Teaching Groundwater Resources and Geoethics in Portuguese Secondary Schools

Gina P. Correia and Hélder Pereira

Abstract

The growing importance of geoethics justifies its inclusion in formal education, particularly, when related to essential themes to the sustainability on Earth. In Portugal, the study of groundwater resources is part of the curriculum of subject areas, such as geology and geography. In order to evaluate the possibility of address geoethics while teaching about groundwater resources in secondary education, we analysed the curriculum reference documents of biology and geology (11th grade - 16th years old students), geography A (10th grade - 15th years old students), geography C (12th grade - 17th years old students) and geology (12th grade). The data obtained show that, although the concept of geoethics is not formally integrated into the analysed curricula, it is possible to explore the principles and moral values about the importance of preserving the Planet, throughout formal activities. This is important as we consider it to be fundamental that, by the end of upper secondary education, students should have acquired a responsible and geoethical awareness that could influence their daily life and actions. In our opinion, this should not only be a competence of Earth science professionals but, should involve all professions and all citizens, to which the promotion of non-formal activities can also contribute.

Keywords

Curriculum • Education • Geosciences

1 Introduction

The concept of geoethics has evolved, as its use in the contemporary geoscientific panorama has increased. If its initial use was related to the sustainable exploitation of non-renewable resources, currently, the definition of geoethics is much broader, as can be seen from the content of the "Cape Town Statement on Geoethics" (Di Capua et al. 2017). According to several authors (e.g. Bobrowsky et al. 2017), it is geosciences and geoscientists who seem to have the proper competence for addressing and resolving issues on sustainability and protection of the planet, including those related to the exploration and maintenance of the quality of groundwater resources.

In the Portuguese secondary education system, the teaching of groundwater resources is carried out within the geoscience content of science/humanities courses (one of secondary education offers that are mainly aimed at students wishing to continue their studies in higher education) in the subject areas of biology and geology (11th grade - 16th years old students) (BG11), geography A (10th grade - 15th years old students) (GeoA10), geography C (12th grade - 17th years old students) (GeoC12) and Geology (12th grade) (G12). With this study, we intended to evaluate the possibility of address geoethics through the scope of the teaching of groundwater resources in secondary education in Portugal.

2 Methods

This study focused on the analysis of current curriculum reference documents: curriculum programmes and core learning from subject areas such as BG11, GeoA10, GeoC11 and G12, on the contents/domains/themes in which groundwater resources are taught (Table 1).

With the analysis of the curriculum reference documents, we wanted to identify the objectives, competences and core

G. P. Correia (✉)
University of Coimbra, Centre for Earth and Space Research (CITEUC), Coimbra, Portugal
e-mail: gina_maria@sapo.pt

H. Pereira
Escola Secundária de Loulé, Loulé, Portugal

M. Abrunhosa et al. (eds.), *Advances in Geoethics and Groundwater Management: Theory and Practice for a Sustainable Development*, Advances in Science, Technology & Innovation,
https://doi.org/10.1007/978-3-030-59320-9_74

Table 1 Groundwater resources in the curriculum reference documents of scientific-humanistic courses in secondary education (Alves et al. 2001; Amador et al. 2003; Amador and Silva 2004; Martins et al. 2002; ME 2018a, b, c, d)

Level of education	Subject areas	Contents[a]/Domain[b]/Theme[c]
10th grade	Geography A	The natural resources available to the population uses, limits and potentialities
11th grade	Biology and geology	Sustained exploitation of geological resources
12th grade	Geography C	A world of contrasts
	Geology	The Earth yesterday, today and tomorrow

[a]Designation on the curriculum programmes
[b]Designation on the BG11/G12 core learning
[c]Designation on the geography core learning

learning that allow students to acquire knowledge and develop skills in geoethics. For convenience and curriculum likeness, the subject areas were divided into two analysis groups: BG11 and G12; GeoA10 and GeoC11.

3 Results

The data obtained from curriculum reference documents analysis are presented in Tables 2 and 3.

4 Discussion

The data obtained, in the content and subject areas under consideration, allows us to affirm that in the teaching of this curriculum there is an obvious approach of ethical, social and cultural values that form an individual ethically committed to the preservation of the Geo-Planet.

Thus, in the BG11 and G12 curriculum reference documents (Table 2) and in those of GeoA11 and

Table 2 Results of the analysis of the curriculum programmes and the core learning in the subject areas of biology and geology (11th grade) and geology (12th grade) in the contents/domains/themes in which groundwater resources are taught

	Biology and geology 11th grade	Geology 12th grade
Curriculum		
Contents	Theme IV—Geology, problems and everyday materials Subtheme 3—Sustained exploitation of geological resources	Theme III—The Earth yesterday, today and tomorrow Subtheme 3.1—Water exploitation and contamination
Main goals	• To identify geological resources and their applicability in a Science, Technology, Society and Environment (STSE) perspective • To develop attitudes of geological heritage valorization (memory of the Earth)	• To recognize the role of mankind in water exploration and contamination • To synthesize, within the framework of geological knowledge, the main environmental problems at the beginning of the twenty-first century
Skills	• To recognize the contributions of geology in the areas of geological risk prevention, spatial planning, environmental resource management and environmental education • To assume opinions supported by a scientifically based environmental awareness • To assume attitudes in defence of the geological heritage	
Core learning		
Domain	Sustained exploitation of geological resources	The Earth yesterday, today, and tomorrow
Core learning	• To relate the geological characteristics of a region to the aquifer formation conditions (unconfined and confined) • To analyse data and formulate critical judgments, scientifically based, on the sustainable exploitation of geological resources in Portugal	• To explain experimental data related to contamination of geological resources, appreciating knowledge from other disciplines (e.g. mathematics, biology, computer applications B) • To infer on possible scenarios for the twenty-first century, because of global warming and environmental changes
Transversal core learning	• To formulate and communicate critical opinions, scientifically grounded and related to Science, Technology, Society and Environment (STSE) • To communicate knowledge from different subjects to deepen geological contents	

Table 3 Results of the analysis of the curriculum programmes and the core learning in the subject areas of geography A (10th grade) and geography C (12th grade) in the contents/domains/themes in which groundwater resources are taught

	Geography A 10th grade	Geography C 12th grade
Curriculum		
Contents	Theme 2—Natural resources available to the population: uses, limits and potentialities Subtheme 2.3—Water resources	Theme 4—A world of contrasts Subtheme 4.3—Environmental problems, different human impacts?
Main goals	• To be interested in reconciling economic growth and improving the quality of life of the people, associating them with the enhancement of the natural and cultural heritage • To speak about the existence of conflicts in the use of space and resource management with situations of unequal development at local and/or regional level	
Skills	• To recognize the role of the water cycle in the Earth's balance preserving • To relate water availability with the amount and type of precipitation • To know the factors that condition aquifer productivity • To recognize that human activities interfere with water quantity and quality • To assess risks in water resources management • To infer the need to establish international agreements in the management of water resources • To discuss measures leading to the control of water quantity and quality	• To understand the global dimension of some environmental problems • To understand the need for international cooperation to solve global problems • To discuss measures proposed at international conferences to address global environmental problems • To relate the different impacts caused by environmental degradation to the degree of development of countries • To discuss the sustainability capacity of large urban agglomerations
Core learning		
Theme	Natural resources	A world of contrasts
Core learning	• To relate the distribution of the main features of the subsoil with the geomorphological units • To compare the distribution of major energy resources and energy distribution and consumption networks with hydrography, solar radiation and underground resources • To relate water availability to energy production, agricultural use, population water supply or other uses • To identify the main river basins and their relationship with water availability	• Issue an opinion on concrete actions that enhance the appropriate use of essential resources at the global level. • To discuss and express an opinion on the measures proposed at international conferences to solve global environmental problems, considering the sustainability of the planet

GeoC12 curriculum reference documents (Table 3), it is clear the intention to develop in the geoscience student, a future conscious and ethically responsible citizen, skills that will allow him to make concrete decisions, in his daily actions and as a professional, for the conservation of the geoenvironment or to deal with the global economic and environmental challenges (e.g. Bobrowsky et al. 2017); and, at the same time, to face one of the challenges of Geoethics that of having a greater social intervention (Almeida and Vasconcelos 2014). In these curriculum reference documents, the following main goals/core learning become more relevant: 'to develop attitudes of geological heritage valorization' (curriculum programme, BG11); 'to recognize the role of mankind in water exploration and contamination' (curriculum programme, G12); 'to analyse data and formulate critical judgments, scientifically based, on the sustainable exploitation of geological resources in Portugal' (core learning, BG11); 'to infer on possible scenarios for the twenty-first century, because of global warming and environmental changes' (core learning, G12); 'to speak about the existence of conflicts in the use of space and resource management with situations of unequal development at local and/or regional level' (curriculum programme, GeoA11 and GeoC12); 'issue an opinion on concrete actions that enhance the appropriate use of essential resources at the global level' (core learning, GeoC12). To achieve all these skills the effectiveness of using a didactic methodology incorporating hands on skills should be explored.

5 Concluding Remarks

Studying geoethics in geosciences can contribute to broadening the applications of geology to everyday life; to achieving a greater perception of the characteristics of

geological knowledge and the potential and limits of this knowledge in society; to clarify the role of the geoscience professional in the search for a path for the development of a humanity that is more just and more respectful of the environment (Almeida and Vasconcelos 2014). In this context, we believe that the secondary education curriculum in which groundwater resources are taught, enables the training of citizens who, at the end of compulsory education and regardless of whether they undertake a professional activity in the geosciences area, demonstrates an ethical awareness and a capacity to act responsibly on the abiotic environment. Therefore, these citizens should be able to evidence a personal awareness and capacity for autonomy and responsible actions in daily life as well.

This study focused on the approach to geoethics through formal education. However, the training of an individual is not confined to what he learns only in the curriculum. His full education includes non-formal learning in which the above-mentioned skills can also be developed. Examples of these non-formal learning activities include: the Side-Event to the Geoethics and Groundwater Management Congress, an educational programme that promoted a national competition/contest (GEOETH&GWM'20) and the International Geoethics Day promoted by the IAPG (2019), the first for pre-university school communities and the second for society in general.

Acknowledgements CITEUC is funded by National Funds through FCT—Foundation for Science and Technology (project: UID/Multi/00611/2020) and FEDER—European Regional Development Fund through COMPETE 2020—Operational Programmer Competitiveness and Internationalization (project: POCI-01-0145-FEDER-006922).

Reference

Almeida A, Vasconcelos C (2014) Dilemas da Geoética: suas potencialidades na perceção das características do conhecimento geológico. Comunicações Geológicas 101(III):1189–1192

Alves ML, Brazão MM, Martins OS (2001) Programa de Geografia A 10.º e 11.º anos – Curso Científico-Humanísticos de Ciências Socioeconómicas e de Ciências Sociais e Humanas. DES, Ministério da Educação, Lisboa

Amador F, Silva CP, Batista JP, Valente RA (2003) Programa de Biologia e Geologia. Componente de Geologia. 11.º Ano. DES, Ministério da Educação, Lisboa, pp 15–36

Amador F, Silva M (2004) Programa de Geologia 12.º ano – Curso Científico-Humanístico de Ciências e Tecnologias. DGIDC, Ministério da Educação, Lisboa

Bobrowsky P, Cronin VS, Di Capua G, Kieffer SW, Peppoloni S (2017) The emerging field of geoethics. In: Gundersen LC (ed) Scientific Integrity and ethics with applications to the geosciences. Special Publication American Geophysical Union, Wiley, Washington, DC, USA, pp 175–212

Di Capua G, Peppoloni, S, Bobrowsky, PT (2017) The Cape Town statement on geoethics. Ann Geophys 60, Fast Track 7. https://doi.org/10.4401/ag-7553

GEOETH&GWM'20—Geoethics & groundwater management congress homepage. https://geoeth-gwm2019.wixsite.com/porto. Last accessed on Jan 2020

IAPG—International Association for Promoting Geoethics (2019) Homepage. https://www.geoethics.org/. Last accessed on Jan 2020

Martins OS, Brazão MM, Alves ML (2002) Programa de Geografia C 12.º ano – Curso Científico-Humanísticos de Ciências Socioeconómicas e de Ciências Sociais e Humanas. DES, Ministério da Educação, Lisboa

ME—Ministério da Educação (2018a) Aprendizagens Essenciais de Biologia e Geologia 11.º Ano Ministério da Educação, Lisboa

ME—Ministério da Educação (2018b) Aprendizagens Essenciais de Geografia A 10.º Ano Ministério da Educação, Lisboa

ME—Ministério da Educação (2018c) Aprendizagens Essenciais de Geografia C 12.º Ano Ministério da Educação, Lisboa

ME—Ministério da Educação (2018d) Aprendizagens Essenciais de Geologia 12.º Ano Ministério da Educação, Lisboa