumentation/exposition.	5

Table 8. Proposal of a rubric for the evaluation of the activities carried out in the different phases of the didactic proposal.

The following ranges of points are proposed to evaluate the results of the rubric:

- 0 to 5: The student has not achieved the objectives of the project.

- 6 to 12: The student has partially achieved the objectives of the project, observing differences between the different phases of the project.

- 13 to 20: The student has generally achieved the objectives of the project, although aspects of some phases can be improved.

- 21 to 25: The student has achieved the project objectives in a consistent and equal manner across the different phases of the project.

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4. CONCLUSIONS

This work has presented a didactic proposal that emphasizes the importance of breaking with gender stereotypes and promoting respect for diversity in the classroom, so that it does not become an obstacle to socialization and professional expectations based on gender or other personal circumstances. This proposal is framed in a learning situation that not only involves the learning of certain geology contents, but also includes methodological and attitudinal aspects emphasizing historically contextualized teaching. We have focused the proposal on the search and analysis of biographies of women geologists of different nationalities, cultures, race and religions, to serve as a reference for a diverse student body in increasingly multicultural classrooms. In addition, these personal circumstances are expanded with aspects related to the functional diversity of the selected women, which is intended to be an example for students with disabilities, so that they do not set limits to their own training, thus supporting their scientific vocations through real references.

Simultaneously, a transversal treatment is made through debates, which not only involves a subject of the Primary School or Secondary School curriculum, but intends to have an inter and multidisciplinary approach so that students are aware of the complexity of the world that integrates a multitude of interconnected relationships. Most of the basic competences indicated for these educational periods can be worked from this didactic proposal.

The proposed methodologies are cooperative work and inquiry, under the prism of the Universal Design for Learning that is reflected in the current legislative frameworks of compulsory education. In the search for the answer to scientific questions with the development of a greater control of learning by the students, as well as the development of attitudes that promote coexistence and respect among them. Enhancing then their self-esteem and gender identity, as well as the ability to face new challenges.

Finally, a teaching-learning sequence that should be evaluated in at least three phases, before, during and after the proposed quarterly project, is proposed.

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We incorporate the proposal of an evaluation rubric as a basis so that it can be validated and adapted to the different contexts in which it can be used.

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APPENDIX

The following tables show the basic information both at the biographical level and at the level of possible resources and discussions that could be carried out in relation to each of the women selected for Primary and Secondary education. Among many others, teachers interested in this proposal can expand the information presented here in pages such as https://www.fembio.org/english/biography.php; https://11defebrero.org/ y https://mujeresconciencia.com/; as well as in references on this subject such as: Álvarez Lires et al. (2003); Calvo (2022); Jiménez Jiménez (2009); Solís-Espallargás (2018).

Table 1. Female referents for working with biographies of female geologists in Primary Education.

Female geologist	**Biographical highlights**	**Possible aspects to be addressed in the classroom, resources or work methodology**
Mary Anning (19th century) British	- A working-class, self-taught paleontologist (she was a fossil collector on the Jurassic coasts of Dorset from a young age).	Documentary film screening and discussion on women and social classes in science: *Mary Anning - Princess of*

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	- At the age of 12 she discovered the first complete ichthyosaur and plesiosaur skeleton. - She studied comparative anatomy. - Only after her death, she was recognized for her contributions to this science by the Geological Society of London.	*Paleontology* (https://www.youtube.com/watch?v=a-CW0B4YeBQ) The teacher can provide a summary text in Spanish of the most interesting aspects of the documentary. The subject of comparative anatomy and adaptations to the environment can be worked on based on this biography.
Mariam Al-Ijli (10th century) Syrian	- Arab and Muslim astronomer (daughter of the most famous astronomer and astrolabe maker of the time - Kushiar Al Ijili Al Astrulabi). - Her refinement of the astrolabe greatly improved shipping of the time. - With their contributions, navigators could know more precisely their position and time of day, according to the position of the Sun, the Moon, and the stars.	Teacher's explanations of theoretical aspects and some practical activities to know our position (orientation), distinguish the cardinal points, etc. aided by the position of the Sun, the Moon, the stars (shadows, Moon phases, etc.). Debate on women and religious beliefs and race in science.
Mary Douglas Leakey (1913-1996) British	- Geologist and paleontologist. - At 17 she began a career as an illustrator, meeting her future husband Louis Leakey (renowned paleontologist who determined the origin of mankind in Africa). - She was involved in the description of several fossil remains (Proconsul africanus, Australopithecus boisei, Homo habilis...).	A visit to one of the natural history or paleoanthropology museums near the school or the use of web pages with images of human evolution through its fossils can be made. This should lead to a reflection on the importance of enlightenment in the sciences and discussions on how to break racist stereotypes with the positioning of the origin of

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	- Fossilized footprints from *La Etoli* showed that the species *Australopithecus afarensis* already walked upright.	humanity in Africa.
Caroline Herschel (1750-1848) German	- Astronomer and planetologist. - She discovered dozens of twin stars, comets and described the sixth and seventh moons of Saturn. - She explained that Saturn's rings are formed by rocks of different sizes orbiting around it. - She was only 130 cm tall due to a childhood illness, which led to social isolation for most of her life.	The planets of the Solar System and their characteristics can be worked on. Debate on what kind of society we want and the rights of people with functional diversity. It also serves to show how people with disabilities are capable of overcoming many difficulties if they persevere.
Katia Krafft (1942-1991) French	- Geologist and volcanologist. - She was killed during an eruption in Japan while collecting data and photographing volcanic activity from a short distance and was caught in a pyroclastic flow. - A woman of great courage and bravery who risked her life on multiple occasions to obtain scientific data. - Her studies allowed the definition and implementation of different surveillance and evacuation protocols in volcanic risk areas. - An important work of dissemination of scientific knowledge that earned her	The topic of volcanism and its typologies can be worked on, introducing the subject with one of the documentaries of this geologist: "The Volcano Watchers". The topic of volcanic hazard can be discussed in relation to the aspects of prevention, prediction, and mitigation of its consequences, as well as the importance of protocols. Bravery can be debated. There tends to be a bias as to what the imaginary of the student body considers to be bravery, which in part by movies and series is usually exemplified as a young and generally white male (Rodríguez Pérez et al.,

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	various international awards.	2014). Finally, the important work of dissemination can make students see the importance of the third phase of this project, in which they will be the disseminators of their work.
Eunice Newton Foote (1819-1888) American	- Climatologist, researcher on the effect of carbon dioxide on current global warming. - He proposed and popularized the use of the term "greenhouse effect". - Women's rights activist.	It is interesting to introduce aspects related to the functioning of the climate and its complexity due to the large number of factors involved. As well as an introduction to aspects such as climate change, ozone layer, greenhouse effect, etc., etc. Her biography can be used to emphasize the importance that scientific terms can have on understanding and proper use. Finally, it is possible to discuss in a transversal way the importance of having a critical conscience and seeking in democracy the rights of all people regardless of their particular characteristics.
Wang Zhenyi (1768-1797) Chinese	- Astronomer and poet. - During her childhood she was able to begin her education thanks to the books of her grandparents and her father (a physician). - At that time, study for women was only reserved for the upper classes.	Although she is an astronomer and not directly a geologist, much of her research has to do with aspects that are dealt with in Primary education such as the equinoxes or eclipses. It is important the presence of this scientist as well as others mentioned from the Arab or Hispanic world to

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	- In addition, she learned martial arts, archery and horseback riding. - She reviewed the scientific works of several colleagues and made them accessible to the entire population by simplifying their language. First seeds of scientific dissemination. - Among other topics, she dealt with gravity on Earth, lunar eclipses, equinoxes, etc. - She used simple models to teach and disseminate lunar eclipses.	show how all cultures and races are equal in science and that it is only a matter of having the opportunity to dedicate oneself to what the children like to do. We can discuss the importance of growing up in an environment where there are many books (reading habits) and the importance of curiosity and the desire to learn. It can be emphasized how intellectual training is not at odds with physical instruction. The importance of dissemination so that everyone has access to the basic right to understand the environment around us. Finally, you can try to build simple models to deal with eclipses or equinoxes in class.

Table 2. Female referents for working with biographies of female geologists in Secondary Education.

Female geologist	**Biographical highlights**	**Possible aspects to be addressed in the classroom, resources or work methodology**
Fanny Bullock Workman (1859-1925) American	- Cartographer, explorer, geographer and mountaineer (one of the first professional climbers). - Much of her work was done in and on the	It is worth noting that sport and science are not incompatible and that many female scientific explorers were also great sportswomen.

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	Himalayas and their glaciers, as well as various travel guides. - Activist for women's rights and among others for Women's Suffrage. - From an upper-class family, she had some problems with the workers in her expeditions.	We can discuss the importance of workers' rights and of preserving the environment which, as we have seen in recent years, even in the highest peaks of the Himalayas is endangered by the abandonment of garbage, overcrowding.... Topics related to glaciation and geomorphology of cold environments.
María Tarsy Carballas Fernández (1934-present) Spanish	- Soil scientist who studied the genesis, classification, and mapping of soils in humid temperate zones of Spain. - Although she has a PhD in Pharmacy and a degree in chemistry, soil science is a multidisciplinary science that is closely related to geology. - Several studies and awards on forest fire prevention.	The importance of soil as an interface between geosphere, biosphere, atmosphere, and hydrosphere and how it influences important aspects such as the environment (forest fires, loss of fertile soils, desertification...), agriculture, construction, etc. can be worked on. In addition, soil is one of the places where most drug components have been found and hence it is also closely related to pharmacy and chemistry careers.
Purificación Fenoll Hach-Alí (1935-present) Spanish	- Degree in Chemistry and Geology. - Specialized in mineralogy and geochemistry of clay minerals and their industrial uses. - Member of the Club of Rome and the Euro-Arab Foundation.	The importance and presence of minerals in everyday and industrial objects can be worked on. It is possible to talk about the Club of Rome and discuss some of its important reports on sustainable development, as well as the close relationship between Spain and the countries of North Africa in many geological

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		investigations.
Mary Emilie Holmes (1850-1906) American	- Geologist and paleontologist. - First woman to receive a PhD in Earth Sciences in the United States. - She studied the morphologies of corals. - She illustrated many of her collections of fossils, minerals, plants, etc. with drawings. - First woman to be a member of the Geological Society of the United States. - Co-founder of Mary Holmes College, a school for teaching African-American women.	It is possible to work on the energy of the media based on coral morphologies and their adaptations to different environmental conditions. We can highlight the importance of scientific illustrations as a way of visualizing fauna, flora, environments, etc. of the past that facilitate their study and dissemination. Discussion about people of color and especially the injustices that have been committed against the black race in countries such as the United States.
Kate Hutton (1963-present) American	- Sismóloga con estudios iniciales en astronomía. - Estudios sobre sismicidad de Estados Unidos y otras partes del planeta. - Gran presencia mediática en medios de comunicación. - Referente de la comunidad LGTBI.	The topic of seismic risk zones and their relation to specific areas of the planet ("plate tectonics"), the importance of prevention measures and behavior before earthquakes can be worked on. Taking advantage of the media aspect of this scientist, activities such as reading and critical-scientific analysis of certain geological news that appear in the media, in movies, etc. can be used. The issue of sexual freedom can be addressed in democratic societies.
Alva C. Ellisor	- Along with other contemporary women such	The topic of energy resources and their

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(1892-1964) American	as Hedwig Kniker and Esther Richards Applin, they were pioneers in the field of petroleum geology through their expertise in micropaleontology. - On some occasions they had problems of rejection in their clearly male-dominated work environments.	importance for industrial and economic development and their negative consequences for the environment can be addressed. It is possible to discuss the importance of fostering peaceful work environments in which everyone is integrated, and no one feels isolated by linking the issue of bullying across the board. A didactic activity can be organized in natural science or geological museums to understand the importance of fossils, especially microfossils.
Inge Lehmann (1888-1993) Danish	- Seismologist and geophysicist. - She had the unconditional support of her father to be able to study up to higher education. - She went to one of the first coed schools where learning was done on an equal basis (everyone sewed or knitted, and everyone also played soccer). - She discovered the existence of the Earth's inner core, and a discontinuity called the Wiechert-Lehmann-Jeffreys discontinuity. - She studied the propagation velocities of seismic waves and the	This character lends itself to the introduction of natural and geological hazards, including earthquakes and their causes and effects. You can work the interior of the Earth and how indirect studies are used to know it. In a cross-cutting manner, aspects such as the importance of family support for students and its importance in scientific careers can be discussed. Finally, reading her biography can help students to appreciate the effort that many scientists had to make in their research when there were no computers or the ease of obtaining data that we have today with the Internet. As a complement, it

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	change of their trajectories at certain depths. - She had great difficulty in working the data manually at a time when computers did not yet exist.	could be proposed to carry out an activity first with a computer and then without the technological aid.
Catherine Raisin (1855-1945) British	- First licensed female geologist and the second to be awarded a PhD. - First head of a geology department in Great Britain (Bedford College). - She dedicated her studies to petrology and mineralogy using the optical microscope. - He made great advances in the field of metamorphism. - Although the Geological Society of London awarded her the "Lyell Fund" prize, a colleague had to collect it for her as women were not yet allowed to join the institution.	It is possible to take advantage of this opportunity to carry out an introductory activity to the visualization of rocks and minerals under the optical microscope. One can dedicate the reading of his biography to introduce the importance of metamorphism studies. It is possible to discuss in a critical way some obsolete and unfair rules of some societies and how knowledge and democratic advancement allow equality among all members of a society. It is possible to talk about equality and the importance of both women and men being able to reach the highest levels of education and positions of responsibility.
Marie Tharp (1920-2006) American	- Geologist and cartographer. - Co-author of the first map of the floor of the Atlantic Ocean together with Professor Heezen. In it they showed the Mid-Atlantic Ridge. - These papers were the first	Reference should be made to the importance of studies of the ocean floor (still less explored than some areas of outer space). You can work with simple maps and comment on the historical importance of cartography.

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	seeds of what would become the evidence for continental drift and eventually plate tectonics.	It is obvious that reading her biography and watching videos should lead to the explanation and discussion of such important theories as continental drift and plate tectonics. https://www.youtube.com/watch?v=TgfYjS0OTWw&feature=youtu.be.

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