A geoethics syllabus for higher education: Evaluation of an intervention programme

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Article

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 had 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

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, 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. 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 has been scientifically proven that they impact the Earth system with their actions [1,2]. 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. To better understand human actions' impacts on the Earth system, it should be noted that it comprises five distinct subsystems - atmosphere, biosphere, cryosphere, geosphere, and hydrosphere. The latter are interdependent and share cycles of matter and energy flow [2,3], 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 [4-6], with its dynamic equilibrium that is affected by and affects 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. 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 [7-10]. 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 [7,11]. 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 [12] as well as being aware of the responsibility and social role that they also have beyond scientific practice [13], principles that geoethics defends.

Sustainable development is already widely recognised by society [14] 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 [15], even by geoscientists. Therefore, geoethics must be included in school curricula so that it can be increasingly practised by as many citizens as possible [16,17]). It also needs its integration into higher education geoscience curricula, or even lower education levels so everyone can know geoethics. It should be noted that geoethics also contributes to the fourth SDGs, which has as its motto 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 [18,19]

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 developed a syllabus (curriculum programme) for teaching geoethics in higher education and educational resources [20]. The latter were all based on the different scientific areas of the experts involved in the project, thus bringing together subjects such as mineral resource management, geological risks, geological heritage, and water. All the educational resources, as well as the curriculum itself, focus on geoethics and its relationship with sustainable development. Regardless of the country, these educational materials can be used, although it is more aimed at higher education geoscience students [21].

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.

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 encourage knowledge of the theoretical framework of geoethics and the potential contributions of its application to sustainable development; and (iii) to encourage the consolidation of geoethics as a scientific area.

Geoethics: Origins and evolution

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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 [22-24]. However, geoethics is a recent and developing scientific area [7,25], 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 done through 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 [26-28].

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. Socrates concluded that there are no essential differences between them, integrating the human being as an element of nature itself [26]. Some Roman philosophers also shared Socrates' ideas [29]. 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 [23]. According to the Stoics, there had to be equity between human beings, and they shouldn't 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 [23,30]. 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 [29].

This relationship of human domination over nature continued as science and technology developed in the modern period [23,31]. 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 [23].

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 [32]. 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 [2,33,34]. As such, Stoppani considered that society's awareness of this fact gave it the responsibility to respect planet Earth. Through Stoppani reflections, this geoscientist can be considered a true forerunner of geoethical thinking, and several authors call him one of the "fathers of geoethics" [2,23,35]. 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 [2,23]. 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 [2,5]. 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 [33,36]. 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. The geoscientist 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, 37].

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 including these ethical considerations in the education system [38]. On the other hand, Cronin [39] 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 symposium in Krakow, by geological engineer Václav Němec. The latter used the word geoethics in connection with ethics for geology, and the term was born out of the need for ethical principles for mining [35][40-42]. The same year saw the emergence of the new and emerging scientific field of geoethic [25,32,43], with some authors considering Němec to be the father of geoethics [25]. Thus, in 1992 the first association dedicated to geoethics was created - the International Association for Geoethics (IAGETH) in Czechia [44].In 2008, the first definition of geoethics was proposed, reflecting various aspects of ethical concerns regarding Earth and Planetary sciences and the respective behaviour of specialists studying the abiotic world [32,40]. The inclusion of planetary sciences in geoethics was justified because the current development of space exploration can also be subject to ethical and scientific integrity issues, and the planetary protection required in these studies that go beyond the terrestrial planet [25,40].

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 [25]. 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 geoethic [7,44,455]. 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 [34, 44]. The latter definition includes the habits of all citizens in the abiotic world and does not only assign ethical responsibility to geoscience experts. It also gives humans the ethical responsibility to care for the planet (Bobrowsky et al., 2018).

The number of scientific publications on geoethics has been 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" [46]. 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 [7,11,25,26,27,34,41].

In 2017, Peppoloni and Di Capua (2017) proposed a definition of geoethics that was used in this study: "research and reflection on the values that underpin appropriate behaviour and practices whenever human activities interact with the Earth system" [11] (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 system to this scientific area.

Geoethycs syllabus: The intervention programme

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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 [4,5,47,48] 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 [20,49,50]. This methodology can enable the development of various competencies currently essential for their future in the 21st century, like 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, so needed to teach geology [51,52] was referred to regarding geoehics aspects to have in the field [53] Those geoethics values were also mentioned while teaching lessons related to geological heritage, where fieldwork is also an everyday activity [54,55].and geoethics values and principles must be achieved. The other lesson topics covered the specific content of the curricular unit. However, a 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). 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 in 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.

Sample

This research used a convenience sample of higher education students from a public university. The sample consisted of 90 students (n=90), aged between 18 and 58, with an average age of 22.66. The sample included 48 (53.33%) female students and 42 (46.67%) males. In terms of the school year, 33 (36.67%) participants were in their first year, 13 (14.44%) were in their second year, 41 (45.56%) were in their third year, and 3 (3.33%) were doing extraordinary curricular units (curricular units beyond the compulsory ones in your courses). The choice of the research sample was justified partly 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 related to geoscience.

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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).

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

Topics	Curricular Unit	f	
		n	(%)
Geoethics and the management of geological resources	Prospecting Methods	4	7,69
Geoethics and the management of geological risks	Natural Risks	6	11,54
Geoethics and the management of geological heritage	Regional Geology	7	13,46
Geoethics and the Earth system	Geoscience Education	13	25,00
Geoethics and the management of water resources	Hydrogeology	7	13,46
		15	28,85

Instruments

As referred to, 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 done 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 and aim to assess an accurate evaluation.

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 4 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,

Procedure

Before implementing the intervention programme the questionnaire was administered to assess the students' preconceptions of geoethics and its relation with sustainable development. Although it was not timed, the average time to complete the questionnaire was 20 to 30 minutes. 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 who attended the intervention programme and had volunteered to participate in this study stage. (n=52). Students were contacted after the intervention programme lesson to book an interview. Responding to the interview took 40 to 50 minutes per student. All interviews were done 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 well-being 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

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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; 71.11 per cent) did not correctly define the concept of geoethics. However, 39 of the students interviewed (75.00%) 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; 78.89%) agreed that geoscientists need to behave ethically in their work. Some of them (n=22; 42.31%) 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; 98.08%) 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, 41.11%) agreed that geoscientists are more responsible for the Earth system. Regarding the students' view of the usefulness of geoethics for ordinary citizens, the respondents to the questionnaire (n=87; 96.67%) 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 (38.89%) were able to suggest contributions from geoethics, such as:

√ *"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; 92.22%) answered in the affirmative, mentioning (n=48; 53.33%) 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; 71.43%) 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 (72.72 %) indicated the role of geoethical values in water management. An example of this is the following quote: *"In cultural*

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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; 57.78%) 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 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 [55,56]. 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 [57,58] 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, 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 the concept of Geoethics. However, after participating in the intervention program, the interviewees acquired some Geoethics knowledge.

Finally, a reference to a study developed by Cronin [60] highlights the issue of teaching geoethics to students. Additionally, the literature references a book previously mentioned [20] 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" [59] where it is possible to access videos and documentation that can aid in teaching and learning Geoethics.

5. Conclusion

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 develop 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.

Thus, although more studies are needed, this research emphasises that incorporating a syllabus for learning Geoethics in Higher Education has had 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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