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Transfer in Teacher Training: Integrating Socio-Environmental Issues Through an Educational Trail

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Abstract

Education through geotourism plays a key role in advancing the Sustainable Development Goals. This study presents the results of a service-learning project in which a pre-service teacher, conducted under the academic supervision of university faculty members within the framework of a Bachelor's thesis course, collaborated with public entities to design and implement an educational trail, establishing strategic partnerships to promote Sustainable Development Goals outcomes. The objective of this article is to present the outcomes of the implemented service-learning methodology project: on one hand, the creation of the trail; on the other, the analysis of the perceptions of the stakeholders involved in its development. To assess stakeholder perceptions, a qualitative approach was applied through focus groups. As a result, an accessible educational trail was successfully created. Moreover, the results evidence a consensus among participants regarding the value of the trail as an educational, touristic, and environmental infrastructure. Consequently, teacher training is reinforced as a platform for sustainability-driven action, enabling the creation of partnerships that facilitate the achievement of the Sustainable Development Goals. In addition, the experience and methodologies developed through this project demonstrate potential for replication in other educational and social contexts.

Keywords: didactic trail; sustainability; inclusive education; sustainable development goals; teacher training; service-learning approach

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1. Introduction

Trails, in various forms, are the most common type of self-guided activity, allowing visitors to independently explore and experience geotourism features. They represent the most widespread form of geotourism, offering opportunities for discovery at one's own pace. A trail is generally defined as a path or track, often found in natural settings or created by people [1]. Some of the most representative itineraries include tourist [2,3], cultural [4], recreational [5,6], sports [7], ecological [8], photographic [9], geological [10,11], and educational [12] trails.

Among these, the educational trail stands out for its ability to offer an active, reflective, and contextualized approach to curricular content. According to the Federation of Mountain Sports of Castilla-La Mancha [13], not only do educational trails facilitate learning about local flora and fauna, culture, and monuments or points of interest—often while

incorporating physical activity—but they also provide a safe and engaging environment for doing so.

Traditional nature trails, which have been in use for nearly a century, typically focus on delivering on-site information about natural phenomena through static informational panels [14]. These trails are characterized by a primarily passive mode of learning and have traditionally served for educational, informative, and guiding purposes. Over time, however, they have also been adopted as tourism products. Despite evolving alternatives, traditional nature trails remain the most used type [14].

In contrast, experience trails adopt a more dynamic and participatory approach, actively engaging visitors in their interaction with the natural environment. This is achieved using elements such as view tubes, interactive panels (e.g., ring binders, folding displays), and verbal instructions. These trails emphasize the activation of motor and sensory skills, providing a more immersive, hands-on experience that encourages deeper personal connection with the surroundings [15].

1.1. Education and the Sustainable Development Goals

For some time now, environmental education has been present in primary education due to the importance of natural resources and the potential harms of pollution, as well as its prevention [16]. This responds to the changing terrestrial conditions caused by the impact of various human activities [17], which are encompassed under the holistic concept of the Anthropocene. In this era, sustainability has been understood as a vital approach where societies possess the necessary competencies to solve problems, seize opportunities, and maintain active engagement [18].

In this regard, it is considered essential that pre-service teachers know how to apply this perspective to education. To do so, they must incorporate, among other things, the opportunities provided by the 2030 Agenda and the Sustainable Development Goals (SDG) [19]. Geography holds a key position in working towards Sustainable Development due to the interconnectedness of the content it addresses regarding the different elements and actors of the environment [20,21]. Additionally, the Lucerne Declaration [22] highlighted that geographical education and Education for Sustainable Development (ESD) are closely related. Therefore, this discipline is considered essential to work on SDGs [21]. The systematic review conducted by Flaherty and Liddy [23] showed that when educational interventions focus on the SDGs, there is an improvement in the acquisition of environmental values and the development of a more critical citizenship. According to Chen et al. [24], psychological characteristics such as attitude, interest, motivation, and self-efficacy, which are key to understanding the SDGs, are also developed through integrative teaching methods that combine interdisciplinary, collaborative, experiential, and transformative approaches. All these dimensions are integrated into the service-learning methodology we adopt in this work. This is particularly relevant given that, as Chen et al. noted [24], integrative teaching strategies that promote education for sustainability (ES) in higher education have received limited attention to date. Similarly, the study by Bonilla-Jurado et al. [25] concluded that educational interventions based on the SDGs enhance academic performance, motivation, and engagement, as well as strengthen students' ability to solve complex problems in a sustainable manner.

Considering what has been explained above, ESD is recognized as one of the essential components that should be included in a high-quality geotourism trail [26]. In this sense, the incorporation of ESD into geotourism trails allows visitors not only to appreciate the landscape and natural resources but also to understand the threats these elements face due to human activity and climate change [27]. However, most of the trails are not designed from this educational perspective, which can hinder visitors' understanding and

learning [14]. Also, the principles of sustainability and the importance of environmental conservation are not conveyed.

To find a solution to this issue, it is recommended to involve a professional in geoeducation. According to Megerle [28], well-structured geoeducation not only enhances the understanding of geological and natural phenomena but also promotes conscious and responsible education regarding the interaction between humans and the environment. By combining ESD with geography education, awareness regarding the impact of human beings on their natural surroundings can be promoted, which is crucial for fostering conservation practices and a deeper respect for ecosystems [29]. Therefore, the training of trial guides, the creation of appropriate educational materials like panels and didactic proposal, and the integration of new technologies are key aspects in achieving effective geoeducation aligned with sustainability principles.

1.2. Benefits of the Educational Trails

Continuing the educational benefits of the trails according to Gómez [30], they improve intrinsic motivation as they foster curiosity and increase students' interest. According to García de la Vega [31], they are a motivating, highly useful, and valuable teaching resource for students. This approach allows for direct experiences in the environment, which promotes deep learning [32]. In fact, what is experienced in the landscape is understood and remembered more easily than what is learned solely in the classroom [33]. This type of experiential learning becomes a fundamental pillar in students' education, as it is directly linked to ESD, which seeks an integrated understanding of the natural and social environment [34].

The learning enhanced in these trails not only involves the acquisition of theoretical knowledge but also engages the "knowing how" and "knowing being", two fundamental pillars of meaningful and transformative education [35]. As has been explained, the involvement of a geoeducation and ESD professional in the design of these trails means that students not only learn theoretical contents about geography and ecosystems but also develop practical skills that allow them to actively participate in environmental conservation [33]. In this sense, following Delgado's ideas [36], when activities are planned in a natural environment, they not only foster theoretical understanding but also develop practical skills that students can apply in their daily lives. Immersion in nature, contact with landscapes, and the solving of real-world problems contribute to students acquiring key competencies for making responsible decisions regarding environmental preservation [34]. All in all, when children are involved in the natural environment, protecting the landscape and the natural resources, critical and responsible citizenship is promoted.

Another educational advantage of the trails is that they promote transversal and integrative learning which lets children relate to different disciplines such as natural sciences, geography, and environmental education [35]. This approach not only fosters academic development but also enhances environmental awareness that extends beyond the classroom, as students feel involved and committed to protecting their natural surroundings [34]. This transversal methodology has the potential to foster an integral ecology, which integrates environmental, cultural, and human dimensions, something crucial in the current context of ecosystem threats posed by climate change and the overexploitation of natural resources.

The connection between geoeducation and ESD reinforces the idea that educational trails should not only be conceived as spaces for learning about geography and nature but also as vehicles for ecological awareness and the development of responsible attitudes toward the conservation of natural heritage [36]. Additionally, this integrative vision promotes critical education, allowing students to understand the relationship between

human dynamics and ecosystems, and how their actions can contribute to or mitigate the environmental challenges we face globally.

Ultimately, the integration of the SDGs, professional geoeducation, and ESD in educational trails has the power to transform the way students from diverse age groups and academic stages relate to their environment, providing a profound educational experience that not only fosters academic knowledge but also critical awareness and active commitment to sustainability [34].

1.3. Cognitive Accessibility and Educational Trails

In addition to the previously mentioned advantages offered by educational trails, it is essential to ensure real learning opportunities for everyone to obtain benefits from them. To achieve this, we must consider cognitive accessibility, since each person has different abilities. As Caro [37] points out, this type of accessibility allows for the adaptation of environmental information so that individuals with cognitive difficulties can understand it.

In this regard, Janeczko et al. [38] highlight that many informational panels on nature trails are not adapted to the visitors due to the complex or technical language used, which prevents a significant portion of visitors from understanding the information. This lack of adaptation limits the ability of everyone to fully benefit from the educational experiences these trails can offer [38].

Cognitive accessibility relies on the use of augmentative and alternative communication systems, which, according to Luckasson et al. [39], are essential tools to promote personal development, education, and well-being. These systems support individuals in functioning more autonomously in their environment, allowing them to interact with and explore the world around them while also enhancing their self-esteem [40].

As a result, many people in our society require these systems to improve their quality of life and achieve greater autonomy. According to the Federation of Organizations of People with Intellectual or Developmental Disabilities [41], cognitive accessibility is defined as "the characteristics of things, spaces, or texts that make them understandable to everyone" (p. 13).

1.4. Educational Collaboration with Institutions in the Context of Sustainable Development Goal 17 (SDG 17: Partnerships for the Goals), Using the Service-Learning Methodology

Service learning (S-L) is a methodology that promotes academic learning through a meaningful and transformative service to the community. According to López-Fernández and Benítez-Porres [42], one of the fundamental objectives of S-L is the transfer of knowledge acquired at university into real-world applications, based on the practical implementation of curriculum content. In this sense, students actively participate in community settings, offering a beneficial service to society while enhancing their own learning process [43,44].

S-L is built upon two interrelated dimensions: on the one hand, the generation of common good through community service, and, on the other, the acquisition of knowledge, skills, and values essential to students' holistic development [44,45].

According to Puig et al. [46], every S-L project should follow four fundamental phases:

- Diagnosis of the situation: identifying real needs through environmental analysis.
- Development of an action plan: designing the project collaboratively and empowering students as change agents.
- Implementation of the proposal: delivering the service by applying knowledge in a tangible way to benefit society.
- Evaluation of results: assessing the project's impact and the achievement of the proposed objectives.

This methodology, in addition to fostering significant learning, aims to develop individuals with critical thinking and sensitivity to social, cultural, and environmental challenges within their communities. For a faithful implementation of S-L, certain quality criteria must be met, such as its connection to the curriculum, addressing a real community need, contributing to social transformation, offering adequate preparation to students beforehand, and promoting autonomous decision-making [47].

In this context, S-L is closely aligned with SDG 17 of the 2030 Agenda [19], which seeks to strengthen partnerships among governments, the private sector, academia, and civil society to ensure that no one is left behind in the path toward sustainable development. Specifically, the trail initiative contributes to Target 17.17 [19], which focuses on encouraging and promoting effective partnerships in public, public–private, and civil society spheres, leveraging the experiences and resource strategies of these collaborations. At the same time, this approach contributes directly to other key SDGs: SDG 3 (Good Health and Well-being), by promoting physical activity and emotional well-being through engagement with nature; SDG 4 (Quality Education), by offering inclusive and experiential learning opportunities; and SDG 10 (Reduced Inequalities), by integrating accessibility measures that ensure all individuals—regardless of their abilities—can participate equally and also SDG 15 (Live on land). Thus, the trail and its S-L framework become a multidimensional tool that strengthens education, equity, health, and collaboration in alignment with the 2030 Agenda.

S-L fosters active collaboration between educational institutions and various social actors—such as local governments, and community associations—serving as a practical and transformative platform for the advancement of such alliances [44,45]. Projects based on this methodology are conceived from a collaborative perspective that enables academic knowledge to be translated into collective actions with real social impact. These actions are grounded in mutual respect, reciprocity, and shared responsibility [44,45].

Through this methodology, students not only become protagonists of their own learning but also emerge as active agents of sustainable development, participating in initiatives that generate shared value. Thus, S-L represents an effective educational pathway to advance the fulfillment of SDG 17 by strengthening university-community connections, consolidating cooperation networks, and promoting social transformation through education [46].

Based on the theoretical framework, this article pursues two related main objectives: (1) To propose the methodological development of a S-L project aimed at designing an educational trail as a community service initiative led by the Faculty of Education, with the goal of contributing to the achievement of various SDGs; and (2) To analyze the perceptions of the stakeholders involved in the design and implementation of the project.

Specifically, the article highlights the outcomes of the S-L initiative: the creation of the educational trail, and the qualitative assessment of stakeholder perspectives regarding its development and impact.

2. Methodology

This study focuses on a single case of a didactic trail (Sendero del Panzo Trail), which allows us to explore the processes involved in the design and development of the trail in depth, taking the actors responsible for its planning, management, and implementation as a direct reference. The choice of a case study responds to the interest in understanding not only the technical and logistical aspects, but also the social, cultural, and territorial dynamics that influence this type of initiative.

2.1. Methodology of the Design of the Trail

An innovative, collaborative approach involving the university, local government, and the Mountain Federation was adopted to design, accredit, and make accessible an educational trail in Quintanar de la Orden (Castilla-La Mancha, Central Spain) (Figure 1).

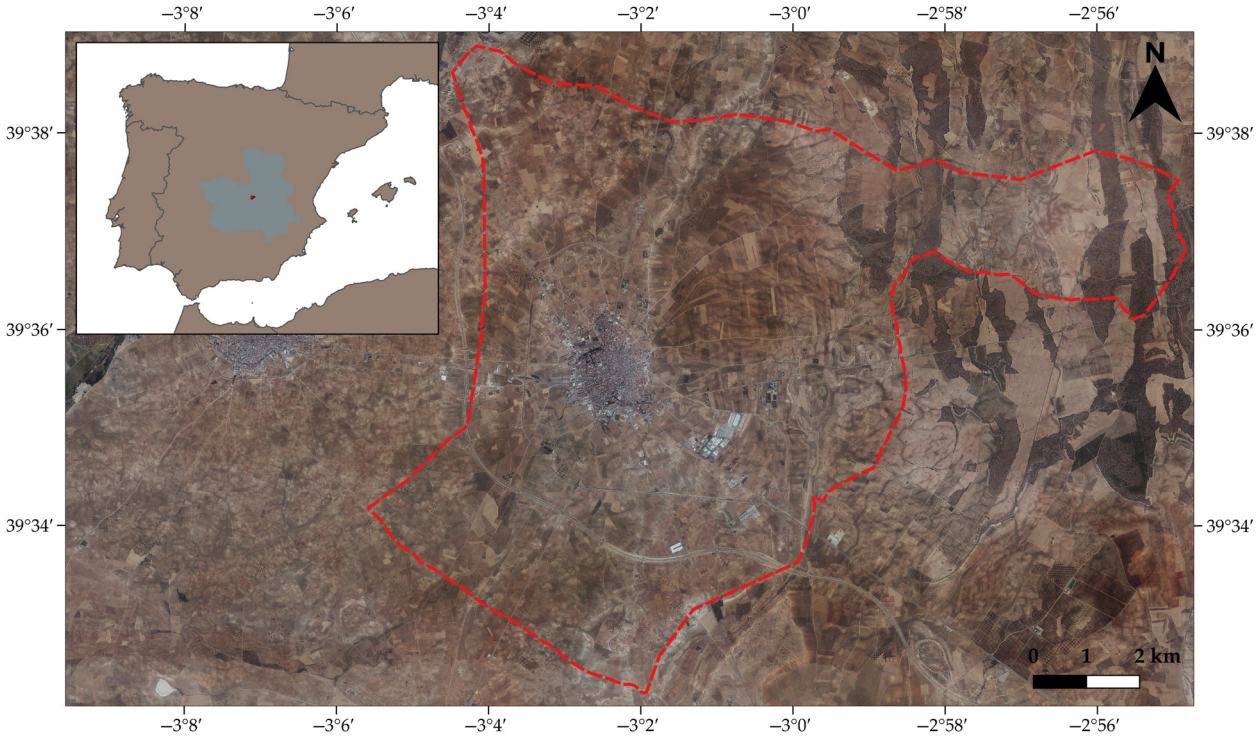

Figure 1. Left: The location of the municipality of Quintanar de la Orden (red) in the autonomous community of Castilla-La Mancha (gray) and in Spain. Right: The municipal boundary of Quintanar de la Orden on a satellite image.

This municipality of 11,161 inhabitants according to the National Statistics Institute of Spain [48] lies 695 m above sea level in the 'La Mancha Alta' region and plays a key role in the regional agro-industrial sector.

The climate in Quintanar de la Orden is classified as Mediterranean with continental influences, characterized by cold winters and hot, dry summers. Rainfall is scarce and concentrated in spring and autumn, with an annual average of less than 400 mm. Temperatures can exceed 40 °C in summer and drop below 0 °C in winter, which significantly influences both natural vegetation and agricultural practices.

According to the Geological and Mining Institute of Spain [49], the geological substratum of the area comprises formations from the Mesozoic and Cenozoic eras. The Mesozoic is represented by Jurassic micritic, oolitic, and bioclastic limestones and Lower Cretaceous detrital deposits. The Cenozoic succession includes both Paleogene and Neogene materials, which are part of the marginal facies of the Madrid Basin. These deposits reflect the basin's evolution from the Paleogene through the lower Neogene, indicating a continuous sedimentary record across these periods. The surface geology is dominated by Cenozoic sediments, primarily composed of continental detrital facies (conglomerates, sands, silts, and clays), forming a gently undulating plain typical of the southern Iberian sub-plateau. These deposits are associated with fluvial and lacustrine environments and are largely responsible for the current geomorphology of the area. The region shows little recent tectonic activity, although it retains structures inherited from Alpine orogenic phases.

The most significant aquifer is the 'Western La Mancha' aquifer, an unconfined aquifer composed of porous materials such as sands and gravels, though it is under considerable

pressure due to agricultural overexploitation. Groundwater quality varies, with occasional nitrate presence due to intensive fertilizer use.

The predominant soils are calcareous, with loamy to sandy-loam textures, moderately deep, and well-drained. They are suitable for cultivating vineyards, cereals, and olive trees, although they are somewhat vulnerable to water erosion in sloped areas.

The economy of Quintanar de la Orden is strongly linked to the agri-food sector, with viticulture as the main activity. The town is part of the 'La Mancha Denomination of Origin', which has fostered the development of wineries and cooperatives. Other crops include cereals, olives, and horticultural products. In recent decades, there has been diversification into sectors such as the agrifood industry, logistics, and services, although the primary sector remains dominant.

The creation of the proposed itinerary is based on an existing route, promoted by the City Council of Quintanar de la Orden in 2016, known as the 'Cervantino year', and whose purpose is to publicize passages in which the writer Miguel de Cervantes was set to write Don Quixote [50]. The town is located in the heart of the region of La Mancha and within the Route of Don Quixote, cultural heritage of La Mancha and Spain.

Instrument and Procedure

In the university context, from an educational perspective and in line with López-Fernández and Benítez-Porres [42], this S-L methodology has, among its main objectives, the transmission of the knowledge acquired during the training period. Considering this, the project has been developed within the framework of the Final Degree Project course, part of the bachelor's degree at the Faculty of Education in Toledo. This course provides students with the opportunity to design and carry out research or innovation projects that integrate academic learning with practical application.

As previously mentioned, the key actors engaged in the project included a student and two professors (a tutor and a collaborator) from the Faculty of Education, and another professor from the School of Civil Engineering. Also, a city councilor from the local government and a technical advisor from the Spanish Mountain Sports and Climbing Federation (FEDME).

Each participant had specific responsibilities that contributed to the overall success (Figure 2). The student played a central role, being primarily responsible for the design and implementation of the trail in all phases of the project, especially from 1 (diagnosis) to 3 (implementation). As such, the university tutor and the other faculty professor not only collaborated during the design and implementation phases but also supervised the student's academic work, monitored their progress, and formally evaluated the project to ensure that the APS objectives were met through the development of the trail. The role of the engineering professor has also been key in monitoring the project, especially in the more technical aspects such as layout and cartography. The final outcome of the work was assessed and formally graded by an academic committee composed of faculty members from the Faculty of Education.

The main competences, among others, required to acquire by the student at the end of the Final Degree Project are as follows:

- The students are able to apply their knowledge to their work or vocation in a professional manner.
- The students have developed the learning skills necessary to undertake further studies with a high degree of autonomy.
- The students can maintain a critical and autonomous relationship with respect to knowledge, values, and public and private social institutions.

- The students can collaborate with various sectors of the educational community and the social environment. They embrace the educational dimension of the teaching role and promote democratic education for active citizenship.
- The students value individual and collective responsibility in achieving a sustainable future.

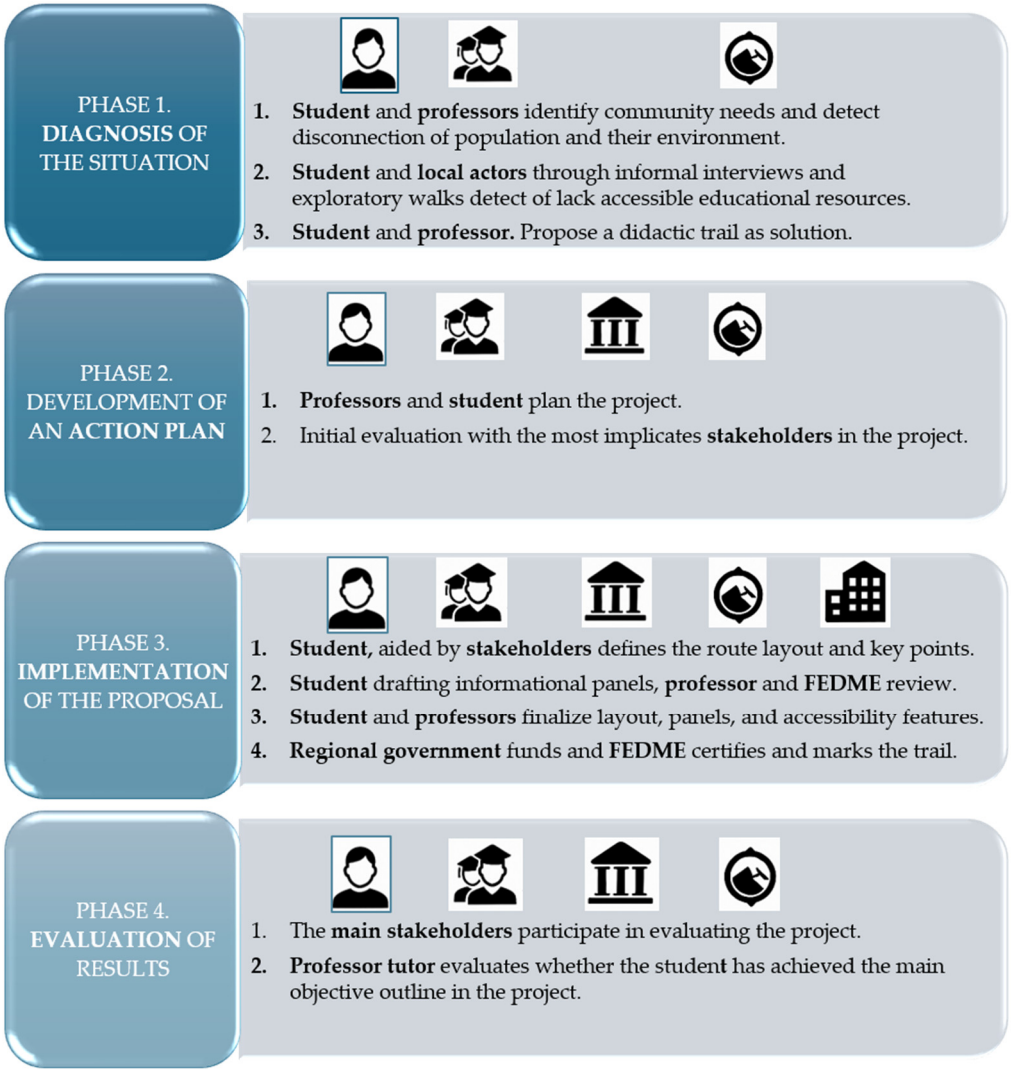

Figure 2. S-L-based methodology diagram of collaboration among stakeholders in the design of the Sendero del Panzo Trail.

The involvement of the other stakeholders (a city councilor from the local government and a technical advisor from the FEDME) was crucial in assessing the feasibility of the trail from both logistical (mainly, funding the cost of the federation's technician, supporting the trail's candidacy in the competition aimed at financing its signage, providing timely information about the feasibility of the route layout, and highlighting the significance of certain elements along the trail) and regulatory perspectives (completing the homologation process to guarantee the trail's safety and contributing to the installation of panels in the trail). Beyond evaluating the project's viability, they also offered institutional support, aligning the initiative with broader community and environmental goals and ensuring that it met the standards required for official approval and long-term sustainability. In addition to these stakeholders, there were others involved in the project whose contributions were essential to its quality: forest rangers, farmers, local residents who regularly use the trail, as well as associations representing people with disabilities.

During the diagnosis phase the student actively participated in identifying the community's needs, observing a significant disconnection between the population—especially children—and their natural and cultural surroundings. Through informal interviews with residents and teachers, as well as exploratory walks through the area, the student detected a lack of accessible educational resources that promote learning about the local environment outside the classroom. In response to this need, the student proposed the creation of a didactic trail that would integrate curricular content with direct experiences in the local setting.

In the development of an action plan, the professors and the student collaboratively designed the project with the goal of developing the trail. Furthermore, the student helped define the project's objectives, ensuring they addressed both the community's needs and the students' interests. At the suggestion of the professors, the student also organized a meeting for the initial evaluation of the project and to clarify the roles of each stakeholder involved.

During the implementation of the proposal, the student actively participated in planning the didactic trail, contributing both pedagogical and organizational ideas. First, the student proposed the layout of the route—after noticing that there was a pre-existing path that was neither marked nor officially recognized—and selected key points along the trail after speaking with various members of the local community and under the guidance of FEDME (Tables 1 and 2) and professors. Additionally, the student began drafting informational panels taking into account the criteria of Table 3, and designed a didactic proposal related to the trail, guided by the professors.

Table 1. Procedures and criteria for the design of the trail.

Criteria	Criteria Definition
1	Determine the purpose of the trail. Why am I creating a trail?
2	Who is the target audience?
3	Analyze the geographical and historical background of the area to plan the trail route.
4	Conduct fieldwork to identify key points of interest for the trail's route
5	Conduct field assessments to identify risk zones that the trail must avoid ensuring safety and prevent accidents.
6	Identify points of interest and restricted zones on a map. Then, design the trail route so that the points of interest are interconnected.
7	Obtain official certification, with a technician marking and validating the trail.
8	Plan the physical construction of the panels.

Source: Based on the work [51]. Own elaboration.

Table 2. Steps followed for trail homologation.

Steps	Description
Initial Request	Contact the relevant regional federation to submit the trail certification proposal.
Feasibility study	Federation conducts a viability assessment, evaluating route layout, access, environmental impact, and safety.
Project Execution	Implement the project on the ground, including signposting and trail preparations per standards.
On-site Review and Certification	A federation technician inspects the trail; if standards are met, the trail is officially certified.
Maintenance and Periodic Review	Certified trails undergo regular inspections to ensure continued safety and quality.

Table 3. Basic criteria for the design of interpretation panels.

Steps	Description
Panel Content	Text should be simple and fluid, using clear, direct language. Content must be written for the intended audience; it should be engaging and well-organized.
Panel Layout	Information should be organized into distinct blocks. It should include images, graphics, etc.
Panel Size	Ensure it is still legible from a reasonable distance.
Regulations and Legislation for Panels	Styling and content are left to the researchers' discretion. *

Elaboration based on data obtained from the observation tourism office [52] and recommendations for developing interpretive panels. * In our case, those established by the Regional Government's Department of the Environment have been considered, since it is the body that finances them and sets standards to ensure uniformity across the entire regional trail network.

The FEDME is the main responsible for the certification of trails in Spain. This process is implemented in collaboration with the regional federations and follows a series of established steps to ensure the quality and safety of the trails. Considering its certification criteria, the steps presented in Table 2 have been developed.

The educational proposal (see the table in Section 3) was carried out in accordance with the content and competencies established by the regional regulations in effect at the time of writing this work [53]. The contents and skills in the subject of Geography are aimed at the second cycle of primary education (3rd and 4th grades; 8–10-year-olds). In the development of the proposal, it has been considered that teaching in trails implies the study of environmental, social, economic, and cultural dimensions. The panels were also cognitively adapted for individuals with diverse disabilities, with the student receiving support from local disability associations. Alternative and augmentative communication systems have been developed and evaluated to enhance the cognitive accessibility of the trail. Specifically, the panels include Braille, pictographic symbols, easy-to-read formats, and audio guides. Their design follows the principles of universal design for learning (UDL) [53] and is framed within the broader concept of Universal Accessibility. According to Alonso [54], this approach considers individuals with diverse characteristics and abilities, aiming to address a wide range of educational needs. Finally, the student, with the help of the municipal technician—who also funded the report certifying the safety of the trail—prepared a technical report including the materials generated during the project, with the aim of having it approved by the regional government. After presenting and defending it, the report was approved for the trail to be signposted.

Finally, an evaluation of the project has been carried out, assessing the perceptions of the main stakeholders involved, in two phases, which is presented in the following section.

2.2. Research Methodology

A qualitative methodology was employed, focusing on the analysis of a specific case study: the Sendero del Panzo Trail.

The main data collection instrument used was the discussion group. This qualitative technique facilitated interaction among participants, encouraging an exchange of ideas, perceptions, and experiences that enriched the analysis. In this case, discussion groups were conducted at two key moments: before and after the design and implementation of the trail. This temporal strategy aimed to identify potential changes in the expectations and perceptions of the stakeholders involved, thereby evaluating the impact of the process and the extent to which initial projections aligned with the final outcomes.

Through this two-stage approach, it was possible to capture not only technical or functional evaluations of the project, but also its symbolic, social, and emotional dimensions, providing a more comprehensive understanding of the role such interventions play in the territory and within local communities.

Regarding the participants, the focus group brought together most of the key stakeholders involved in the development of the trail. This inclusive approach ensured a diverse range of perspectives and experiences, which enriched the quality and depth of the qualitative data collected. Specifically, the group included (i) the student, a central figure who contributed both conceptual and practical insights; (ii) the city councilor from the local government, representing the institutional and political dimension of the initiative, and providing valuable information about the municipality's role in supporting and promoting the project; (iii) a university professor who had been actively involved in the development of the trail, offering an academic and technical perspective that helped frame the project within broader discussions on sustainable development and environmental education; and (iv) a technical advisor from the FEDME, who contributed the viewpoint of the organization of outdoor recreation activities, bringing to light considerations on trail quality, accessibility, and its integration into existing hiking networks.

The composition of the focus group thus reflected a deliberate effort to include a cross-section of actors, each of whom had played a significant role in the creation and implementation of the Sendero del Panzo Trail. This variety of roles and backgrounds allowed for a rich and nuanced discussion, capturing both the aspirations that guided the project's inception and the evaluations that emerged following its completion.

Regarding the instrument, as explained previously, the focus group was chosen due to the benefits it conveys. Based on the literature review, this qualitative research allows us to capture how individuals express their views within a group context and their interactions [55]. Two focus groups were conducted, both with the same participants to know their perceptions before and after the implementation of the trail. The scripts of the focus group were elaborated based upon the previous literature review [43–46]. Before starting the focus groups, the themes were thoroughly explained to the participants.

Continuing with the methodology, the procedure was structured in alignment with the different stages of the trail's design and implementation. The first phase involved establishing initial contact with all relevant stakeholders to determine their interest and willingness to participate in the project. Once a positive response was received from all parties, in-person meetings were held to initiate collaboration and define the working dynamics.

Following these preliminary steps, the first focus group session was conducted. Its objective was to explore the participants' initial perceptions, expectations, and to identify potential challenges or concerns that might arise during the development of the trail. The insights gathered during this session served as a valuable foundation for guiding the subsequent design and implementation of the Sendero del Panzo Trail.

Once the trail was completed, a second focus group was carried out. This follow-up session aimed to compare participants' initial views with their post-implementation perceptions in order to assess any changes in attitudes and to evaluate the impact and effectiveness of the project as a whole.

The information was analyzed using a qualitative methodology. In the initial phase, the research team conducted a detailed reading of the textual material with the aim of interpreting meanings, identifying actions, and detecting potential units of analysis. This process was carried out through comparative work among the researchers and continued until data saturation was reached, with the support of the version 9 of Atlas.ti software.

The development of categories began with a deductive approach, to which inductive elements were later added as the analysis progressed. Coding was carried out by several

analysts. The involvement of multiple coders helped ensure the consistency of the analysis and strengthened the methodological rigor of the study. In Table 4, the categories and subcategories can be seen associated with the questions for both focus groups.

Table 4. Categories evaluated in the analysis of participants' perceptions of the project.

Categories	Subcategories	Questions (Initial Focus Group)	Questions (Final Focus Group)
1. General impact of the trail	1.1 Community expectations 1.2 Perceived value 1.3 Relevant aspects in the initial/final phase	What expectations are there regarding the impact of the trail on the local community? What educational, touristic, and environmental values are attributed to the project? What aspect seems most relevant in this initial phase of the trail's design and implementation?	Once the design and signage of the trail are completed, how is the educational, tourist, and environmental value of the trail now perceived? Which elements have proven to be the most relevant in the implementation phase?" What lessons can be learned to replicate this model?
2. Educational dimension	2.1 Curricular integration 2.2 Development of competences 2.3 Educational accessibility	How could the trail be integrated into teaching and learning processes? What competencies can be developed through the educational use of the natural environment? How can educational accessibility and adaptability of the project be guaranteed?	How has the trail been integrated into real learning experiences? How have you experienced the process of designing the trail as part of your training? What skills have you personally developed during the project? What improvements would you suggest to make it more inclusive and to involve students in the future? How has the interdisciplinary approach been put into practice?
3. Technical and institutional dimension	3.1 Technical criteria 3.2 Institutional support	What technical and administrative requirements are considered fundamental to starting the project? Is there institutional support and strategic planning backing this initiative?	What impact has the project had on the network of institutions? How is community participation expected to be evaluated?
4. Evaluation and homologation	4.1 Safety 4.2 Signage 4.3 Difficulty of the trail	What recommendations from the federation should be considered? What criteria are typically used to issue a favorable trail evaluation? What benefits does the trail's approval by the Federation bring?	How has the signage and safety of the trail been managed? What steps remain to consolidate its official recognition and public visibility?

The trail accessibility and the effectiveness of its adapted resources was also evaluated in different user profiles with specific needs: (i) audio guide, tested with older adults experiencing reading and writing difficulties; (ii) pictograms, conducted with a child on the autism spectrum, enrolled in a public school in Villamayor de Santiago; and (iii) easy-to-read texts, implemented with a middle-aged woman with intellectual disabilities and basic literacy skills, requiring verbal and physical support. The evaluation took place on-site with observation by specialized teaching staff. Specific criteria were used to assess comprehension, element recognition, and content accessibility.

3. Results

As a result, an accessible educational trail was successfully created (Figure 3). It was selected through a competitive process and officially marked by the regional government as PR-TO 45 Sendero Cueva del Panzo within the Castilla-La Mancha Trail Network. The trail can be accessed at the official trail registry of the region of Castilla-La Mancha at the following web address: PR-TO 45 Sendero Cueva del Panzo—Senderos de Castilla-La Mancha.

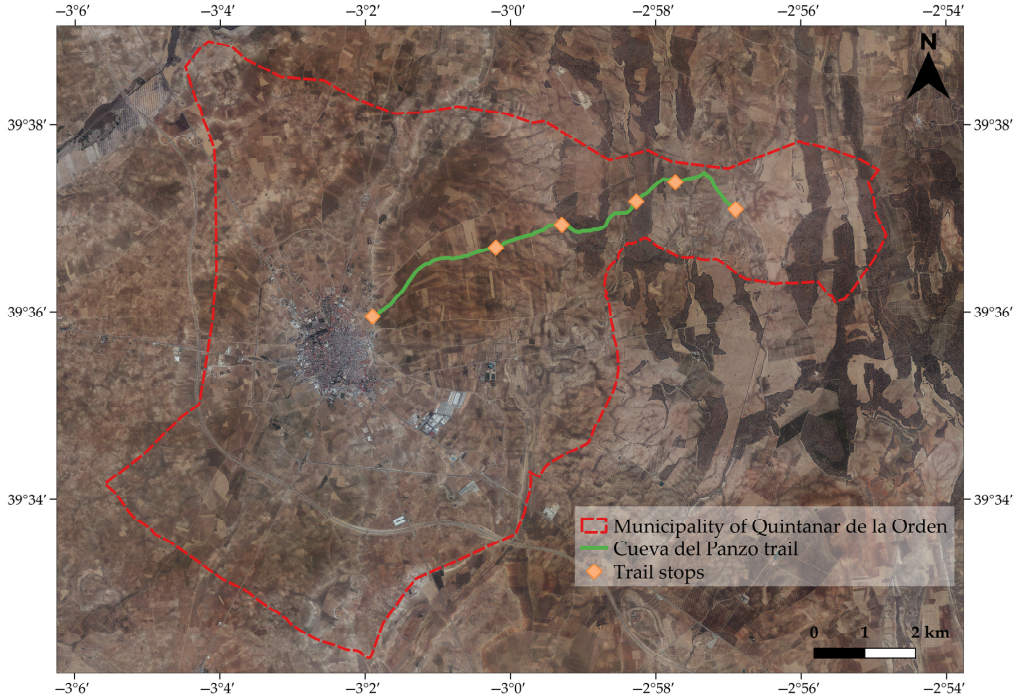

Figure 3. The location of the trail stops in the municipality of Quintanar de la Orden.

3.1. Didactic Proposal

As outlined in the methodology, the trail has been designed to be accessible to a wide range of users. In addition, an educational trail specifically tailored for primary school students has been developed, promoted by teachers and the trainee teacher from the Faculty of Education. This trail incorporates a variety of curricular contents (Table 5) to be explored throughout the trail experience.

Table 5. Contents, key competencies, and evaluation criteria selected in the Spanish primary education curricula (subject of Geography, included around knowledge of natural, social, and cultural environments).

Block of Curricular Content	Specific Content Within the Curriculum	Main Curricular Competencies Contribution	Examples of Evaluation Criteria
A. Scientific Culture; Life on Our Planet	Characteristics of animals and plants. Ecosystems and their relationship with humans.	Mathematical competence and competence in science, technology, and engineering and civic competence.	Recognize the characteristics, organization, and properties of elements of the natural, social, and cultural environment (. . .). Identify simple and direct connections between different elements of the natural, social, and cultural environment (. . .).

Table 5. *Cont.*

Block of Curricular Content	Specific Content Within the Curriculum	Main Curricular Competencies Contribution	Examples of Evaluation Criteria
C. Societies and Territories; Challenges of the Modern World	Maps and plans at different scales. Orientation techniques through the observation of physical environment elements and other means of spatial location. The climate and the landscape. Uses of space by humans and the evolution of productive activities.	Mathematical competence and competence in science, technology, and engineering and civic competence.	Recognize the characteristics, organization, and properties of elements within the natural, social, and cultural environment (. . .). Identify simple and direct connections between various elements of the natural, social, and cultural environment (. . .).
C. Societies and Territories; Societies Over Time	Natural and cultural heritage.	Competence in cultural awareness and expression.	To learn about and appreciate the natural and cultural heritage (. . .)
C. Societies and Territories; Civic literacy	Commitments and norms for life in society. The customs, traditions, and ethnocultural manifestations of the environment.	Civic competence. Competence in cultural awareness and expression.	Internalize basic rules for social coexistence (. . .). To learn about people, relevant social groups, and ways of life in different societies (. . .)
C. Societies and Territories; Ecosocial awareness	Climate change. Ecodependence and interdependence between people, societies, and the natural environment.	Mathematical competence and competence in science, technology and engineering and Civic competence.	Identify eco-social problems, propose possible solutions (. . .) protect the environment and promote the sustainable use of natural resources, while expressing the positive and negative changes caused in the environment by human activity.

Regional Ministry of Culture, Education and Sports [53]. Own elaboration.

3.2. Didactic Trail

The certified trail, known as the Cueva del Panzo Trail, is classified as a Short-Distance Trail (PR®) according to the trail regulations [56]. It begins at the Camino de la Rizosa and is designed to be completed on foot, although it can also be completed by bicycle or car, among other means. The route covers a distance of 8750 m, taking approximately 2 h or 4 h for a round trip (17,500 m). In terms of elevation, the trail ranges from a minimum height (above sea level) of 687 m to a maximum of 796 m, resulting in an elevation gain of 109 m. On the trail, five stops with informational panels stand out, along with an initial panel providing general information (Figure 3).

Although a route of 8750 m may be too long for a school group, the time required to make the round trip, stopping at the informational panels and taking a break, is compatible with a school day in Spain. In addition, the road is in good condition to be able to make the journey by bike, car or bus, which allows, for example, to make only the outward journey, using a bus to pick up the children, or travel by bus for the first section (up to information panel 1), which shortens the journey to 5700 m.

The Cueva del Panzo Trail follows pre-existing public rural roads (mainly the "Camino de la Rizosa") located within the municipality of Quintanar de la Orden. They are compacted dirt roads, whose surface consists of packed earth, gravel, and occasional stones, typical of unpaved rural infrastructure in the region. Maintenance of this type of rural

roads falls under the responsibility of the municipal government often with support from the provincial council. These authorities oversee ensuring the road remains passable and safe. In addition, the Mountain Federation made sure that the roads were in good condition before the approval of the trail, so one of the first steps of the local administration in this project was to ensure a good condition of the roads.

3.2.1. Trail Layout and Panel

According to the trail regulations, the trail has been classified as easy, considering the distance, elevation gain, and the type of terrain it traverses. Each of the panels along the trail (Figure 4) presents information about the most notable features that can be observed at each stop. The initial panel (Figure 4a) includes details such as the name of the route (Didactic Trail Cave of the Panzo), Maps showing the trail's location (where green lines with red dots at the start and end show the trail's path), a graph showing its elevation profile and the elevation changes, the difficulty level (DIFFICULTY: Low), the estimated duration (ESTIMATED TIME: 4 h), the total length (ROUTE LENGTH: 17.9 km), as well as relevant signs to be found along the route and the logos of the organizations involved in its design. Finally, the name of the student involved in the project. On the back side of the panel (Figure 4b), there is information about notable elements that can be found along the route, as well as some related images.

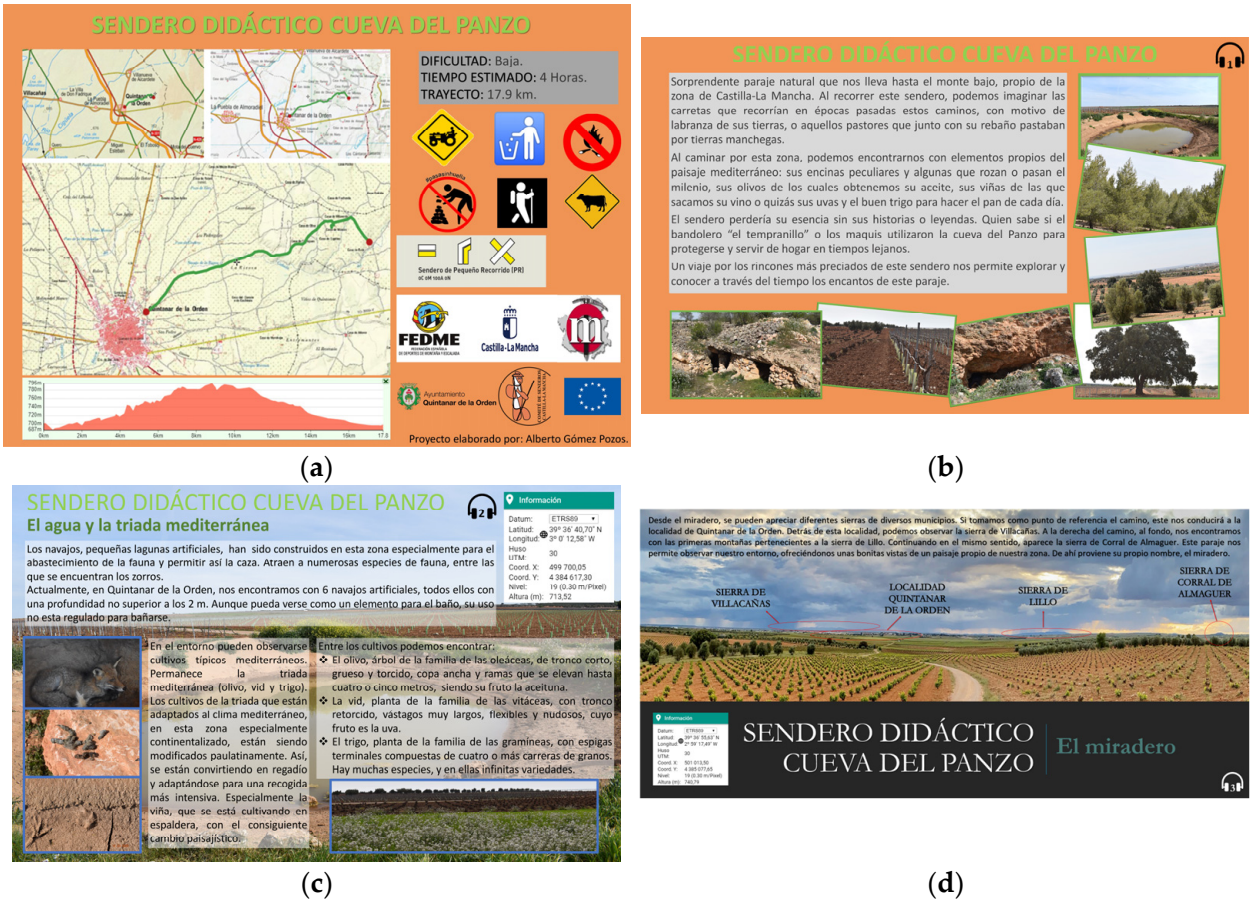

Figure 4. *Cont.*



Figure 4. Informational panels of the Cueva del Panzo trail. (**a**): the initial panel of the trail; (**b**): the back side of the initial panel; (**c**): panel of the second stop; (**d**): panel of the third stop; (**e**): panel of the fourth stop; (**f**): panel of the fifth stop; (**g**): final panel of the trail.

The second stop will take place at the *Navajo de la Rizosa* (Figure 4c). Here, we can find information about water in the area and how it is used, especially by local farmers and wildlife. Specifically, the water comes from small artificial ponds, which are locally known as *navajos*. In addition, there is information about the crops of the Mediterranean triad—wheat, olive, and vine—which can be seen at this stop next to a *navajo*.

The third stop is intended to allow visitors to especially appreciate the area's landforms, focusing on the geomorphology and landscape of various small mountain elevations (Figure 4d).

At the fourth stop, called *El Itar del Clavelito* (Figure 4e), referring to the *Itar* that can be observed, a hard-type soil that farmers must remove in order to cultivate. This is due to the precipitation of carbonates from the limestone soil of the area. This stop, in addition to addressing soil science, is also designed to cover the biogeography of the area, including both the flora and fauna.

The next stop on the trail is at the *Encina del Chori* (Figure 4f), a name given to this ancient oak tree in the area, named after the nickname of the landowner where it is located. Once again, at this stop, the biogeography of the area is addressed, as well as some local customs, as during Christmas, the inhabitants of the town of Quintanar de la Orden often decorate the tree with lights.

Finally, the sixth and last stop takes place in the cave that gives the trail its name, the Cave of Panzo (Figure 4g). It is a cave carved into the limestone rock that has served as a refuge for shepherds and their livestock, as well as farmers who spent days away from home. Additionally, according to the elderly people of the town, this cave has also served as a refuge for bandits or refugees during the Spanish Civil War. In the cave, one can

better understand the relief, climate, history, or the ethnographic traditions and customs of Quintanar de la Orden.

3.2.2. Alternative and Augmentative Communication Systems to Improve the Cognitive Accessibility of the Trail

The trail serves not only as an educational tool but also as an inclusive space that promotes the active participation of individuals with disabilities in recreational and educational activities. In addition to the initial informational panels, alternative versions have been developed to enhance cognitive accessibility for the widest possible range of trail users. Some of these resources are included on the panels themselves and can be accessed by any user via the QR code found on the main route panel. Others, such as the panel texts in Braille (Figure 5a), pictographic format (Figure 4b), and easy-to-read format (Figure 5c), must be requested in advance from the local town hall before starting the route.



Figure 5. Examples of information panels for the Cueva del Panzo trail in (**a**) Braille; (**b**) pictographic format (on the left panel, there is a map displaying the outlined trail, a green line with red dots at the beginning and the pictograms; map-mapa. Them, the name of the trail trail -sendero, cave-cueva- of-del-, Panzo and haiking –senderismo- on the right panel, in addition to the trail name, pictograms appear with this meaning: the caves are used for protection from cold, rain, or heat; and (**c**) easy-to-read format.

Using this audio guide is very simple. In addition to the QR code on the main panel, it can also be accessed by downloading the free IZI.TRAVEL app and typing 'Sendero Cueva del Panzo' into the search bar. To link each audio segment to the corresponding panel, an icon with the stop number (Figure 6) can be found on each panel.



Figure 6. Icon indicating the audio guide stop number displayed on each panel.

The audio guide whose corresponding code, which is displayed on the panels along the route, is available at the following address https://izi.travel/es/ff36-sendero-cueva-del-panzo/es?lang=es (accessed on 22 May 2025), not only allows us to listen to the content of each panel but also provides the written text. In addition, it offers another valuable feature: the route map. This enables users to see their current location along the trail, helping them avoid getting lost.

On the other hand, panel texts in Braille (Figure 4a), pictographic format (Figure 4b), and easy-to-read format (Figure 4c) allow access to information for individuals with limited vision, autism spectrum disorders, motor disabilities, and cognitive impairments, respectively.

Finally, it should be noted that, to test the effectiveness of the audio guide and to inform future adaptations in the design of the last two types of panels, the route was completed by two individuals: one with autism spectrum disorder and another with an intellectual disability (Figure 7). Also, the audio guide was tested with older adults experiencing reading and writing difficulties. The use of QR codes activating the audio guides proved to offer autonomous access to trail content via audio. At the same time, the evaluation of pictograms helped the participant successfully identify and understand elements of the landscape, demonstrating the effectiveness of visual aids. And adapted panels using easy-to-read formats enabled comprehension and interaction with the trail, promoting greater autonomy.

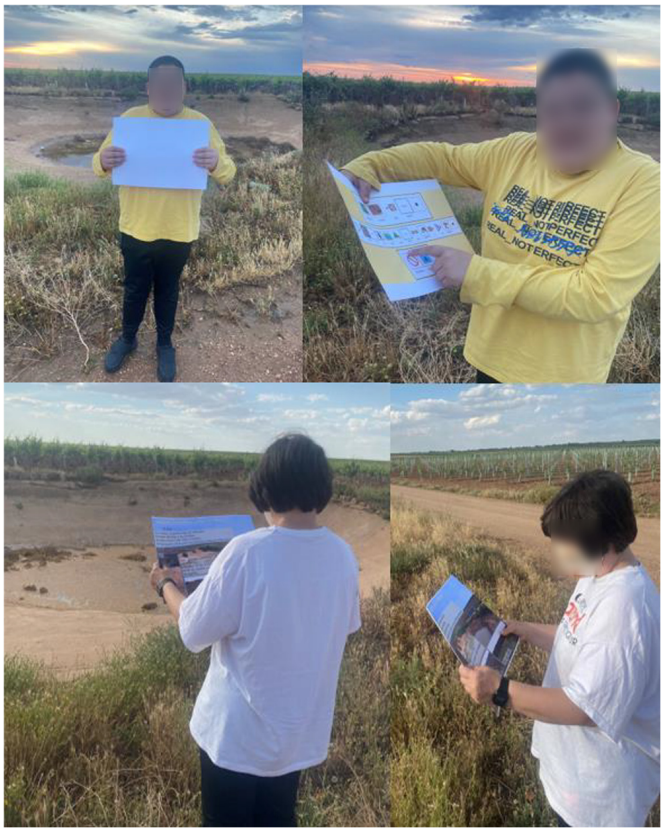

Figure 7. People testing panels in pictographic format and easy-to-read format in the second stop of the Cueva del Panzo Trail.

As a result of the development of the project, along with the materials created within it, a significant contribution has been made to the achievement of multiple SDGs, in alignment with the 2030 Agenda (Figure 8). These outcomes highlight the project's potential as a model for integrating sustainability into educational and community-based initiatives.

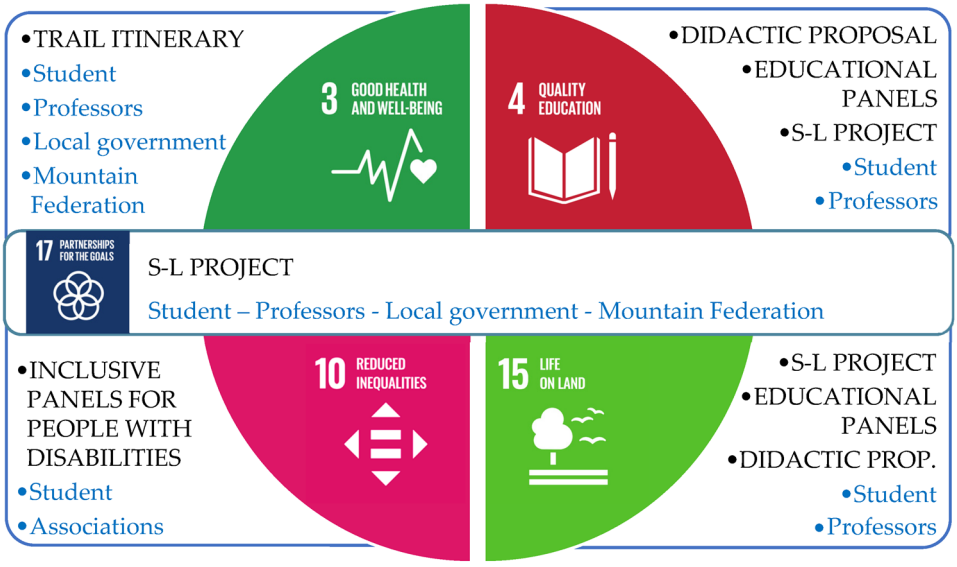

Figure 8. Relationships between the educational materials created in the S-L project and the SDGs. In black letters, educational materials; in blue letters, involved actors in the creation.

3.3. Qualitative Results

3.3.1. Initial Phase: First Focus Group

Starting with the first category, general impact of the trail, all the participants consider that the trail could strengthen the sense of belonging and pride among residents, promote civic participation, and become a space for intergenerational connection. Additionally, it is anticipated to boost the local economy through sustainable tourism, bringing direct benefits to small businesses and community enterprises. In this sense, it is of upmost importance to include the quote from the councilor: "I believe this trail could be beneficial, as it could become a space for people to connect and come together." Furthermore, all the participants highlighted the value of the trail from the educational, tourism, and environmental points of view. The student explained that "the trail is seen as a living learning resource that enables hands-on learning connected to the environment and integrates content from various subjects in an interdisciplinary way". The tutor from the university said that "not only the educational value, but also the touristic and environmental value should be considered, as tourists could seek authentic and sustainable experiences". Finally, within this category, one of the main aspects to take into account in this initial phase should be the active collaboration of the local community in designing the trail. This collaborative approach has helped identify cultural landmarks, local stories, and environmental points of interest that enrich the trail experience and strengthen the connection between the land and its people.

Continuing with the next category, educational dimension, we have to outline that the student presented a high level of motivation to start this project. Similarly, the tutor of this student said that "the trail could be considered an outdoor classroom in contact with the nature in a specific territory where an experiential, interdisciplinary, and contextualized approach can be developed, providing learning opportunities for the community while also fostering skills in the student involved in its development. Additionally, it can integrate tourism development to promote local growth. In this case, the student is going to be the

main responsible for the teaching-learning process by the S-L methodology supported by the municipal institutions and the federation". All the participants also consider that all the competences could be promoted through this project; the professor stated that "the undergraduate student can enhance service competences due to the project with the aim of contributing to an Education based on sustainable development".

With respect to the category named technical and institutional dimension and its relationship with evaluation and homologation category, the councilor explained that "the main aspects to take into consideration are essentially safety, signage, and maintenance". Also, he added that "it should be attractive and safe, especially we have to guarantee the safety of the route and its access". Within this category, the councilor manifested that "I commit to supporting the development of the project, financing the work of the Mountain Federation, and advocating for the project's funding through higher-level management bodies. I offer direct support for the development of the trail as both an educational and touristic infrastructure. This includes a commitment to technical funding and intersectoral coordination. The potential of S-L as a replicable model is acknowledged".

Finally, all participants emphasized the need to collaborate from different perspectives and roles. For example, from the university institution: identifying needs, designing the route, selecting points of interest, and creating informational panels in various formats. Also included is the pedagogical evaluation of its usefulness with students, as well as the design of an evaluation questionnaire for local tourism staff.

The local manager commits to accepting the initiative and supporting it financially, institutionally, and technically so that it can be developed. A technical advisor of FEDME commits to officially approving it and promoting it on their website. Regarding the future roles of each participant in the project, they could include from the university, leading literacy initiatives and evaluating student learning outcomes; from the local government, promoting the trail, ensuring its maintenance, and collecting feedback from non-school visitors. The FEDME would be responsible for its promotion and visibility. There is direct support for the development of the trail as both educational and touristic infrastructure, along with a commitment to technical funding and intersectoral coordination. The potential of S-L is recognized as a scalable and replicable model.

3.3.2. Final Phase: Second Focus Group

Starting with the first category, all the participants agree that the trail was perceived as a highly valuable educational, touristic, and environmental infrastructure. From an educational standpoint, it was seen as an extension of the classroom that enabled experiential, contextualized, and cross-curricular learning, aligned with the principles of ESD. It promoted active student participation and fostered the development of key competencies. In terms of tourism, the trail generated interest as a local resource offering meaningful experiences for both school groups and the general public. Its potential to boost the local economy through sustainable and environmentally respected tourism was highly valued. From an environmental perspective, the trail contributed to awareness and education, encouraging respect for nature, local biodiversity, and the need to conserve ecosystems. It also served as a community resource for environmental literacy. Also, several elements emerged as relevant during the development of the project: collaboration between the institutions, the active role of the students based on S-L approach, the application of UDL, adapted signage and educational content, and finally, institutional and technical commitment.

Regarding the educational dimension, the student stated that "I am highly satisfied with the project because I have developed curricular competencies and a genuine commitment to the environment. I propose strengthening the inclusive and digital approach, as well as involving more students through active methodologies in future phases. It has been

a transformative experience that has allowed me to develop curricular, social, and technical skills". Similarly, the professor considers that the project has had a significant impact on that student mentioned. However, there is a need for continuity and expansion of the project. The trail as a learning tool remains powerful. Nevertheless, planning is required to involve more students and to implement tools to evaluate its educational impact.

Continuing with the technical and institutional dimension, following the implementation of the project, the municipal institution is now considering broader participation in similar initiatives in the future. At the same time, they remain committed to supporting the current trail by promoting it both as an educational resource and as a valuable destination for visitors.

They recognize the trail's potential to serve as a model for sustainable development, environmental awareness, and community engagement. As such, the municipality plans to highlight its importance through ongoing inclusion in touristic promotional materials. This continued support underscores the institution's commitment to fostering long-term impact and ensuring the trail remains a vibrant, well-used public asset.

All the participants believe that the trail is safe and well signposted. In this sense, the representative of the FEDME stated that "the safety, signage, and visibility of the trail have been optimally ensured". All of this highlights the need to use this project as a model to be replicated. Therefore, dissemination is essential.

Finally, the cooperation among all the agents involved in the project has been positive and adequate. To assess the social impact, all members agree on the need to strengthen inter-institutional collaboration through shared action plans.

4. Discussion

Starting with the first objective, a trail that fulfills the principles of sustainability proposed by Marion [57] has been thoughtfully designed and managed.

Also, the trail stands out for its commitment to cognitive accessibility, offering information in a variety of formats to ensure inclusiveness. The results obtained through the on-site evaluation of the trail allow us to conclude that the inclusive adaptations implemented were effective in terms of accessibility, content comprehension, and overall user experience. This consolidates their usefulness in real-world settings.

Visitors can access interpretive content using an audio guide available via QR codes placed in the panels along the route interpretive. Also, Braille signage, pictograms, and easy-to-read texts have been elaborated by adapting the information displayed on the panels. These resources are designed to accommodate diverse needs, making the trail an inclusive space for learning and exploration. Such considerations are still uncommon in trail planning, where cognitive accessibility often receives little attention despite its crucial role in promoting equal access to environmental education. However, in the future, it would be useful to include translations of the trail signage and the online text and audio materials into languages other than Spanish to enhance accessibility, promote tourism, and support educational goals.

Beyond the physical and environmental advantages offered by educational trails, it is essential to create inclusive learning opportunities for all users. This involves recognizing that not everyone processes information in the same way and that design must reflect this diversity. As Caro [37] argues, adapting environmental information to be cognitively accessible enables individuals with comprehension difficulties to engage meaningfully with their surroundings.

Janeczko et al. [38] also point out that many interpretive panels found on nature trails remain inaccessible to the general public, primarily due to the use of overly technical or complex language. This creates a barrier to understanding, limiting the potential

for educational engagement and excluding visitors who might otherwise benefit from the experience.

To address this issue, it is essential to incorporate augmentative and alternative communication systems. According to Luckasson et al. [39], these tools are fundamental for fostering personal growth, access to education, and overall well-being. They support individuals in navigating and interacting with their environment more independently, while also enhancing their confidence and sense of self-efficacy, as noted by Montero [40].

Consequently, the need for cognitive accessibility extends beyond convenience—it is a matter of social inclusion and equity. As stated by the Federation of Organizations of People with Intellectual or Developmental Disabilities [41], cognitive accessibility refers to "the characteristics of things, spaces, or texts that make them understandable to everyone" (p. 13). Ensuring this level of accessibility in natural settings is not only a matter of good design but a necessary step toward truly inclusive outdoor education and recreation. The results obtained through the on-site evaluation of the trail allow us to conclude that the inclusive adaptations implemented were effective in terms of accessibility, content comprehension, and overall user experience, thereby confirming their usefulness in real-world contexts.

Furthermore, this trail has been designed with a strong focus on ESD. Our goal was not only for visitors to enjoy the natural surroundings, but also to raise awareness about the threats these environments face due to human activity and climate change. In this case, both objectives have been successfully achieved.

According to Megerle [28], a well-structured geoeducation approach not only deepens the understanding of geological and natural phenomena but also fosters responsible and conscious learning about the relationship between humans and the environment. By integrating ESD with geography education, it becomes possible to raise awareness of the human impact on natural systems, an essential step toward encouraging conservation practices and cultivating a greater respect for ecosystems [29].

To achieve this, several strategies have been implemented within the trail's design. These include the training of guides specialized in environmental education, the development of educational materials tailored to different audiences, and the incorporation of new technologies. All these elements contribute to an effective geoeducational experience aligned with sustainability principles, supporting the broader goal of empowering individuals to act more responsibly toward nature.

In addition to its environmental and educational objectives, this trail directly contributes to the achievement of several United Nations SDGs [19]:

Firstly, by encouraging physical activity in a natural setting and promoting mental well-being, the trail contributes to SDG 3, enhancing public health and quality of life. Exposure to green spaces has been consistently linked with physical and psychological benefits, including stress reduction, improved mood, and increased levels of physical fitness.

Secondly, the trail functions as an open-air classroom, offering inclusive and engaging learning opportunities for all users, aligned with SDG 4. Through well-designed interpretive materials, cognitive accessibility features, and trained guides, it supports life-long learning and environmental education—especially within the framework of ESD. This strengthens people's capacity to make informed decisions that benefit themselves, their communities, and the planet.

Thirdly, by incorporating accessibility measures—such as Braille panels, easy-to-read content, pictograms, and multiple means of information—the trail fosters inclusion and equity, directly linked with SDG 10, which focuses on reducing inequalities. It ensures that people with cognitive, visual, or learning disabilities can enjoy and benefit from the experience on equal terms.

Continuing with the second objective, it was to analyze the perceptions of those involved in the design and implementation of this project. The results reveal a clear consensus among participants regarding the value of the trail as an educational, touristic, and environmental infrastructure. From an educational perspective, the trail was perceived as an extension of the classroom, enabling experiential, contextualized, and cross-curricular learning aligned with the principles of ESD. It also fostered active student participation and the development of curricular, social, and technical competencies. For future stages, it is suggested to strengthen the inclusive and digital approach and to involve a greater number of students through active methodologies. Additionally, the need to implement tools for evaluating the educational impact of the project is emphasized.

In terms of tourism, the trail has generated interest as a local resource offering meaningful experiences for both school groups and the general public. It holds strong potential to stimulate the local economy through sustainable and environmentally respectful tourism. From an environmental standpoint, the trail was valued for its contribution to ecological awareness, understanding of local biodiversity, and promoting the conservation of ecosystems. It is recognized as a key community resource for environmental literacy.

The literature supports the view that the S-L methodology is among the best practices for promoting sustainability [58–60]. Several critical elements were identified throughout the project's development: effective collaboration between institutions, the active involvement of students through the S-L approach, the integration of UDL, the implementation of adapted signage and educational materials, and a strong institutional and technical commitment. These findings align with existing studies, which highlight not only improved institutional collaboration but also educational enhancements, such as the application of UDL principles [61–63].

Institutional support was highlighted as a decisive factor. The local government expressed its willingness to continue supporting and promoting the trail, integrating it into local educational programs and tourism materials. The municipality also sees the trail as a potential model for sustainable development, environmental awareness, and civic engagement. Safety, visibility, and signage were also considered to have been properly ensured, reinforcing the trail's suitability as a replicable example for similar initiatives.

All stakeholders evaluated the inter-institutional cooperation positively. However, one key area for improvement is the assessment of the trail's social impact. To address this, participants recommended designing joint action plans, conducting surveys among visitors, and establishing specific indicators to evaluate its educational use and broader community impact.

Lastly, the long-term sustainability of unsealed trail beds is a critical issue, especially if usage increases. In this case, the trail's integration into an existing, maintained public road network reduces the need for additional infrastructure investment. However, it would be advisable to monitor the surface wear and user impact over time. Future educational trail-building projects should consider incorporating periodic surface assessments and community-based maintenance strategies to ensure durability and safety.

Regarding future research, it would be valuable to assess the level of literacy and engagement related to the use of this educational trail. Such an analysis would provide in-sights into how effectively visitors understand and interact with the interpretive content, as well as the extent to which the trail fosters meaningful learning. By evaluating cognitive, emotional, and behavioral outcomes, researchers can better determine the trail's real impact on visitors' knowledge, attitudes, values, and even potential shifts in environmental behavior. This type of assessment would also help identify areas for improvement in educational design, accessibility, and communication strategies to further enhance the trail's role as a tool for ESD. Another future research line could be the study of visitors' profiles

and their satisfaction with the trail. It could offer a more comprehensive understanding of the trail's reach and effectiveness.

5. Conclusions

To conclude, it is important to highlight that this article presents an innovative methodology, based on the service learning methodology, that fosters new alliances among universities, schools, public administrators, and policymakers. In this way, the role of education and teachers is not limited solely to instruction, as it also involves promoting services that support community development—such as, in this case, the creation of an educational trail.

The development of the didactic trail through service learning has demonstrated considerable educational, social, and environmental impact. It enhanced student competencies—including civic engagement, critical thinking, and environmental stewardship—while also contributing to community involvement and the promotion of sustainable tourism. Notably, the student played an active and transformative role in the project, acting as a connector between academic knowledge and local realities, thereby embodying the core principles of experiential learning.

The initiative also reinforces the potential of service learning as a replicable and scalable model, though future efforts should prioritize continuity, expanded student participation, and systematic impact evaluation to ensure sustained outcomes.

Through the design and implementation of this educational trail, several Sustainable Development Goals (SDGs) have been promoted, including SDG 3 (Good Health and Well-being), SDG 4 (Quality Education), SDG 10 (Reduced Inequalities), SDG 15 (Life on land ecosystems), and SDG 17 (Partnerships for the Goals), which focuses on building effective collaborations between institutions.

Another key aspect is that the trail has been designed to ensure both physical and cognitive accessibility, ensuring it is a safe and inclusive space for all visitors, regardless of their abilities.

Thus, while the trail serves not only as a recreational and educational resource but also as a meaningful space to foster environmental awareness and promote values such as care, respect, and responsibility toward nature, it also presents a valuable field for further research. Future studies should aim to monitor user profiles and satisfaction levels, as well as to propose improvements that enhance its potential as a tool for both formal and informal environmental education.

Finally, we would like to conclude with some advice and lessons learned from the project have been the next ones.

First, interdisciplinary collaboration proved essential. Involving diverse stakeholders—such as educators, municipal representatives, and experts from outdoor or environmental organizations—ensured that the trail met educational goals while remaining feasible from a logistical, environmental, and regulatory perspective. Regular communication and clearly defined roles helped maintain alignment throughout the project. At the same time, it is essential that all stakeholders demonstrate a genuine commitment and a willingness to collaborate. In particular, the involvement of the local government was critical, given the necessity of undertaking improvements to the route prior to the evaluation by the FEDME representative, as well as the need to allocate specific financial resources for this purpose. Likewise, the fact that the project was carried out in the students' hometown proved to be a decisive factor, as it significantly enhanced their motivation and engagement with the process.

On the other hand, embedding the project into an academic framework, such as a Final Degree Project, provided structure, theoretical–practical grounding, and consistent supervision. Despite its short duration, this format enabled more personalized monitoring

and attention, which would have been unfeasible with a larger student group due to the intensive time and personal involvement.

In terms of design principles, prioritizing accessibility, safety, and clarity in the educational content were key factors in creating an engaging with and inclusive trail. Educational signage should be visually clear, pedagogically sound, and adapted to different age groups and learning styles. The integration of digital tools (e.g., QR codes and mobile apps) could also enhance interactivity and accessibility.

However, several challenges and pitfalls were also encountered. One of the first challenges identified was the lack of information about points of interest in the trail by the student. To address this, testimonies were collected from local residents with extensive knowledge of the area, such as forest rangers, farmers, and individuals with experience in the life and environment of the mountain.

One common obstacle was navigating administrative procedures and obtaining necessary approvals, which can delay implementation if not addressed early. It was also necessary to consult the land registry to ensure that the trail runs exclusively along public roads. Environmental considerations also posed constraints, requiring adjustments to ensure that the trail did not negatively impact local ecosystems. Furthermore, maintaining a balance between educational content and user enjoyment can be difficult; overly dense or academic information may discourage engagement from casual visitors.

Another challenge encountered was acquiring the necessary training to develop the most inclusive proposal possible. Specifically, there was a lack of knowledge regarding how to prepare information for individuals with visual impairments. However, the National Organization of Spanish Blind People (ONCE) provided the student with a Perkins machine and offered guidance on its operation and the proper structuring of Braille content.

Overall, this experience underscores the importance of planning, flexibility, and stakeholder engagement. Future projects should aim to build strong institutional partnerships from the outset, develop clear educational goals, and anticipate the regulatory and environmental requirements specific to their location. With careful design and collaborative execution, educational trails can serve as powerful tools for place-based learning, environmental awareness, and community engagement.

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Abbreviations

The following abbreviations are used in this manuscript:

SDGs	Sustainable Development Goals
EDS	Education for Sustainable Development
S-L	Service learning
QR	Quick response
FEDME	Federation of Mountain Sports of Castilla-La Mancha
UDL	Universal design for learning

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