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A Geoethics Syllabus for Higher Education: Evaluation of an Intervention Programme

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Abstract: Geoethics is a field of knowledge currently in full development. Researchers in geoethics are primarily concerned with the anthropogenic interaction with the Earth system. Due to its nature, geoethics holds particular importance in sustainable development due to its nature as it aims to promote ethical human behaviour that does not negatively impact the Earth system. In the present research, we implemented an intervention program addressing various issues related to the sustainability of the Earth system, such as the exploitation of geological resources, the management of geological risks, and the conservation and promotion of geopatrimony. The intervention program was applied to higher education students in the geosciences field. A sample of 90 students from various geosciences courses completed an initial questionnaire, revealing limited knowledge about geoethics. This study resorted to mixed-method research involving interviews with some students who volunteered (n = 52). The results showed that after applying the intervention programme, most students developed a deeper understanding of the topics addressed and recognised the contributions this scientific area can make to sustainable development. Additional research in geoethics education is essential to foster the integration of geoethics into the curricula of higher education institutions.

Keywords: geoethics teaching; geoethics syllabus; higher education; sustainable development goals

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1. Introduction

The relationship between society and planet Earth is becoming increasingly urgent, given the significant global problems we currently face, such as dwindling drinking water, the overexploitation of non-renewable resources, high consumption and production patterns, and climate change. The choices we make every day have a direct or indirect impact on the Earth system [1]. For this reason, decision making must always be accompanied by reflection on the positive and negative consequences of our future actions. Human beings are considered "geological agents", as it was scientifically proven that they impact the Earth system with their actions [2,3]. Morally, humanity must protect planet Earth and avoid behaviours that harm it. The impact of human beings on the Earth system is widely recognised, particularly by organisations of various kinds, such as NATO and the United Nations [4,5]. To better understand the impact of human actions on the Earth system, it should be noted that it comprises five distinct subsystems—atmosphere, biosphere, cryosphere, geosphere, and hydrosphere. The last is interdependent and shares cycles of matter and energy flow [1,6], demonstrating a deep interconnection. This particularity results in the fact that actions taken in one of the subsystems will affect the others. As such, the Earth system is characterised as a holistic, complex, and adaptive system [1,7,8], with

its dynamic equilibrium affected by and affecting human actions, a dynamic that results in severe disturbances that reflect current global challenges.

The progressive concern for the Earth's sustainability led the United Nations to develop the 2030 Agenda for Sustainable Development, published in 2015. This agenda should guide the nations involved towards sustainability. To this end, the fulfilment of human rights for all individuals, society's prosperity, and the need to ensure the planet's future must be considered. Thus, to fulfil the Sustainable Development Goals (SDGs), it is essential to reflect on and understand human actions on the Earth system to know what needs to change to ensure sustainability [9]. To this end, the solutions to the problems faced require the reflection of each citizen, making it very important that decisions are made on an ethical basis [10–13]. Consequently, it is vital to investigate geoethics, which is concerned with improving and reflecting on the relationship between human beings and the Earth, and sustainable development, which aims to ensure that we have a habitable and prosperous planet in the future.

In geosciences, geoscientists study the Earth system, and the knowledge and practices of this scientific field have proven to be essential in enabling us to understand the planet's limits so that it remains habitable [10,14]. Thus, the role of the geoscientist is fundamental to the beginning of a more sustainable future. Geoethics can play a role in solving problems by considering different aspects, such as the environmental and social impact of different solutions, helping geoscientists, for example, to decide on a more geoethical solution. In addition, geoscientists should collaborate with professionals from other areas from an interdisciplinary perspective that allows them to take advantage of more diverse knowledge that can complement each other [15], as well as being aware of the responsibility and social role that they also have beyond scientific practice [16], which are principles that geoethics defends.

Sustainable development is already widely recognised by society [17] and is even included in the educational curriculum of some countries. The same is not true regarding geoethics, a developing disciplinary area little known by society, even among geoscientists. Therefore, geoethics must be included in school curricula so that it can be increasingly practised by as many citizens as possible [18,19]. It also requires integration into higher education geoscience curricula or even lower education levels, so everyone can understand geoethics. It should be noted that geoethics also contribute to the fourth SDG, whose motto is the promotion of quality education for all, enabling citizens to acquire knowledge, competencies, principles, and values that are vital for promoting sustainability in the present and the future [19–21].

Based on this gap in the curriculum, the Erasmus + Geoethics Outcomes and Awareness Learning (GOAL) project was born, an international project that brought together experts from six countries with different expertise that gathered different perspectives during the work. The project created a comprehensive syllabus and educational program for imparting geoethics within higher education [22]. This initiative encompassed the development of educational resources, drawing upon the diverse expertise of the project's participating experts, thereby converging multiple scientific disciplines, including mineral resource management, geological risk assessment, the preservation of geological heritage, and water sciences. Every educational resource, along with the core curriculum, is specifically designed to emphasise the intricate connection between geoethics and sustainable development. This initiative encompassed the development of educational resources, drawing upon the diverse expertise of the project's participating experts, thereby converging multiple scientific disciplines, including mineral resource management, geological risk assessment, preservation of geological heritage, and water sciences. These educational materials are adaptable for use across various countries, although they are primarily tailored to cater to the educational needs of geoscience students in higher education [22].

The literature review has shown that although some attempts have been made to apply a syllabus of geoethics in higher education, this is the first to do so by integrating it into different curricular units. For instance, research conducted by two esteemed scholars [23]

underscores the significance of integrating ethics into science modules across various disciplines. This particular study serves as an illustrative example within the context of a comprehensive introductory geoscience course. This approach offers a unique opportunity to not only enhance students' grasp of scientific concepts but also nurture their critical thinking abilities.

As such, according to the literature reviewed, the research described here marks the first time that a syllabus for teaching geoethics has been operationalised and evaluated. This syllabus's operationalisation was intended to promote geoethics and its potential contributions to sustainable development in higher education geoscience courses. It should be noted that geoethics is a term used in other disciplinary areas, such as geography, and is discussed among social science researchers [24]. Some authors also suggest that it is possible and necessary to approach geoethics from different epistemological perspectives [24,25] or even mention the interdependence of epistemology and ethics [26]. However, this study is more practical, highlighting the theoretical approaches for other publications focusing on constructivist epistemology or complementary approaches.

The research problem that particularly motivated the development of this study was to assess whether a geoethics syllabus aimed at higher education students could promote knowledge about geoethics and its potential for the sustainability of the Earth system. Based on the research problem, the following objectives were defined: (i) to contribute to the teaching of geoethics in higher education by applying and evaluating a syllabus (intervention programme), (ii) to promote a deeper understanding of the theoretical foundation of geoethics and the potential benefits it offers when applied to sustainable development, and (iii) to encourage the consolidation of geoethics as a scientific area.

1.1. Geoethics: Origins and Evolution

Given the long history of the development of geoethics, this section was limited to presenting the aspects considered most relevant to its evolution as a still-emerging scientific area.

Ethical thinking about the relationship between human beings and planet Earth originated thousands of years ago [27,28]. However, geoethics is a recent and developing scientific area [10,29], given the outstanding commitment to its research and reflection. In its early days, geoethics focused its research on the specific ethical conduct of geoscientists. Nowadays, geoethics extends its research to the ethics that ordinary citizens should have regarding the Earth system. According to geoethics, human beings are responsible for caring for and preserving planet Earth, and this can be carried out via actions that mirror and respect this responsibility. It can be hypothesised that the application of geoethics could have a positive influence on planetary sustainability, both at a biotic and abiotic level [30,31].

In the works of Socrates (469 BC–399 BC) and from an environmental ethics perspective, reflections on the role humans, animals, and plants have throughout their existence were referred to. Socrates concluded that there are no essential differences between them, integrating the human being as an element of nature itself [31]. Some Roman philosophers also shared Socrates' ideas [32]. Later came Stoicism, a philosophical school founded by Zeno of Scythia (333 BC–263 BC), whose main idea was respect for all forms of life and nature itself [28,33,34]. According to the Stoics, there has to be equity between human beings, and they should not worry about material goods or money. Everyone should achieve self-sufficiency, moral integrity, and intellectual freedom, and, as Socrates argued, all living beings should be seen as equal and worthy of respect [28,35]. Nevertheless, these values seem almost forgotten in Western civilisation as Christianity grew and expanded. At the time, it was believed that God had given humans dominion over nature and the right to exploit it. Thus, the relationship between humans and the environment was not considered ethical [36].

This relationship of human domination over nature continued as science and technology developed in the modern period [27,35]. Over the years, the demand for natural

resources grew, leading to an imbalance between what humans exploited and what the planet could provide. Even before the Industrial Revolution in the 16th century, some thinkers were already aware of this unbalanced relationship between humans and the Earth system. In the 17th century, authors such as Matthew Hale (1609–1676) and William Petty (1623–1687) warned of the dangers of population growth and the subsequent exhaustion of natural resources [28].

In some presented cases, concern for the abiotic elements of the Earth system is undervalued; the inanimate part of the planet that sustains all life and allows it to exist has been the object of less concern for much of history. Ethical issues focused more on the biotic world, and in environmental ethics, the abiotic elements were mainly in the background. However, in the 19th century, the Italian geoscientist and expert geoscience communicator Antonio Stoppani (1824–1891) emphasised geosciences and their role in the progress of society, revealing ethical concerns for both biotic and abiotic elements. Stoppani considered humans to be "geological agents", given their ability to alter the dynamics of the Earth system [2,37,38]. As such, Stoppani considered that society's awareness of this fact gave it the responsibility to respect planet Earth. Stoppani is a true forerunner of geoethical thinking, and several authors call him one of the "fathers of geoethics" [2,28,39]. It should be noted that Stoppani argued that humanity must contribute to the ethical management of geo-resources. He introduced the concept of the "Anthropozoic Era" to characterise the period of geological time in which human behaviour changed and continues to change the evolution of the Earth's dynamics. This concern with the changes that human behaviour has on the dynamic balance of the planet can be considered a preamble to the current definition of geoethics [2,28]. It is easy to compare Stoppani's suggestion of a new "Anthropozoic Era" with the concept of the Anthropocene, a geological epoch proposed by Paul Crutzen (1933–2021) that is still being discussed by the scientific community [2,7]. The latter is a concept created following scientific evidence that human actions have significantly impacted planet Earth since at least the latter part of the 18th century, at the start of the Industrial Revolution [37,40]. Antonio Stoppani formulated some geoethics criteria that should underpin the decisions made by geoscience experts. His ideas came from observing the beauty and harmony of nature, and he emphasised the need for experts from various disciplines to work together, including the humanities, giving human beings an ethical duty to manage the environment well. Stoppani had a vision of the planet very similar to the contemporary holistic perspective of the Earth system described above, which is now essential for resolving geoethics issues and for the geoethical management of the environment, geo-resources, and geological risks [2,41].

In the last decade of the 20th century, the first references to the word geoethics appeared. The report "Adult Education for International Understanding, Human Rights and Peace" resulted from a meeting held at the United Nations Educational, Scientific and Cultural Organisation. From the Institute for Education in Hamburg, Kaisa Savolainen reflected on the right to an education that includes bioethical and geoethics approaches and classifies the latter as environmental ethics, warning of the urgency of having these ethical considerations in the education system [42]. On the other hand, Cronin [43] used the word geoethics at the annual meeting of the Geological Society of America, referring to the ethical responsibility of geoscientists regarding a scenario of potential geological risk and associated economic interests.

Another reference that gave direct attention to ethical concerns about the geosphere was made in 1991 at the 70th anniversary of Professor Adam Trembiecki's symposium in Krakow by geological engineer Václav Němec who used the word geoethics in connection with ethics for geology. The term geoethics was born out of the need for ethical principles for mining [39,44–47]. The same year saw the emergence of the new scientific field of geoethics [30,47], with some authors considering Němec as the father of geoethics [30]. Thus, in 1992, the first association dedicated to geoethics was created—the International Association for Geoethics (IAGETH) in Czechia [48].

The five-day conference in 1997 conducted by the Geological Society of America was a very relevant effort to access geoethics since geologists saw great value in developing their core values of professionalism in geoscience. Despite many differences in geologist professionals, all of them agreed that the core values should include scientific studies of the Earth, the development and production of resources, identifying hazards, applying knowledge to environmental issues, and providing education to the public, new geoscientists, and the profession [49].

In 1998, UNESCO's World Commission on the Ethics of Scientific Knowledge and Technology emerged, whose main concern was to create ethical principles so that decision-makers would not rely solely on economic aspects and would consider the ethical implications of their decisions [30].

In 2008, the first definition of geoethics was proposed, reflecting various aspects of ethical concerns regarding Earth and Planetary sciences, and the respect of space exploration can also be the behaviour of specialists studying the abiotic world [44]. The inclusion of planetary sciences in geoethics was justified because the current development is subject to ethical and scientific integrity issues, and the planetary protection required in these studies goes beyond the terrestrial planet [30,44]. In 2009 and 2011, two conferences followed, and geoethics was promoted.

In 2012, during the 34th International Geological Congress in Brisbane, Australia, the International Association for Promoting Geoethics (IAPG) was founded as a non-profit international multidisciplinary scientific association based in Italy, dedicated to research, reflection, and the dissemination of geoethics [10,49,50]. The IAPG thus proposed a second and expanded definition of geoethics, which focused on research and reflection on values that should guide behaviour and practices in the relationship between human beings and the geosphere [38,49]. The latter definition includes the habits of all citizens in the abiotic world and does not only assign ethical responsibility to geoscience experts. It gives all humankind the ethical responsibility to care for the planet [10].

The number of scientific publications on geoethics is growing, and in 2015, the first book on the subject edited by the IAPG was published, *Geoethics: Ethical Challenges and Case Studies in Earth Sciences* [51]. Despite this, geoethics experts have found it challenging to materialise contributions to the literature in quality scientific publications to contribute to the recognition of geoethics by the scientific community. The relevance of geoethics was high, but this last obstacle limited its research and dissemination, and few geoscientists devoted their work to this scientific area [10,14,30–32,38,45].

In 2017, Peppoloni and Di Capua proposed a definition of geoethics that is used in this study: "research and reflection on the values that underpin appropriate behaviour and practices whenever human activities interact with the Earth system" [14] (p. 2). This definition already covers the need to conserve all the Earth's subsystems, not just the geosphere, adding the holistic dimension of the Earth's system to this scientific area.

1.2. Geoethics Syllabus: The Intervention Programme

This research evaluated an intervention programme (based on parts of the GOAL project's syllabus) applied in higher education. The intention was to develop knowledge in geoethics and its connection with various topics relevant to promoting the Earth system and SDGs. The literature reveals the need to teach the Earth system approach [6,7,52] to geoscience students who need that knowledge to develop geoethics values and principles to apply in daily life and their profession.

Case-based teaching was selected as the teaching methodology to address the different topics due to the possibility of working with real events/cases/dilemmas, promoting discussion, and changing positions, values and even principles. The lesson plans and teaching methodology for our intervention are discussed in detail in [22]. This methodology can enable the development of various competencies currently essential for their future in the 21st century, such as critical thinking and collaborative work. The curricular units where

the topics and educational resources of the intervention programme were implemented are shown in Table 1.

Table 1. Curricular unit and respective geoethics topics taught.

Geoethics Topics	Curricular Units
Geoethics and the management of geological resources	Prospecting Methods
Geoethics and the management of geological risks	Natural Risks
Geoethics and the management of geological heritage	Regional Geology
Geoethics and the Earth system	Geoscience Education
Geoethics and the management of water resources	Hydrogeology

In all lessons of the intervention programme, geoethics values and principles were taught. During the lessons in the curricular unit of geoscience education, the fieldwork activity needed to teach geology [53,54] was referred to regarding geoethics aspects necessary in the field [55]. Those geoethics values were also mentioned while learning lessons related to geological heritage, where fieldwork is also an everyday activity [56,57]. The other lesson topics covered the specific content of the curricular unit. However, the connection was made to geoethics values related to water (in the Hydrology curricular unit), geologic risks (in the Natural Risks curricular unit), and the management of geological resources in the Prospecting Methods curricular unit (in this curricular unit it was not addressed the water resource). The lessons followed a case-based teaching methodology where students were split into groups of four to six students to promote discussion and critical thinking. The average time to apply the educational resources for each topic was four hours, split into one or two lessons. The same teacher, familiar with the Goal project and trained to use case-based teaching, gave all the lessons.

2. Methodology

This study opted for mixed-method research and collected quantitative data in the study's first phase and qualitative data in the second phase. Researchers resorted to surveys using a questionnaire and an interview.

2.1. Sample

This research used a convenience sample of higher education students from a public university in Portugal. The sample consisted of 90 students (n = 90) aged between 18 and 58, with an average age of 22.6. The sample included 48 (53.3%) female students and 42 (46.7%) males. Thirty-three participants (n = 33; 36.7%) were in their first year, 13 (14.4%) were in their second year, 41 (45.6%) were in their third year, and 3 (3.3%) were conducting extraordinary curricular units (curricular units beyond the compulsory ones in your courses). Our choice of research sample is justified because the selected participants because the participants selected had a satisfactory diversity in age, gender, year of study, and course attended. It should be noted that the participating students were enrolled in five different higher education courses, but all were related to geoscience.

Due to the voluntary nature of their participation, not all the students who filled in the initial questionnaire were interviewed. Thus, the sample interviewed consisted of only 52 students (n = 52) who attended the intervention programme and agreed to be interviewed (Table 2).

2.2. Instruments

As mentioned above, in this study, researchers resorted to a questionnaire and an interview script, both of which were validated using content validation and the expertise of three experts in the field. Regarding reliability, a pilot study was also conducted with four students from the geoscience course (not involved in the sample of this study) to

guarantee comprehension of the questions on the questionnaires and the interview script. That procedure was carried out aiming to assess an accurate evaluation.

Table 2. Sample interviewed by topics and curricular units (n = 52).

Topics	f	
	n	**(%)**
Geoethics and the management of geological resources	4	7.7
Geoethics and the management of geological risks	6	11.6
Geoethics and the management of geological heritage	7	13.5
Geoethics and the Earth system	13	25.0
Geoethics and the management of water resources	7	13.5
	15	28.9

The questionnaire comprised three pages. The first two pages had closed questions, but the third contained two open-ended answers. The 11 closed questions were mainly multiple-choice, but four were on a Likert scale of 5-points.

The script for semi-structured interviews contained 14 questions. The interviews were intended to assess the development of students' geoethics knowledge after the application of the intervention programme (those interested in obtaining information about the questionnaire and interview guide can contact the first author to obtain these assessment instruments).

2.3. Procedure

Before implementing the intervention programme, the questionnaire was administered to assess the student's preconceptions of geoethics and its relationship with sustainable development. Although it was not timed, the average time to complete the questionnaire was 20 to 30 min. All participants (n = 90) answered the questionnaire, and the answers were statistically analysed. After collecting the questionnaires, the intervention programme was administered.

The last phase of the research involved interviewing the students (n = 52) who attended the intervention programme and had volunteered to participate in this study stage. Students were contacted after the intervention programme lesson to book an interview. Responding to the interview took 40 to 50 min per student. All interviews were carried out between two to three weeks after the student's participation in the intervention programme. The interviews were recorded and transcribed for further content analysis.

Ethical issues: All the students took part in all stages of the study in an informed, voluntary, and consenting manner. The students' identities were known to the researchers, but this information was confidential, meaning it was not revealed at any study stage. In this research, the wellbeing of the participants was ensured, as well as honest and transparent conduct. The informed consent of the students and the professors of the curricular units involved was collected and guaranteed their access to the results. In addition, a positive opinion was requested from the Ethics Committee of the Faculty of Sciences of the University of Porto to implement the intervention programme. All rules of research ethics in the social sciences were taken, and students also consented to the data collected being stored for research purposes.

3. Results

The initial analysis of the questionnaire made it possible to verify the lack of knowledge about geoethics among the students and a progressive and enriching learning with the intervention programme since the responses to the interview were more positive. In the questionnaire, most participants (n = 64; 71.1%) did not correctly define the concept of geoethics. However, 39 of the students interviewed (75.0%) could name the areas of knowledge contributing to geoethics, i.e., geosciences, philosophy, sociology, and economics.

The questionnaire also revealed that most participants (n = 71; 78.9%) agreed that geoscientists need to behave ethically in their work. Some of them (n = 22; 42.3%) could already describe how much the geoethical values (cultural, environmental, and ethical) influence the geoscientist's decision. The interviews showed that almost all participants (n = 51; 98.1%) considered that geoethics could contribute to a better understanding of the geoscientist's professional ethics and help them understand the values and principles of geoethics. Most questionnaire respondents (n = 37, 41.1%) agreed that geoscientists are more responsible for the Earth system. Regarding the students' views of the usefulness of geoethics for ordinary citizens, the respondents to the questionnaire (n = 87; 96.7%) considered geoethics to be very important for the future of society. In the interview, all respondents answered a similar question positively (n = 52). A total of 35 respondents (38.9%) were able to suggest contributions from geoethics, such as (the citations presented in the article were translated into English for a better understanding):

√ "*Raising awareness through education. Inserting the issue into the school curriculum*".

√ "*Using resources ethically, without favouring or disadvantaging anyone*".

√ "*Strengthening resilience in the ability to adapt to the risk of natural disasters in all countries*".

√ "*Geoethics can help in the transition to renewable energies*".

√ "*Geoethics, by investigating the values that can support different types of behaviour, can find a way to strike a better balance between these two situations, overconsumption and overproduction*".

Also, the students were asked if they knew the SDGs in the questionnaire. The majority (n = 83; 92.2%) answered in the affirmative, mentioning (n = 48; 53.3%) that they thought geoethics could contribute to sustainable development.

Concerning the intervention programme for students on the topic "Geoethics and the management of geological resources", all four respondents were able to refer to the value of geoethics in the sustainable management of resources, as can be seen in the following quote of a student: "*Geoethical values can help raise awareness of this issue in society by explaining the consequences of such exploitation to satisfy high consumption patterns (. . .) Geoethics values teach us the need to preserve and follow ethical rules of conduct when exploiting and consuming mineral resources*".

Regarding the students on the topic of "Geoethics and the management of geological risks", all the interviewees (n = 6) replied that geoethics values were important in risk management and mentioned, for example "*Maybe if a geoscientist with these values is on the decision-making side, they won't build houses or anything else in risk zones*".

On the topic of "Geoethics and the management of geological heritage", the contribution of geoethical values to the management of geological heritage was appreciated by the majority of interviewees (n = 5; 71.4%) who said, for example "*Geoethics can also help to implement heritage care in culture and to improve land use planning*".

Concerning the topic "Geoethics and the Earth system", all the students mentioned the holistic relationship between the Earth's subsystems. One of the responses was

"*Social values involve preventing certain consequences, in other words, educating to prevent and to adapt to the need to understand that in fact, all ecological parameters are interconnected and interdependent and that we also depend on them. It's not the other way round, they don't depend on us*".

On "Geoethics and the management of water resources", 16 interviewees (72.7%) indicated the role of geoethical values in water management. An example of this is the following quote:

"*In cultural values, geoconservation, in particular, could help improve water management, so as not to alter the river system, so that the composition of the water doesn't change, for*

example, not to tamper too much with the natural system that already exists, to conserve what exists".

Finally, it is possible to confirm that more than half of the initial sample (n = 52; 57.8%) responded to the final interview, and students revealed that they had built up knowledge about geoethics and its link to sustainable development. This analysis allowed us to consider that the implementation of the intervention programme (as mentioned, a short geoethics syllabus) was successful and contributed to promoting geoethics knowledge and its link to sustainable development and the Earth system.

4. Discussion

In the literature, there is a notable scarcity of studies addressing the applications and assessment of the impact of geoethics education. This deficiency underscores the imperative for its implementation. Furthermore, given that geoethics is an emerging field of knowledge, it is not surprising that its inclusion in higher education has been limited. Nevertheless, literature frequently emphasises the necessity of teaching geoethics across various disciplines [49,56,57]. The results of the present study indicate a need to bridge the gap between theory and practice and engage researchers in the quest for evidence supporting the integration of geoethics education across all educational levels.

Students who participated in the questionnaire and interviews often highlighted the importance of responsible management of geological resources, which was not mentioned regarding all other aspects explored in the four topics. This notorious reference aligns with findings from other authors [58,59] whose respondents shared similar views. This suggests that the subject matter is covered to some extent in higher education, albeit without explicit ties to geoethics issues and their connection to the Sustainable Development Goals (SDGs).

In the same study [58], it was observed that secondary school students lacked knowledge of the applicability of geoethics and struggled to provide accurate answers regarding geoethics values. As the study's authors mentioned, initially, the participants could not offer a precise definition of geoethics. However, after participating in the intervention program, the interviewees acquired some geoethics knowledge.

Finally, a reference to some studies that highlighted the issue of teaching geoethics to students [27,43,60]. Additionally, the literature references a book previously mentioned [22] and developed as a delivery of the GOAL project, focusing on a possible syllabus for teaching geoethics in higher education. The IAPG website also mentions a "Geoethics school" [61] where it is possible to access videos and documentation that can aid in teaching and learning geoethics.

5. Conclusions

All the participants in the intervention programme had the opportunity to learn about geoethics, its relationship with sustainable development and a specific topic about the Earth system. The students interviewed showed that their geoethics knowledge had evolved in all topics, revealing the intervention programme's enrichment effect. Although the competencies that the participating students may have developed were not ascertained, the nature of the educational resources and case-based teaching methodology required students to build critical thinking, argumentation, and collaborative work skills.

The professors of the curricular units involved, who also attended the classes taught in the intervention programme, had the opportunity to encounter geoethics for the first time, which is expected to lead to greater interest in geoethics and contribute to its teaching in higher education.

The study was conducted with a non-probabilistic sample of university students, emphasising the importance of continuing research with students at this educational level. It is crucial to involve more extensive and diverse samples to enhance the generalizability of the findings and to assess the long-term retention of geoethics principles. Such investigations would deepen our understanding of the current findings. Additionally, research should explore how awareness of geoethics can be translated into public policies for sustainable

development. Furthermore, this research initiates discussions about integrating geoethics into science curricula, thereby increasing the societal relevance of earth sciences, including geosciences. This study represents a significant step in recognising the educational gaps in geoethics and underscores the pressing need for interdisciplinary education to address the challenges of sustainable development.

Thus, although more studies are needed, this research emphasises that incorporating a syllabus for learning geoethics in higher education has a positive effect, indicating that it should be used in different countries to boost geoethics education worldwide and in different disciplines. The study underscores the urgency of developing and integrating geoethics education as an independent curriculum unit or as modules within subjects encompassing the learning of geoethics values and principles, as demonstrated in this study.

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References

1. Ribeiro, T.; Orion, N. Educating for a Holistic View of the Earth System: A Review. *Geosciences* **2021**, *11*, 485. [CrossRef]
2. Bohle, M. Recording the Onset of the Anthropocene. In *Engineering Geology for Society and Territory*; Lollino, G., Arattano, M., Giardino, M., Oliveira, R., Peppoloni, S., Eds.; Springer: Berlin/Heidelberg, Germany, 2015; Volume 7, pp. 161–163.
3. Lucchesi, S.; Giardino, M. The role of geoscientists in human progress. *Ann. Geophys.* **2012**, *55*, 55–359. [CrossRef]
4. Verbeek, A. Planetary Security: The Security Implications of Climate Change. NATO Review. 2019. Available online: https://bit.ly/3RESagH (accessed on 3 October 2023).
5. United Nations. Warning Humanity Still Doing More Harm Than Good to Nature, Speakers Urge Corrective Action, at Preparatory Meeting for Stockholm International Environmental Conference, ENV/DEV/2042. 2022. Available online: https://bit.ly/3PUsSKq (accessed on 3 October 2023).
6. Bilham, N.; Di Capua, G. Setting the scene. In *Exploring Geoethics: Ethical Implications, Societal Contexts, and Professional Obligations of the Geosciences*; Bohle, M., Ed.; Palgrave Pivot: London, UK, 2007; pp. 1–24. [CrossRef]
7. Vasconcelos, C.; Orion, N. Earth Science Education as a Key Component of Education for Sustainability. *Sustainability* **2021**, *13*, 1316. [CrossRef]
8. Steffen, W.; Sanderson, A.; Tyson, P.D.; Jäger, J.; Matson, P.A.; Moore III, B.; Oldfield, F.; Richardson, K.; Schellnhuber, H.J.; Turner, B.L.; et al. *Global Change and the Earth System: A Planet under Pressure*; Springer: Berlin/Heidelberg, Germany, 2005. [CrossRef]
9. Resolution, G.A. Transforming Our World: The 2030 Agenda for Sustainable Development. UN Doc. A/RES/70/1 (25 September 2015). Available online: https://www.unep.org/resources/report/transforming-our-world-2030-agenda-sustainable-development (accessed on 3 October 2023).
10. Bobrowsky, P.; Cronin, V.S.; Di Capua, G.; Kieffer, S.W.; Peppoloni, S. The emerging field of Geoethics. In *Scientific Integrity and Ethics in the Geosciences*; Gundersen, L.C., Ed.; John Wiley & Sons: Hoboken, NJ, USA, 2018; pp. 175–212.
11. Oreskes, N. Science and public policy: What's proof got to do with it? *Environ. Sci. Policy* **2004**, *7*, 369–383. [CrossRef]
12. Sachs, J.; Lafortune, G.; Kroll, C.; Fuller, G.; Woelm, F. *From Crisis to Sustainable Development: The SDGs as Roadmap to 2030 and Beyond. Sustainable Development Report 2022*; Cambridge University Press: Cambridge, UK, 2022. Available online: https://s3.amazonaws.com/sustainabledevelopment.report/2022/2022-sustainable-development-report.pdf (accessed on 31 July 2023).
13. Singer, P. *Practical Ethics*; Cambridge University Press: Cambridge, UK, 2011.
14. Di Capua, G.; Peppoloni, S.; Bobrowsky, P.T. The Cape Town statement on geoethics. *Ann. Geophys.* **2017**, *60*, 1–6. [CrossRef]
15. Stewart, I.S.; Gill, J.C. Social geology—Integrating sustainability concepts into Earth sciences. *Proc. Geol. Assoc.* **2017**, *128*, 165–172. [CrossRef]

16. McPhaden, M. AGU Adopts Scientific Integrity and Ethics Policy. In *Scientific Integrity and Ethics in the Geosciences*; Gundersen, L.C., Ed.; American Geophysical Union and John Wiley & Sons, Inc: Hoboken, NJ, USA, 2018; pp. 67–76. [CrossRef]
17. The World Economic Forum. Global Survey Shows 74% Are Aware of the Sustainable Development Goals. Available online: https://www.weforum.org/press/2019/09/global-survey-shows-74-are-aware-of-the-sustainable-development-goals/ (accessed on 9 September 2023).
18. Mogk, D.W.; Geissman, J.W.; Bruckner, M.Z. Teaching geoethics across the geoscience curriculum: Why, when, what, how, and where? In *Scientific Integrity and Ethics in Geosciences*; Gundersen, L.C., Ed.; Wiley: Hoboken, NJ, USA, 2017; pp. 231–265.
19. Peppoloni, S.; Bilham, N.; i Capua, G. Contemporary Geoethics Within the Geosciences. In *Exploring Geoethics: Ethical Implications, Societal Contexts, and Professional Obligations of the Geosciences*; Bohle, M., Ed.; Palgrave Pivot: London, UK, 2019; pp. 25–70. [CrossRef]
20. Education 2030—Incheon Declaration and Framework for Action for Implementing Sustainable Development Goal 4. Available online: https://unesdoc.unesco.org/ark:/48223/pf0000245656_por (accessed on 9 September 2023).
21. Transforming Our World: The 2030 Agenda for Sustainable Development. Available online: https://sustainabledevelopment.un.org/post2015/transformingourworld (accessed on 9 September 2023).
22. Vasconcelos, C.; Schneider-Voß, S.; Peppoloni, S. *Teaching Geoethics: Resources for Higher Education*; University. Porto Edições: Porto, Portugal, 2020. Available online: https://goal-erasmus.eu/ehandbook/ (accessed on 31 July 2023).
23. Bank, C.G.; Ryan, A.M. Engaging students in ethical decision-making: A case study from an undergraduate geoscience course. *Int. J. Ethics Educ.* **2020**, *5*, 51–65. [CrossRef]
24. Brennetot, A. Professional Geoethics, Prescriptive Geoethics and Analytical Geoethics. For a constructivist approach of the ethical dimension of geographical space. *Cybergeo Eur. J. Geogr.* **2021**. [CrossRef]
25. Frodeman, R. *Geo-Logic: Breaking Ground between Philosophy and the Earth Sciences*; New York Press: New York, NY, USA, 2003.
26. Stoddard, E.W.; Cornwell, G.H. Peripheral Visions: Towards a Geoethics of Citizenship. *Lib. Educ.* **2003**, *89*, 44–51.
27. Chemhuru, M. Elements of environmental ethics in Ancient Greek philosophy. *Phronimon* **2017**, *18*, 15–30. [CrossRef]
28. Du Pisani, J.A. Sustainable development—Historical roots of the concept. *Environ. Sci.* **2006**, *3*, 83–96. [CrossRef]
29. Theodossiou, E.; Manimanis, V.N.; Dimitrijević, M.S. The cosmological theories of the pre-Socratic Greek philosophers and their philosophical views for the environment. *Facta Univ. Ser. Philos. Sociol. Psychol. Hist.* **2011**, *10*, 89–99.
30. Martínez-Frías, J.; González, J.L.; Pérez, F. RGeoethics and Deontology: From fundamentals to applications in Planetary Protection. *Episodes* **2011**, *34*, 257–262. [CrossRef] [PubMed]
31. Peppoloni, S.; Di Capua, G. Geoethics and geological culture: Awareness, responsibility and challenges. *Ann. Geophys.* **2012**, *55*, 335–341. [CrossRef]
32. Peppoloni, S.; Di Capua, G. Introduction. In *Geoethics: The Role and Responsibility of Geoscientists*; Peppoloni, S., Di Capua, G., Eds.; Geological Society of London: London, UK, 2015; pp. 1–4. [CrossRef]
33. Farabollini, P.; Lugeri, F.R.; Aldighieri, B.; Amadio, V. The role of earth science and landscape approach in the ethic geology: Communication and divulgation for the prevention and reduction of geological hazard. In *Engineering Geology for Society and Territory-Volume 7: Education, Professional Ethics and Public Recognition of Engineering Geology*; Springer International Publishing: Berlin/Heidelberg, Germany, 2014; pp. 115–120. [CrossRef]
34. Tsevreni, I. The ignorant environmental education teacher: Students get empowered and teach philosophy of nature inspired by ancient Greek philosophy. *Environ. Educ. Res.* **2018**, *24*, 67–79. [CrossRef]
35. Von Wright, G.H. Progress: Fact and fiction. In *The Idea of Progress*; Burgen, A., McLaughhlin, P., Mittelstrab, J., Eds.; Walter de Gruyter: Berlin, Germany, 1997; pp. 1–18.
36. Nash, R.F. *The Rights of Nature: A History of Environmental Ethics*; The University of Wisconsin Press: Madison, WI, USA, 1989. Available online: https://amzn.to/3sZjPL9 (accessed on 3 October 2023).
37. Crutzen, P.J. The Anthropocene. In *Earth System Science in the Anthropocene*; Ehlers, E., Krafft, T., Eds.; Springer: Berlin/Heidelberg, Germany, 2006; pp. 13–18. [CrossRef]
38. Peppoloni, S.; Di Capua, G. The meaning of geoethics. In *Geoethics: Ethical Challenges and Case Studies in Earth Science*; Wyss, M., Peppoloni, S., Eds.; Elsevier: Amsterdam, The Netherlands, 2015; pp. 3–14. [CrossRef]
39. Section of Geoethics at the Russian Geographical Society. Available online: http://www.geoethics.ru/ru/content/geoetika.html (accessed on 9 September 2023).
40. Peppoloni, S.; Di Capua, G. Geoethics as global ethics to face grand challenges for humanity. In *Geoethics: Status and Future Perspectives*; Capua, G., Bobrowsky, P.T., Kieffer, S.W., Palinkas, C., Eds.; The Geological Society of London: London, UK, 2020; pp. 1–17. [CrossRef]
41. Steffen, W.; Richardson, K.; Rockström, J.; Schellnhuber, H.J.; Dube, O.P.; Dutreuil, S.; Lenton, T.M.; Lubchenco, J. The emergence and evolution of Earth System Science. *Nat. Rev. Earth Environ.* **2020**, *1*, 54–63. [CrossRef]
42. Education and Human Rights: New Priorities. Adult Education for International Understanding, Human Rights, and Peace. Available online: https://unesdoc.unesco.org/ark:/48223/pf0000095164 (accessed on 9 September 2023).
43. Cronin, V.S. On the seismic activity of the Malibu Coast Fault Zone, and other ethical problems in engineering geoscience. In Proceedings of the 1992 annual meeting of the Geological Society of America (GSA), Cincinnati, OH, USA, 26–29 October 1992.

44. Martinez-Frias, J. Geoethics: Proposal of a Geosciences-Oriented Formal Definition and Future Planetary Perspectives. TIERRA: Spanish Thematic Network of Earth and Planetary Sciences. 2008. Available online: https://www.semanticscholar.org/paper/Geoethics%3A-Proposal-of-a-geosciences-oriented-and-Mart%C3%ADnez-Fr%C3%ADas/f658998d01c7a9c72b26992c659520110d1102ef#citing-papers (accessed on 3 October 2023).
45. Martínez-Frías, J.; de Wever, P. Teaching of Stratigraphy, geological heritage and Geoethics. State of the art. *Ciências Terra* **2013**, *18*, 43–48.
46. Němec, V. Geoethics and Sustainability. In Proceedings of the 2nd World Sustainability Forum, online, 1–30 November 2012; MDPI: Basel, Switzerland, 2012; pp. 1–30.
47. Peppoloni, S.; Di Capua, G. Current Definition and Vision of Geoethics. In *Geo-societal Narratives*; Bohle, M., Marone, E., Eds.; Springer Nature: Berlin/Heidelberg, Germany, 2021; pp. 17–27. [CrossRef]
48. International Association for Promoting Geoethics Constitution. Available online: https://f420cbad-ec08-4c39-902f-b0e5afecb44a.filesusr.com/ugd/5195a5_95c5a38c8f2147cf8427e093d7110c2b.pdf (accessed on 9 September 2023).
49. Forbes, W.; Lindquist, C. Philosophical, Professional, and Environmental Ethics An Overview for Foresters. *J. For.* **2000**, *98*, 4–10. [CrossRef]
50. Definition of Geoethics. Available online: https://www.geoethics.org/definition (accessed on 9 September 2023).
51. Wyss, M.; Peppoloni, S. (Eds.) *Geoethics, Ethical Challenges and Case Studies in Earth Sciences*; Elsevier: Amsterdam, The Netherlands, 2015.
52. Batzri, O.; Assaraf, O.B.Z.; Cohen, C.; Orion, N. Understanding the Earth Systems: Expressions of Dynamic and Cyclic Thinking Among University Students. *Sci. Educ. Technol.* **2015**, *24*, 761–775. [CrossRef]
53. Lima, A.; Vasconcelos, C.; Félix, N.; Barros, J.; Mendonça, A. Field trip activity in an ancient gold mine: Scientific literacy in informal education. *Public Underst. Sci.* **2010**, *19*, 322–334. [CrossRef]
54. Esteves, H.; Fernandes, I.; Vasconcelos, C. A Field-Based Approach to Teach Geoscience: A Study with Secondary Students. *Procedia Soc. Behav. Sci.* **2015**, *191*, 63–67. [CrossRef]
55. Ryan-Davis, J.; Scalice, D. Co-Creating Ethical Practices and Approaches for Fieldwork. *AGU Adv.* **2022**, *3*, e2022AV000762. [CrossRef]
56. Mansur, K.L.; Ponciano, L.C.; Castro, A.R.D. Contributions to a Brazilian Code of Conduct for Fieldwork in Geology: An approach based on Geoconservation and Geoethics. *An. Acad. Bras. Ciências* **2017**, *89*, 431–444. [CrossRef] [PubMed]
57. Demiguel, D.; Brilha, J.; Meléndez, G.; Azanza, B. Geoethics and geoheritage. In *Teaching Geoethics. Resources for Higher Education*; Vasconcelos, C., Schneider-Voss, S., Peppoloni, S., Eds.; University of Porto: Porto, Portugal, 2020; pp. 57–71. [CrossRef]
58. Keane, C.M.; Asher, P. Addressing the geoethics skills gap through co-curricular approaches. *Geol. Soc. Lond. Spec. Publ.* **2021**, *508*, 47–54. [CrossRef]
59. Ayeh, D.; Bleicher, A. One concept fits it all? On the relationship between geoethics and responsible mining. *Extr. Ind. Soc.* **2021**, *8*, 100934. [CrossRef]
60. Cronin, V.S. Facilitating a Geoscience Student's Ethical Development. In *Scientific Integrity and Ethics in the Geosciences*; Gundersen, L.C., Ed.; John Wiley & Sons: Hoboken, NJ, USA, 2018; pp. 175–212.
61. School on Geoethics and Natural Issues. Available online: https://www.geoethics.org/geoethics-school (accessed on 9 September 2023).