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Enhancing Earth and Environmental Science Undergraduate Students' Perception of Geographic Information Systems through Short Clips

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Abstract: Geographic Information Systems (GISs) cover a wide range of Earth and environmental science disciplines that have become essential for spatial data management, easing the digital transformation needs of our society. Despite the usefulness of GISs, they remain underutilised in academia, and many students do not understand the possibilities that these tools offer. To familiarise university students with the potential of GISs, we designed 11 short clips (less than 5 min long) recorded by Earth scientists with diverse backgrounds who shared their work experience with GISs to solve real-world problems. Through these short clips, we emphasised not only the multidisciplinary uses of GISs but also provided professional references for undergraduate students, including societal aspects such as gender equality, national and international mobility, private-to-public-sector transitioning, and different family circumstances. As a result, the students expressed their interest in the applications of GISs, many of which were completely new to them, highlighting the potential of GISs in terms of entrepreneurship and their usefulness in mitigating global change. Thus, we were able to transfer knowledge from research to university education and foster spatial data management skills in Earth science.

Keywords: Geographic Information System; Earth science; environmental science; innovative education; short clip

1. Introduction

Earth science plays a pivotal role in tackling and addressing societal challenges such as managing natural resources; mitigating climate change impacts, including sea level rise and natural hazards; and fulfilling global energy and resource needs in a sustainable way [1]. The role of Earth science is crucial as geological surveys serve as key instruments in the transformation towards a smarter and more resilient society [2]. Despite the relevance of geology for our society, it is becoming increasingly underrated in comparison with other sciences, especially at pre-university educational levels [3], raising the question of how it should be addressed in classrooms to become an attractive science for students.

Earth science generates large amounts of data that, once properly stored, managed, and processed, become a powerful tool to generate a digital twin or adaptive model of the Earth system [4–6]. In this context, Geographical Information Systems (GISs) emerge as indispensable tools for merging data and digital elevation models, with many of them derived from developing technologies such as unmanned aerial vehicles (e.g., drones) and satellite sensors that complement fieldwork, enhancing their research capabilities [7,8]. GISs are widely used to acquire, store, analyse, and display large amounts of spatial data, as well as provide new quantitative methods to face the challenges of the present-day world.

Nowadays, Earth science in higher education requires a range of competencies to conduct quantitative assessments, abstract analyses, and problem-solving exercises. The demands for GIS expertise encompass diverse sectors such as forest management, environmental and public health science [9,10], public administration for effective land use management [11,12], natural hazard assessment [13], and ecosystem preservation [14]. Additionally, private companies also rely on GIS tools for commercial applications, such as environmental engineering, telecommunication network planning, power system management, and feasibility evaluation to establish new industries and businesses [15]. Complementarily, the use of GISs in social science, education and STEM (science, technology, engineering, and mathematics) disciplines is also proof of their versatility [16,17]. Therefore, proficiency in GISs is an essential skill that geoscientists should incorporate into their curricula.

The integration of GISs in classrooms can effectively aid in the attitude and self-efficacy of students in STEM [18], their skills in understanding and analysing georeferenced 3D data [19], and their critical and spatial thinking processes [20,21]. Furthermore, the implementation of GISs in geoscience lessons is relatively easy nowadays thanks to the emergence of open-source GIS solutions. This facilitates their application to specific lessons and degrees [22], as well as in low-resource settings and/or institutions [23,24]. Nevertheless, geology graduate programmes are geared mainly towards an understanding of deep time (geological history) and the Earth's structure and materials [25] and often neglect teaching GIS courses aligned with other science subjects and fieldwork training. In general, there are a limited number of initiatives that strive to counteract this trend by fully integrating GISs within geology lessons, such as Google Earth™ (which is GIS-supported) [26], tablets for fieldwork [27], and web servers for online geoscience data utilisation or teaching classical geology [28].

Our main goal as educators is to prepare undergraduate students for their careers in geoscience [29] by facilitating their training and proficiency in GISs. Thus, motivated by the need for a more practical approach to GIS training and to make this software more accessible to university students, we ran the projects GIS Short Clips: Professional Applications in Earth Science (academic year 2022–2023) and Integration of GISs in Geology and Professional Opportunities (academic year 2023–2024). The projects consisted of 11 videos or short clips featuring entrepreneurs and workers from three private companies, researchers from four Spanish universities, and one UNESCO Global Geopark. Video-based pedagogy is a powerful medium to communicate content and facilitate new learning methods [30] and could also increase the interest of students in GIS-related businesses, international mobility, and interchange between public and private sectors. Furthermore, it may also contribute to visualising the role of women in science as, throughout history, women have been marginalised in this field of knowledge. Even today, the presence of women in STEM, especially in academia, is significantly lower than that of men [31]. We consider that our video-based pedagogy project may contribute to the Sustainable Development Goals of Quality Education and Gender Equality, supporting these skills through education, and building transnational research collaborations [32]. Our specific aims were to (1) give real-world examples showcasing the application of GIS in Earth and environmental science; (2) offer students role models that have gathered multidisciplinary experience in GISs, with an emphasis on equality, entrepreneurship, undertaking, and leadership; (3) enhance multimedia-based learning; and (4) facilitate the dissemination of our project beyond our own institutions.

The short clips projects aimed to serve as a platform to showcase practical examples of data processing in GISs to transfer raw data into required knowledge (e.g., by promoting collaborative learning and teaching and networking with other scientists). Knowledge is, in fact, based on information that has been organised, integrated, and systematised to increase understanding and awareness [33], and that is what we aimed to achieve with these projects. To reach the final goal of wisdom (Figure 1), reasoning, and effective knowledge processing is mandatory. This is the ability to apply relevant knowledge to different situations and act critically or practically in any situation [34]. Reaching this final stage is challenging but is also critical to decision-making, a fundamental tool for professionals in Earth science.

Together, professional experiences with GISs and the use of educational videos will not only broaden students' expectations but also empower them to apply the knowledge acquired during their university studies to their future decision-making processes [35]. Additionally, this approach aims to bring GIS-extracted knowledge closer to policy-makers and governance, as well as to industrial planning and applied science (Figure 1).

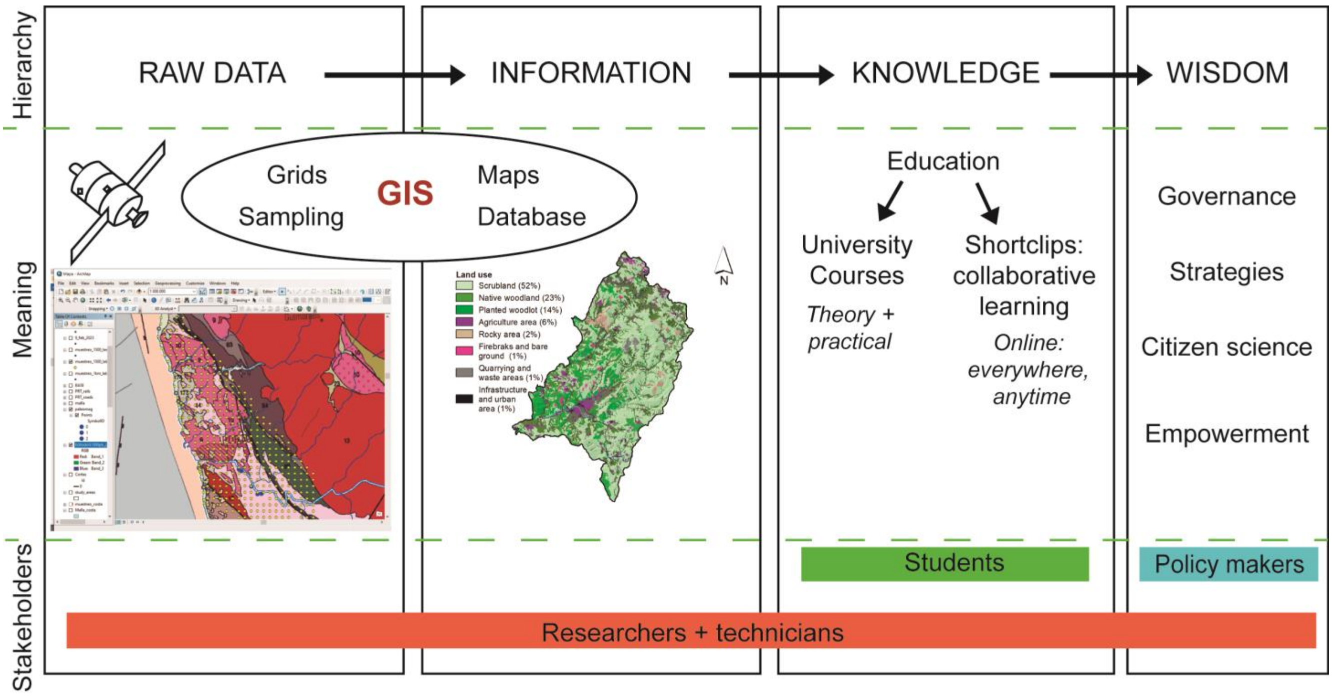

Figure 1. Workflow diagram showing the Data–Information–Knowledge–Wisdom hierarchy [36] for GISs in Earth science and the expertise transfer between stakeholders.

2. Context of the Projects

Nowadays, there is a general decrease in the interest shown in Earth science and geology in society. This is also observed in the decreasing number of students enrolling in BScs in geology at Spanish universities, which is likely related to the gradual disappearance of geological content in pre-university education [37]. Aware of this problem, and with the philosophy of reaching university students in a more innovative, practical, and useful way, we developed this project. It aimed to interconnect and counterbalance the excess of theoretical knowledge with the lack of information regarding real-case applications of a very useful tool in Earth and environmental sciences. All the videos shared the common learning outcomes of showing the personal and professional trajectories of different Earth science professions and the multidisciplinary uses of GISs. This allowed for the transformation of information regarding the uses of GISs into knowledge (Figure 1) in a way that we considered to be effective.

Significant efforts have been made to enhance GIS teaching through training texts, video tutorials, and e-learning courses that promote self-learning [22,28]. In fact, web-based learning has gradually gained prominence as a complement to traditional lecture-based classrooms [38], particularly during the COVID-19 pandemic, when many universities swiftly adjusted their educational materials and methodologies to online learning formats (e.g., [39–42]). As a common medium, videos are relatively easy to record, and the geographic scenarios exposed can provide a strong sense of realness, being easily understood and allowing the audience to access information [43]. However, the effectiveness of teaching–learning processes regarding GISs still lacks full integration and interoperability with other technologies and between different GIS platforms (e.g., spatial visors) or geographical data providers [44]. In addition, the videos provide a more personalised learning experience by considering the teacher (in this case, Earth scientists) as an information facilitator. Therefore, with the former projects, we wanted to focus on GIS possibilities and outcomes, rather than focusing solely on the technical aspect of GISs, to bring awareness among the future generation of geoscientists. Keeping this in mind, we developed the projects following three main steps: (1) content creation: preparation, elaboration, and recording of the videos; (2) implementation: individual visualisation and related survey; and (3) evaluation: evaluation of the project by the feedback provided by the students.

3. Methods

This work presents the results of two innovative education projects. The first of these projects, entitled *GIS Short Clips: Professional Applications in Earth Science*, was conceived to show final-year students of environmental science the different uses of GISs. After this, we decided to apply this content to university students in their first year who did not have extensive knowledge of GISs yet. Aligned with the course content, which included practical activities with Google Earth™, we recorded the 11th short clip, explaining how to prepare a fieldwork campaign. This was encompassed in the second innovative teaching project, *Integration of GISs in Geology and Professional Opportunities*. Thus, the projects we are presenting here resulted from cooperation among Spanish universities and three private enterprises, highlighting the multidisciplinary and interinstitutional nature of the projects (Table 1).

Table 1. Summary of the videos included in the projects.

Subject	Section	Expertise Area Covered in the Video	Institution
Structure of the solid Earth	5.2.1	Solid Earth	University of Salamanca
Local development and windfarm impact	5.2.2	Environmental sciences	Courel Mountains UNESCO Global Geopark
Natural hazards	5.2.3	Surface processes	University of Cantabria
Animal spatial ecology and anthropogenic climate change	5.2.4	Biology	University of León
Geomorphological mapping and analysis	5.2.5	Surface processes	University of Granada
Environmental influence on wild animal microbiota	5.2.6	Biology	University of Granada
Automatic detection of volcanic fans	5.2.7	Surface processes	University of Granada
GIS for geotourism	5.2.8	Geotourism	GeoLag company
GIS for education	5.2.9	Environmental education	Natures S. Coop. And
GIS for entrepreneurship	5.2.10	GIS development	DotGIS corporation
Fieldwork preparation	5.2.11	Solid Earth	University of Salamanca

These teaching projects aimed to provide examples and professional inspiration to environmental science, geology, and geological engineering students from the universities of Granada and Salamanca during the academic years of 2022/2023 and 2023/2024 (Table 2). With this, we intended to complement the theoretical and practical knowledge acquired during teaching hours and show students the wide variety of working options they may encounter in their future careers.

Table 2. Summary of the study cases in this survey.

BSc	Academic Year	Course	No.of Students	Subject Modality	University
Geology	1	Introduction to Geology	16	Compulsory	Salamanca
Geological Engineering					
Environmental Science	2	GISs, Remote Sensing, and Thematic Mapping	26	Compulsory	Granada
Geology	4	Applied Geomorphology	5	Optional	

The videos included a cognitive load divided into two parts: one focusing on key points of the life and career of eleven Earth science professionals with diverse backgrounds and the other on a GIS application to a case study. First, the speakers introduced themselves, sharing their personal and professional trajectories. The second part of the video focused on GIS applications through real case studies (explained in Section 4.2). The videos were designed to be concise, with a duration of less than 5 min each.

The videos were recorded in MP4 file format using the Open Broadcaster Software (OBS.27; https://obsproject.com/, accessed on 12 September 2024) and were subsequently edited by La Fresneda photography studio (https://fotoestudiolafresneda.com/, accessed on 12 September 2024) in Spain. The editing assistance entailed enhancing video quality, adding the project title, including the names and affiliations of the key characters at the beginning of each video, and including copyright information at the end. The speakers used conversational Spanish language to enhance student engagement. As part of the reflective learning, the students were encouraged to interact with the content by providing feedback through a survey in a learning management system, i.e., the Moodle-based platform of the Universities of Granada and Salamanca. The feedback served as an assessment tool to evaluate the utility of the videos, identify the strengths of the project, and discern weak points that needed to be improved. In fact, a future project might include the same inquiry both before and after the visualisation of the videos to assess their usefulness and the understanding of GIS utilities.

Finally, the feedback data provided by the students followed the Organic Law 3/2018 (https://www.boe.es/buscar/act.php?id=BOE-A-2018-16673, accessed on 12 September 2024): (1) the participants were informed in a transparent procedure about the purposes of the Teaching Innovative Projects; (2) the data obtained by their opinion survey, which was voluntary and never mandatory for the purposes of the project, were kept anonymous to protect the identities of the participants; and (3) the data were only used for the specific scientific purposes for which they were compiled.

4. Evaluation

4.1. Design and Strategy

4.1.1. Selection of Participants for the Videos

The Earth scientists that participated in this project met nine criteria to promote a diversity of backgrounds regarding age, regional origin, areas of expertise, working trajectory, current professional position, national and international mobility, public-to-private-sector transition, gender, and family circumstances.

The profiles of the presenters were junior to senior professionals from 28 to 46 years of age with diverse origins. They worked in different disciplines and positions and were committed to showing their personal and professional trajectories to help students comprehend their future possibilities and provide inspiring examples for the first steps of their professional careers. The videos included experts from various regions of Spain, as well as one professional from Uruguay (Figure 2a), with diverse educational backgrounds, ranging from bachelor's degrees (BScs) in geology or biology to master's degrees (MScs) in geology, GIS, biotechnology, or ecology; some of them held a PhD in geology, biology, or biochemistry (Figure 2b). This comprehensive education enabled them to become experts in solid Earth science, surface processes and land uses, ecology, microbiology, and geotourism (Figure 2c). As a result, they had achieved notable positions such as directors of private companies and assistant professors. One was a scientific director of a UNESCO Global Geopark (Figure 2d). These careers implied mobility within Spain, Portugal, France, Italy, and Brazil (Figure 2e), and some transitions from the public to the private sector or vice versa (Figure 2f). Furthermore, the videos emphasised important social aspects related to gender equality and different family circumstances (Figure 2g,h).

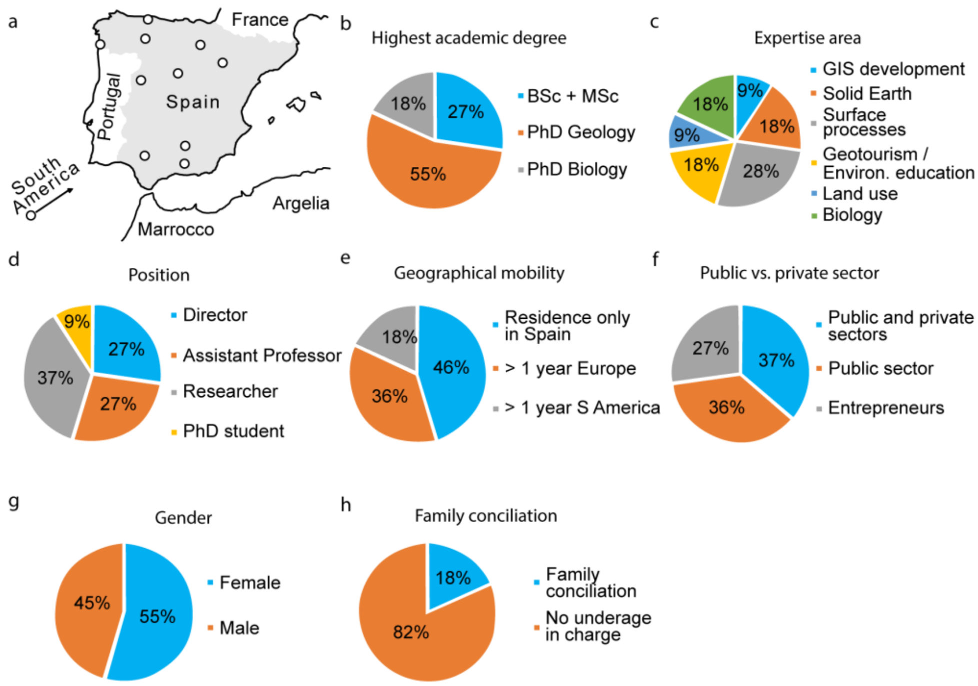

Figure 2. Overview of the main traits of the professionals participating in the short clips projects: (**a**) place of origin, (**b**) academic degree, (**c**) main discipline of work, (**d**) current position, (**e**) geographical mobility, (**f**) public-to-private-sector transitioning, (**g**) gender, and (**h**) work–life balance.

4.1.2. Video Structuration

In the first part of every short clip, the speakers presented aspects of their personal and professional trajectory, like internationalisation experience, multidisciplinary work, entrepreneurship, and industry vs. academic paths, as well as the promotion of social inclusion and the reduction of professional barriers for women (Figure 2). The videos also highlighted professional opportunities in geotourism and other businesses based on GIS technologies and the benefits of mobility during university training (e.g., the European Union supported Erasmus programmes during BSc and MSc courses), engaging in interinstitutional collaborations (e.g., research visits during PhD studies), and transitions between private and public sectors. In the second part of the videos, the speakers focused on how they apply GISs in their own research projects. Data and GIS processes used to address each case study were effectively shown using either ArcGIS 10.3, a commercial software programme widely used mainly in public administration and companies, or QGIS, an open-source programme. Additionally, one video specifically showcased the integration of R statistical computing software with GIS capabilities. The case studies presented encompassed a range of scales, including regional examples from Spain and South America, as well as two examples that displayed a global perspective. This diverse selection of case studies allowed for a comprehensive understanding of the practical applications of data and GIS processes across different geographic contexts.

4.2. Data Sources, Collection, and Analyses

The data presented in the short clips were the result of numerous projects focused on scientific research, applied work, and regional development in which the participants were involved.

4.2.1. Structure of the Solid Earth

GIS is a great tool to plan geophysical data acquisition and store and manage those data. To unravel the structure of the crust and upper mantle, seismic, magnetism, and gravity data are very useful tools. Unfortunately, these methods require significant scientific efforts, are expensive to acquire, and/or cover a geographically limited area [45]. To plan a geophysical campaign, GIS is an essential tool for designing and arranging acquisition geometry. Magnetism and gravity data are natural source methods that provide physical parameters to determine the structure of Earth's interior. To characterise large magnetic anomalies, a high-resolution cartography of local magnetic data is fundamental. A sampling grid with these characteristics was designed using a GIS as a first step to characterise magnetic anomalies in the Iberian Peninsula. Another example of seismic data management is the wide-angle seismic reflection/refraction profile acquired in the Spanish–Portuguese Central System [46,47]. GIS was used in this work to project the acquisition geometry of the experiment over the geological map to investigate the structure at depth.

4.2.2. Local Development and Wind Farm Impact

In Spain, there are 15 UNESCO Global Geoparks (UGGp). Specifically, in the Montañas do Courel UGGp, a comprehensive and exhaustive GIS database has been developed for effective land management of the territory [48]. This GIS database encompasses essential components such as base maps and relevant geological, biological, and cultural data, which serve purposes in geotourism, research, education, and conservation [49]. Ongoing scientific investigations and active involvement of the local population contribute to the continuous enrichment of the GIS database. This allows for addressing new challenges, such as assessing the potential visual impacts arising from the installation of wind farms near the UGGp.

4.2.3. Natural Hazards

Natural hazards related to fluvial, coastal, or slope instability processes often cause relevant damage and economic costs to the population and infrastructure [50]. These processes are influenced by various topographical, geological, geomorphological, and climatic factors, among others, and may exhibit a scattered and uneven distribution through the territory. In this context, the use of GIS is essential to link the location and timing of landslide occurrences with different geological and environmental variables. The example selected for this video illustrated the use of GIS to characterise the climatic triggering conditions for landslides in the surroundings of the city of Oviedo (northern Spain) [51]. GIS allows for the correlation of an inventory of spatially and temporally located landslides with data series of precipitation and soil moisture with different spatial resolutions. This type of analysis forms the basis for the development of early warning systems, which can improve the management of natural hazard scenarios in the future.

4.2.4. Animal Spatial Ecology and Anthropogenic Climate Change

The movement and migration patterns of animals across the globe depend on many intrinsic (e.g., sex, age, morphology, and cognition) and extrinsic (e.g., landscape and environmental variables) factors [52,53]. Among the extrinsic factors, environmental temperature stands out, and comprehending its effects on animal movement is crucial for forecasting and understanding climate change [54]. Thus, GISs is becoming increasingly useful in understanding the ecology of many threatened animal species and mitigating the impacts of anthropogenic climate change. For example, we recently assessed the risk of flooding of marine turtles' nests using digital elevation models and sea level rise projections [55]. In this short clip, the case study presented showed the effect of sea surface temperature (SST) on the aggregation patterns of beluga whales, which were located using machine learning classification of satellite images [56]. The study used GIS analyses of animal locations and SST projections for different climate change scenarios. All GIS analyses were conducted using the free programming language R [57], a powerful and flexible tool that can also motivate students to enhance their programming skills.

4.2.5. Geomorphological Mapping and Analysis

Since its inception, GIS technology has played a pivotal role in supporting various mapping tasks, including landform mapping. Some GIS software has been specifically designed not only to facilitate geological mapping but also to enable the analysis of a region's geomorphology [58]. For example, the SAGA GIS [59] offers a diverse set of tools for visualising and analysing topographic and geological data [60,61]. This short clip showed the use of two features of the SAGA GIS to automatically create an enhanced topographic map that can be exported to Google Earth™. The advantage of Google Earth™ is its virtual 3D environment that eases the identification of landforms and allows for the incorporation of additional spatial and geological information.

4.2.6. Environmental Influence on Wild Animal Microbiota

Microbiota play important roles in the physiology of their hosts, as seen in the case of the hoopoe (*Upupa epops*). These nesting individuals show specific microbiota shifts that provide protection against infections within the hole nests [62]. Beyond these reproduction-associated dynamics, we detected certain variations in the microbiota that seem to depend on environmental factors [63]. Therefore, we intend to explore which specific aspects of the hoopoe's ecology may be driving those variations. This short clip showed that, using GISs, we can overlap nest and habitat maps and create distance matrices that allow for the correlation of different ecological factors with microbiota composition. The results of these analyses, performed in R, demonstrated the effect of certain environmental variables on microbiota dynamics in the studied avian system.

4.2.7. Automatic Detection of Volcanic Fans

This short clip showcased the use of a GIS in a final BSc degree project on volcanic fan systems [64], which are suitable areas for living and farming. However, these areas are vulnerable to geological hazards, such as those associated with landslides or volcanism [65]. The goal of the study summarised in the short clip was to classify the fans based on their location relative to volcanoes to establish general patterns among fans in the same area and compare them with fans of non-volcanic origin. The work integrated the use of the GIS with aerial photography, allowing for the identification of volcanoes with associated fans from all over the world.

4.2.8. GIS for Geotourism

Geotourism is currently developing new strategies to attract a growing public, and GIS tools can provide innovative approaches to reach a new audience. This is the case with GeoLag (https://geolag.com/, accessed on 11 September 2024), an innovative geological enterprise that uses GIS technology to create geological routes and educational resources such as maps and drawings that target a diverse audience of all age groups. By leveraging GIS, GeoLag develops its own unique products and content. For instance, they employ GIS software or layout software to edit illustrations for popular science books, technical reports, and field excursions.

4.2.9. GIS for Education

In close relation to geotourism, environmentally oriented formation represents an opportunity for entrepreneurs, such as Natures S. Coop. And. (http://www.natures.es/, accessed on 12 September 2024). This company uses GIS to create customised maps and other resources for museums and exhibitions, using either their own data or the wealth of geospatial information available online. Additionally, GIS is used to catalogue noteworthy cultural, geological, and scenic sites, setting the basis for innovative geotourism routes. The company employs digital elevation models imported into GIS to generate 3D relief models that effectively link geology and topography. The outcomes of a project like this greatly facilitate accessibility and understanding of the landscape for, for instance, individuals with functional diversity (e.g., blind stakeholders).

4.2.10. GIS for Entrepreneurship

Another company that has established a GIS-supported business is DotGIS Corporation (https://www.dotgiscorp.com, accessed on 12 September 2024), which aims to select cutting-edge location intelligence solutions for new company establishments. Their GIS applications transcend the realm of Earth science, as they currently collaborate with numerous companies, providing advice on optimal locations for new businesses, company offices, and infrastructure projects. Specifically, the presentation delved into the use of GIS to accurately monitor vegetation changes close to high-voltage power lines in Brazil.

4.2.11. Field Work Preparation

Fieldwork is an essential part of research and teaching in geology, providing a wealth of multidisciplinary data and samples for further interpretation. To make the most out of a field trip, much information should be considered in advance, such as accessibility to outcrops, roads, and paths and previously published geological data like maps, cross-sections, stratigraphic and structural models, and/or seismic profiles. Gathering all this information together facilitates the organisation of the fieldwork and the successful achievement of the objectives, especially in remote areas. Google Earth™, a free and versatile tool, allows for the loading of all the spatial data that could be useful into a single file. During the fieldwork, the data collected can be directly loaded and projected into a Google Earth file, merging all the information into a complete project of the study area. This video presented an example of fieldwork preparation beforehand in a remote area.

4.3. Survey and Project Feedback

To encourage the students to consider their future trajectories and develop critical spatial abilities, we designed a rubric according to those principles. After watching the short clips, the students were asked to evaluate and provide feedback on their perception of the videos. The students replied to ten questions individually and from their homes, minimising influences from the rest of the classroom or the professor. The grading criteria and rubric considered for the survey (Table 3) were specifically designed to assess the students' opinions regarding the content. Specifically, questions were multiple-choice (Q1), close-ended with a yes or no answer (Q3, Q7, and Q8), or open-ended, so a larger and more reasoned response could be provided (the rest of the questions).

Table 3. Survey questions with the target aimed.

Statement	Target
Q1. Indicate the fields of work where GISs can be applied	To assess students' understanding of the extensive applicability of GISs, which is one of its key advantages
Q2. Out of the videos you have watched, which GIS applications did you find most intriguing or unexpectedly interesting?	To determine which videos were more appealing to students, gaining insights into their motivations and career orientations
Q3. Do you think it is important to study at different universities and develop professionally in different organizations, companies, and cities?	To assess whether students perceived mobility as a positive or negative factor
Q4. Do you think that GISs will be useful in your professional development?	To assess whether students considered GISs to be useful for their professional trajectories or not
Q5. Are GISs used in the private sector (companies) as well as in the public sector (administration, research...)?	To ascertain students' perceptions regarding the applicability of GISs in both public and private sectors
Q6. Do you think that GISs can be useful for the development of your own company in a hypothetical future?	To evaluate whether students perceived the applicability of GISs in supporting business creation
Q7. Can GISs build a real relief model (made of plastic) with the help of a 3D printer?	To understand student perceptions related to the use of GISs in combination with emerging tools such as 3D printers
Q8. Are GISs useful for the study of Global Change?	To assess students' perceptions regarding the application of GISs in mitigating global change
Q9. One of the videos mentions an international network of women scientists, do you think this type of initiative is useful?	To assess students' perceptions of women in science after watching the videos
Q10. Rate the overall interest of the videos	General opinions rated from 0 to 5

5. Results

The survey revealed a varied perspective among students regarding the versatility of GIS applications, with some differences in trends between geology/geological engineering students and environmental science students.

Among all the students, 38% of first-year geology/geological engineering students, 77% of second-year geology students, and 100% of fourth-year students recognised GISs' widespread utility across all fields presented in the videos (Q1 in Table 3, Figure 3a). In contrast, the remaining students expressed that GISs are limited to specific domains of expertise. In terms of thematic interest and unexpected topics, 36% of first-year geology/geological engineering students selected natural hazards and another 36% selected solid Earth as the most captivating subjects. Natural hazards were chosen by 60% of fourth-year geology students. Regarding environmental science students, they displayed enthusiasm for a diverse array of topics (Q2 in Table 3, Figure 3b). A noteworthy finding indicated that more than 80% of all the students acknowledged the positive impact of mobility during both educational and professional periods (Q3 in Table 3, Figure 3c). However, concerns about the financial implications of inter-university mobility were expressed by 20% of the fourth-year students.

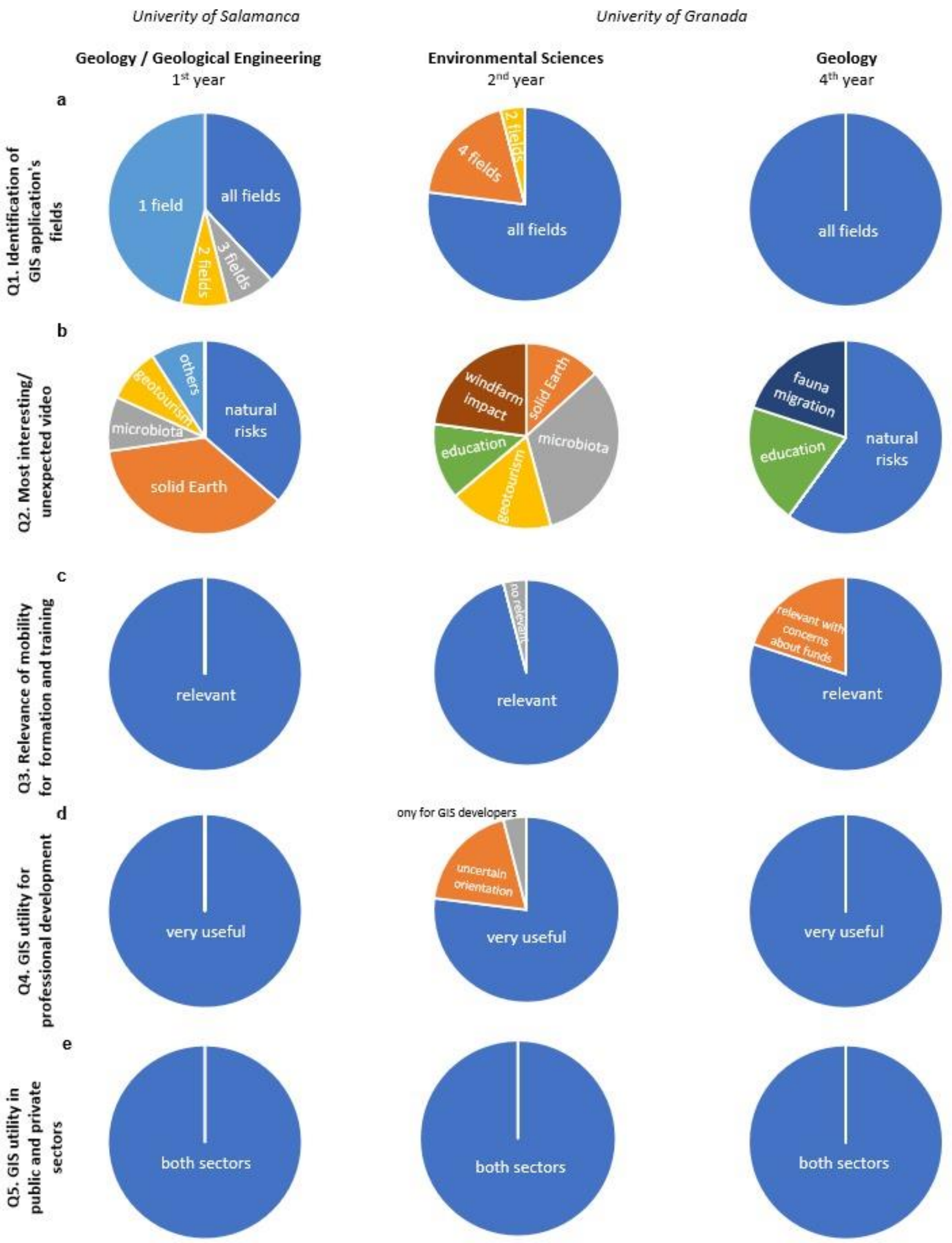

Figure 3. Student answers to survey questions 1 to 5 (**a**–**e**), designed to evaluate the utility of the short clips for teaching about GISs in Earth sciences. Questions are detailed in Table 3.

In terms of professional development (Q4, Q5, and Q6 in Table 2), there was a strong consensus (77–100%) among students regarding the substantial utility of GISs (Figure 3d) in both public and private sectors (Figure 3e). However, a remarkable 19% of environmental science students showed uncertainty about their career orientation, potentially considering roles where GISs may not be a prerequisite. Additionally, 4% of these students believed that GISs could solely be applied by GIS developers (Figure 3d). The survey also explored the perceived business applications of GISs, with 82–100% of students considering them to be beneficial for entrepreneurship (Figure 4a). Nevertheless, 18% believed that their usefulness depends on the nature of the business, while 11% of environmental science students questioned their relevance in public administration roles.

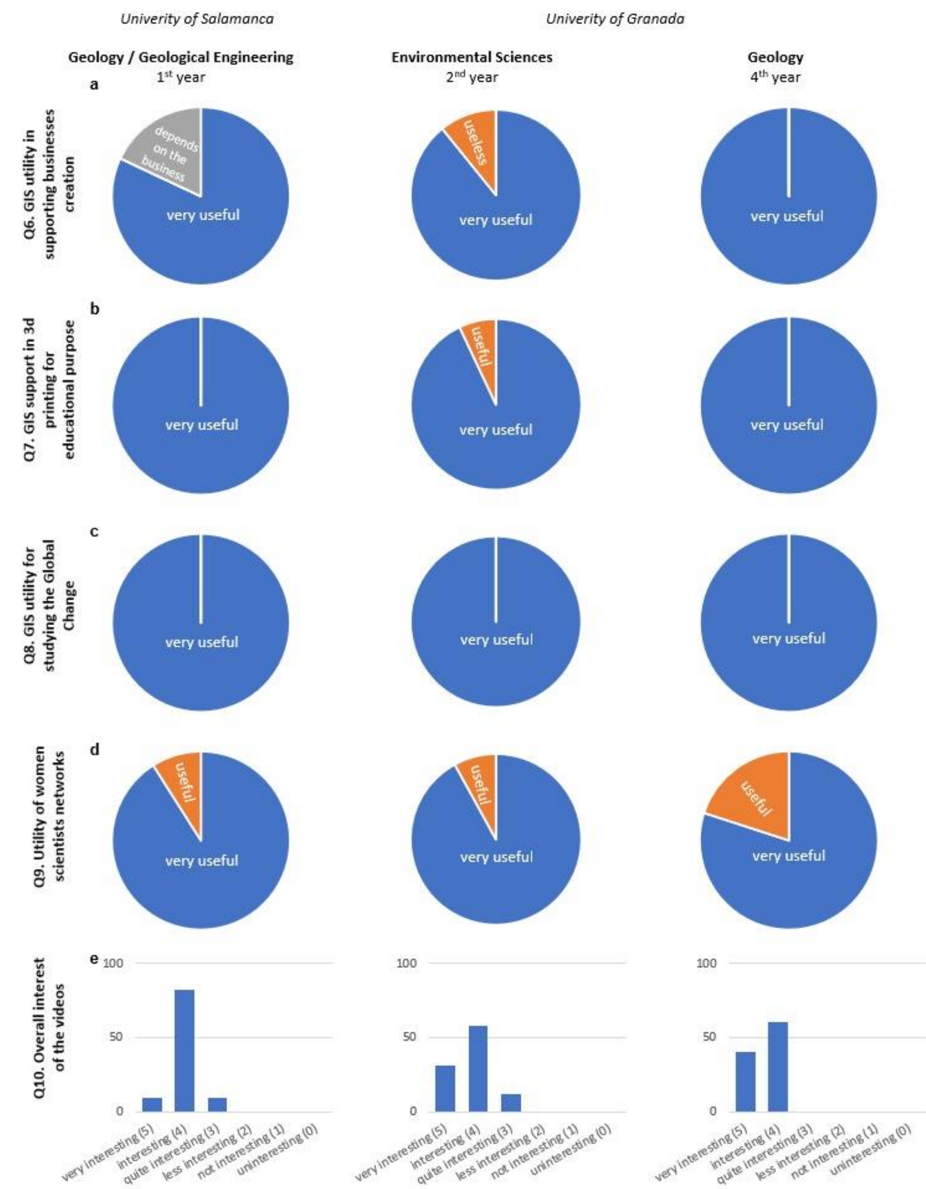

Figure 4. Student answers to survey questions 6 to 10 (**a**–**e**), designed to evaluate the utility of the short clips for teaching about GISs in Earth sciences. Questions are detailed in Table 3.

Regarding the specific applications of GISs (Q7 and Q8 in Table 3), an overwhelming majority (93–100%) of the students recognised the capability of GISs to support the creation of 3D models for educational purposes (Figure 4b). Moreover, 100% acknowledged the role of GISs in studying global change (Figure 4c).

In the context of gender equality in science (Q9 in Table 3), 80–92% of students viewed women scientists' associations as valuable for enhancing the visibility, value, and contributions of women to the advancement of knowledge (Figure 4d). However, 8–20% expressed concerns, believing that such initiatives might inadvertently discriminate or exclude male scientists. Finally, the overall rating of the videos was considered interesting (Q10 in Table 3, Figure 4e), showcasing a range of engagement levels among the surveyed participants. The ratings provided reflect the utility of the short clips for teaching GISs in Earth and environmental science.

6. Interpretation and Limitations

Based on the feedback received, it is evident that the students expressed overall satisfaction with most of the videos (Figure 4e). The students demonstrated awareness of the extensive versatility of GISs within Earth science and related disciplines, encompassing applications in both public and private sectors and the management of diverse and multidisciplinary datasets. However, a noteworthy percentage of students still associated GISs with limited fields of expertise, underscoring the broad applicability of GISs. They also recognised that GIS technology serves as a valuable tool for establishing new businesses, such as in geotourism. This field was revealed as an unexpected opportunity for employment. Overall, the videos were useful in narrowing the gap between academia (research and training) and industry, a benefit notably apparent in the context of virtual education [66]. Moreover, they acknowledged the utility of GIS tools in addressing hot topics like climate change and/or contributing to education while fostering equality, diversity, and inclusion. The students clearly understood the importance of mobility during university education and their professional trajectories. However, there remains a need to further promote the role of women in science to reduce gender inequality [67–69], emphasising that such initiatives do not exclude male geologists. The goal of women empowerment in this context was to reduce the gender gap by providing examples of female researchers and workers in Earth and environmental sciences, fields traditionally dominated by men.

The results suggest that the videos are highly suitable for effectively teaching about GISs in Earth science at the university level. This initiative appears to be successful, offering a model that other university courses can leverage, consult, and adapt for BSc and MSc programmes, thereby promoting Earth science and GIS knowledge to a broader audience.

As previously mentioned, a project like the one proposed here will provide undergraduate students with additional and complementary information to the theoretical contents explained at universities. This will enable them to make decisions in their future careers in an autonomous, self-sufficient, and unbiased manner. This last step requires a high degree of maturity, which is expected of wise professionals (Figure 1). Therefore, the more comprehensive, interdisciplinary, and cross-cutting information undergraduate students can access before completing their education, the greater their chances of success.

According to the main results, we also identified several limitations:

1. The videos were primarily tailored to students with full abilities, with only one video addressing those with visual impairments.

2. The videos were geared towards a Spanish-related audience; therefore, an adaptation (e.g., English subtitles) would be necessary to reach a broader audience.

3. There were insufficient examples showcasing the versatility of GIS tools and a lack of emphasis on using English in university communication, despite sporadic use as a secondary font in videos.

4. The exclusive focus of the videos was on university education, without an adaptation for outreach or social media exposure.

5. There is potential obsolescence of the videos due to the rapid progress in GIS technology development and research advancements.

6. There was a lack of a discussion frame among the students where they could properly evaluate and make the most out of the project.

7. There was an absence of a pre-video survey that prevented us from comparing answers with those given after watching the short clips.

Addressing these issues in future editions of the project can enhance outreach, broaden the scope of the initiative, improve teaching quality, and potentially introduce a novel university training methodology.

7. Conclusions and Future Perspectives

GISs are indispensable tools in Earth and environmental science for a wide range of applications in research, teaching, training, land management, and industry. The well-established and longstanding GIS tools make them indispensable for any professional working with spatial data. Aware of this, we made some of these GIS applications more accessible to university students through two innovative education projects involving short clips. The projects included eleven examples showing different case studies where GISs were used to explore the professional opportunities of geoscientists. With our initiative, we aim to provide younger generations with the tools to become policymakers, researchers, and professionals who can make wise decisions through knowledge, insight, and action.

The projects were successful according to the feedback provided by the students, who found the videos interesting and were surprised by the new applications of GISs and the fields to which these tools can be applied. Furthermore, complementary topics such as geographical mobility, gender equality, and entrepreneurship gave the students a broader perspective on their professional future.

With the philosophy of continuous improvement, we consider that this kind of initiative should be further promoted. For example, the project could be internationalised through incorporation as teaching material in ERASMUS+ projects currently underway (e.g., GEODES, 2023–2025, a project involving African countries aimed at developing models of best practices through shared activities among institutions from the countries involved). This is similar to what has been done with other teaching tools in another ERASMUS+ project, SUGERE (2029–2023 [70]).

Therefore, future projects will promote these activities with broader goals:

1. Teaching across continents and fostering closer ties between Europe, Africa, and Asia through European projects such as SUGERE, GEODES, and others that have been proposed, with the involvement of the University of Salamanca as one European partner.
2. Improving the quality of online teaching, especially during lockdowns [39].
3. Teaching in distant regions with incompatible time zones, enhancing GIS learning in an asynchronous mode, as implemented in the ERASMUS+ projects mentioned above.
4. Promoting this project to a broader audience that includes middle to high school education, other BSc programmes, and even MSc studies focused on education.
5. Service-learning approaches involving students to promote critical thinking and promote novel and practical methodologies in science education (e.g., [71,72]).
6. Expanding outreach and engaging young researchers who could create their own videos to share through networks (e.g., the IUGS network of young geoscience reporters from different continents) to promote GISs in Earth science.

Therefore, we conclude that our project was beneficial and encouraging for the students, although we detected some limitations. For example, we were not able to compare results before and after short clips were administered, as this was not taken into account when designing the innovation project. We intend to expand the applications of the project in the future, including the enrichment of further surveys to detect the effects of the short clips on students' perceptions. In addition, we want to focus on the quality of teaching to provide a more realistic professional perspective of the Earth and environmental scientists, as well as increase exposure through the international implementation and dissemination of results.

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