by Maria Helena Henriques\textsuperscript{1,4}, Carlos Tomaz\textsuperscript{2,4} and Artur Abreu Sá \textsuperscript{3,4}

The Arouca Geopark (Portugal) as an educational resource: A case study

\textsuperscript{1} Departamento de Ciências da Terra, Faculdade de Ciências e Tecnologia da Universidade de Coimbra, Portugal. \textit{E-mail:} hhenriq@dct.uc.pt
\textsuperscript{2} Escola Secundária de Ponte de Sor, Rua General Humberto Delgado, 7400-259 Ponte de Sor, Portugal. \textit{E-mail:} cmfstomas@gmail.com
\textsuperscript{3} Departamento de Geologia da Universidade de Trás-os-Montes Alto Douro, Apartado1013, 5001-801 Vila Real, Portugal. \textit{E-mail:} asa@utad.pt
\textsuperscript{4} Centro de Geociências da Universidade de Coimbra, Portugal.

This paper reports the perceptions and ideas expressed by students about geological heritage and geoparks and learning results within the framework of a research in science education focussed on students from two classes of 11\textsuperscript{th} grade (ages 16 to 18) of a secondary school in Portugal.

Considering that geoparks can be assumed as territories with educational resources of great importance in promoting education for sustainable development, mobilizing knowledge inherent to the Earth Sciences, and to geoconservation in particular, the activities with the students were held in the classroom and in the field, the latter within a field trip to the Arouca Global Geopark (Portugal). In this context, resorting to strategies of fieldwork in small groups, we sought to explore with students, geodiversity elements recognizable in five of its geosites.

The results of this work show that educational interventions involving both cooperative work and practical work, using the Arouca Global Geopark as a resource for the implementation of fieldwork activities, can contribute to promote significant and relevant learning on geology and on geoconservation, as well as to stimulate curiosity and interest for visiting other geoparks and for learning more about Earth Sciences.

Geoparks and research on science education

The geoparks, which preserve the elements of geodiversity judged as significant and worthy of conservation because of their value, represent “places where the amazing story of our planet can be told to the non-specialist without the need for the use of the esoteric language so often employed by geoscientists” (McKeever and Zouros, 2005, p. 274). Due to its potential to promote education and dissemination of Earth Sciences among the general public in environmental matters, and enhance sustainable economic development (Eder, 1999), the geoparks under the UNESCO’s assistance shall: (1) preserve geological heritage for future generations, thus promoting the conservation of the geological heritage of the Earth; (2) provide research facilities for geoscientists, thus contributing for enhancing knowledge concerning Earth Sciences; (3) ensure sustainable development, namely through geotourism; (4) educate and teach the general public about issues in geological landscapes and environmental matters, thus promoting the public understanding of geosciences (Eder and Patzak, 2004).

The education of the public at large in matters concerning geological sciences and the environment is one of the major goals established by the European Geoparks Network (Zouros, 2004), assuming education in a wide sense, i.e., including "not only scientific explanations of geological features but also education on broader environmental issues and sustainable development" (Nowlan et al., 2004; p. 174).

Most of the geoparks have their own educational programmes and publications, and provide, in the field of formal education, materials and services to school teachers (EGN, 2012a), but research focused on their role as a tool to provide educational opportunities for visitors is lacking, namely investigative approaches that seek to assess how geoparks can contribute to stimulate students to learn about Earth Sciences and to adopt, in their daily life, behaviors and attitudes that promote the valorization of the geological heritage of the Earth.

Unlike many other countries in Europe (Fermeli et al., 2011), in Portugal the teaching of geology is a separate discipline in secondary school curricula. In the last 5 years record an increasing number of vacancies on Earth Sciences degrees available at Portuguese universities and institutes as a result of the increasing number of candidates (Henriques et al., 2010).

This work reports the results of a research on science education which addresses the following questions: What are the student’s perceptions and ideas about geological heritage and geoparks? What can students learn about geology as a result of a field trip to a geopark? Can a field trip to a geopark influence student’s behaviors and attitudes concerning geoconservation? Does a field trip to a geopark stimulate student’s interest for visiting other geoparks? Can a field trip to a geopark contribute to motivate students for learning more about Earth Sciences?

The research involved the conception, implementation and assessment of an educational intervention, based on fieldwork developed at the Arouca Geopark – one of the two Portuguese geoparks integrating the European and the Global Geopark Networks (EGN, 2012b, UNESCO, 2012), with 37 students (21 male, 16 female) of two 11\textsuperscript{th} grade classes (ages 16 to 18) of the Secondary School of Ponte de Sor (Central Portugal; Tomaz, 2011). The teacher’s
motivation to develop the research, the appropriateness of the intervention relatively to the curriculum goals and the formal authorization both from the Executive Board of the school and from student’s parents to carry out outdoor educational activities were determinant for the choice of the students involved in this study. The fact that the national Biology-Geology high school examination in the end of the academic years of 2008/2009 and 2009/2010 featured questions related with the geology of Arouca Geopark territory (Geofocus, 2010a) was a decisive argument to convince all educational agents of the importance of performing the intervention, given its innovative character and time consuming.

The available data on the Arouca Geopark Educational Programs Balance have reported that “The programs managed, carried out and attended directly by AGA technicians have had a significant increase demand: 5160 pupils and 536 teachers, from 10 different districts of Portugal (Porto, Aveiro, Braga, Viseu, Lisbon, Viana do Castelo, Santarém, Castelo Branco, Coimbra and Vila Real)” (Geofocus, 2010b, p. 4), mostly of the Basic Education (ages 12 to 15) showing major preferences by one specific field trip (“From Mizarela Waterfall to Rock Delivering Stones”; Geofocus, 2010a) but, until now, no other data on the educational value of these field trips have been published.

From the methodological point of view, this research is qualitative in nature, a study-case type, with data resulting from direct observation and content analysis of the answers presented by students to questionnaires (diagnostic and intervention assessment) and to worksheets, expressly created for the research. Quantitative data has also been integrated, and presented as descriptive statistics (Cohen et al., 2010).

Planning and implementation of the intervention

The intervention included practical work developed in small groups (3 students/each), and several activities both in the classroom and in the field, focused on the curricular subjects “Important geological materials and processes in Earth environments” and “Sustainable exploration of geological resources” of the “Theme IV - Geology, current problems and materials” (Amador et al., 2003). It was developed during the 2nd trimester of the academic year of 2010/2011, along 5 successive sessions, and it was based on the vision that promoting education, particularly science education by mobilizing knowledge in Earth Sciences fostering sustainability, involves breaking with the traditional educational systems (UNESCO, 2005), and highlights the urgent need to develop innovative educational interventions, which should not neglect knowledge concerning geoconservation (Henriques et al., 2011).

Fieldwork is widely considered as one of the most effective learning strategy in geosciences (Orion, 1993, Van Loon, 2008, Stokes and Boyle, 2009). But such “hands on” activities must be more than just isolated activities, of “voyager-type”; instead, they should form an integral part of the curriculum, including outdoor activities adequately articulated with activities before and after the field trip,

| Table 1 The three units of the educational intervention, the resources used for its implementation and the main issues which have been worked by the students |
|---|---|---|
| Units | Resources | Issues |
| Preparatory unit | Multimedia presentation; Worksheets 1-7 | International organizations and initiatives dealing with the promotion of sustainable development and the earth sciences. Geoconservation and the promotion of sustainable development. The Arouca Geopark and the European and Global Geoparks Networks. The geologic time. Earth and life during Ordovician times. Rocks deformation. Metamorphic rocks and index minerals. |
| Field trip | Fieldtrip Guide; 6 Interpretative panels; Geological Time Scale; Geological Map of Portugal (1/50 000); sheet 13 D – Oliveira de Azeméis; Pereira et al., 1980); Photographic camera; compass | The Arouca Geopark and its geosites: location and contents; scientific and social relevance. Geological Interpretative Centre of Canelas: paleontological heritage and sustainable exploration of geological resources. Frecha da Mizarela waterfall: inferring its origin through the interpretation of the geological setting. Mizarela geological contact: contact metamorphism, their processes and products; the meaning of the occurrence of staurolite crystals. Castanheira folds: the geometric elements of a fold and the interpretation of rock deformation. “Pedras Parideiras”: the Castanheira nodular granite and its mineralogical components; interpretation of the weathering processes involved in the biotitic nodules which give rise to the popular idea that at Castanheira geosite “Rocks delivering stones”. |
| Summary unit | Worksheet 9 | To elaborate a poster displaying relevant and significant information related to: the Arouca Geopark and the Global Geoparks Network under the auspices of UNESCO; the Geological Interpretative Centre of Canelas geosite; the Frecha da Mizarela waterfall geosite; the Mizarela geological contact; the Castanheira folds geosite; the Pedras Parideiras geosite. To present and discuss the poster within the class. |
developed in the classroom, according to the three-phase model, constructivist in nature, proposed by Orion (1993), and using cooperative work strategies, based on the “Zone of proximal development” described by Vygotsky (1962) – a concept referred to the potential skill of a person to perform a certain number of tasks alone, which can reach higher levels if he/she works in collaboration (Figure 1).

Activities prior to the field trip were developed in the classroom during one session of 135 minutes and one session of 90 minutes, and they have been conducted by resources especially created for the intervention aiming the student’s cognitive, geographical and psychological preparation for the field trip (Orion, 1993): 7 worksheets, inducing relevant bibliographic research and textual and graphic interpretation, and a multimedia document, presenting the field trip goals, the geographical location of the Arouca Geopark and the geosites to be visited, the materials and instruments needed for the field trip and referring safety and sustainable procedures to be adopted during the field trip (Table 1).

Fieldwork activities have been implemented in the Arouca Geopark (1 day), by exploring geodiversity elements in 5 of its geosites: Geological Interpretative Centre of Canelas, Frecha da Mizarela waterfall, Mizarela geological contact, Castanheira folds and “Pedras Parideiras” (Rocks delivering stones) (Arouca Geopark, 2012a,b). Activities within the field trip included geographic and geological location of the geosites, interpretation of geological processes related to the geodiversity elements recognized in the geosites and data collection for further processing; cooperative work in small groups in the classroom, conducted after the field trip, in which students produced posters that presented and discussed in class.

Results of the research

This research diagnosed in students several limitations of cognitive nature related to substantive knowledge on geology - misconceptions about the relations between minerals and rocks; difficulties to understand processes involving wide space and time scales and to interpret visual representations, including maps; inability to associate...
the formation of folds to a ductile regime – already described in the literature (e.g., Pozo, 2000, Dodick and Orion, 2003; Tables 2 and 3). Concerning the geological heritage, students have revealed narrow conceptions and ideas about it, confined to elements holding scenic and/or indicial contents (Pena dos Reis and Henriques, 2009), and inadequate ideas about geoparks (Figures 3 and 4). Organizations like the IUGS and the Global and European Geoparks Networks, and international initiatives like the International Year of Planet Earth, were completely unknown for them, which underscores the need to implement educational interventions that address not only substantive knowledge on geology, facing concepts and methods inherent to the Earth Sciences, but also dimensions of epistemological and formative nature, which can enable citizens to cope with problems affecting the planet, in a sustainable development perspective (Henriques, 2008).

Concerning the intervention assessment, results show that its implementation seems to have contributed to encourage the development of students’ skills, particularly in terms of knowledge, reasoning, communication and adoption of attitudes consistent with the promotion of geoconservation. In fact, most groups performed adequately the various tasks that were proposed in the intervention, and which involved the interpretation of texts, graphs, charts and maps. Students expressed a positive opinion regarding the activities carried out either in the field or in the classroom, which suggests that the educational resources were relevant to the intervention, and were pleasing to the students. Most of the students have recognized the

Table 2 Student’s conceptions about rock-forming minerals according to their responses to diagnosis (DQ) and assessment (AQ) questionnaires

| Rock-forming minerals of magmatic rocks | DQ | AQ |
|----------------------------------------|----|----|
| Quartz                                 | 1  | 2  |
| Quartz, mica and feldspar              | 3  | 11 |
| Olivine                                 | 1  | 0  |
| Silica                                 | 4  | 2  |
| Iron                                    | 2  | 0  |
| Silica, iron and nickel                 | 2  | 0  |
| Feldspar                               | 0  | 1  |
| Mica                                    | 0  | 1  |
| Do not know / No answer                 | 24 | 20 |

| Rock-forming minerals of sedimentary rocks | DQ | AQ |
|-------------------------------------------|----|----|
| Quartz                                    | 3  | 4  |
| Quartz, mica and feldspar                 | 2  | 2  |
| Silica                                    | 1  | 1  |
| Quartz and rock fragments                 | 1  | 1  |
| Sandstone                                 | 0  | 2  |
| Sand                                      | 6  | 5  |
| Do not know / No answer                   | 24 | 22 |

| Rock-forming minerals of metamorphic rocks | DQ | AQ |
|-------------------------------------------|----|----|
| Calcite                                   | 1  | 1  |
| Carbon                                    | 2  | 1  |
| Feldspar, biotite                         | 0  | 1  |
| Biotite                                   | 0  | 1  |
| Lime                                      | 0  | 3  |
| Depending on the composition of the previous rock | 0  | 1  |
| Quartz                                   | 0  | 1  |
| Do not know / No answer                   | 34 | 28 |

Concerning the geological heritage, students have revealed narrow conceptions and ideas about it, confined to elements holding scenic and/or indicial contents (Pena dos Reis and Henriques, 2009), and inadequate ideas about geoparks (Figures 3 and 4). Organizations like the IUGS and the Global and European Geoparks Networks, and international initiatives like the International Year of Planet Earth, were completely unknown for them, which underscores the need to implement educational interventions that address not only substantive knowledge on geology, facing concepts and methods inherent to the Earth Sciences, but also dimensions of epistemological and formative nature, which can enable citizens to cope with problems affecting the planet, in a sustainable development perspective (Henriques, 2008).

Concerning the intervention assessment, results show that its implementation seems to have contributed to encourage the development of students’ skills, particularly in terms of knowledge, reasoning, communication and adoption of attitudes consistent with the promotion of geoconservation. In fact, most groups performed adequately the various tasks that were proposed in the intervention, and which involved the interpretation of texts, graphs, charts and maps. Students expressed a positive opinion regarding the activities carried out either in the field or in the classroom, which suggests that the educational resources were relevant to the intervention, and were pleasing to the students. Most of the students have recognized the

Table 3 Student’s conceptions about the different types of rocks according to their responses to diagnosis (DQ) and assessment (AQ) questionnaires

| Magmatic rocks | DQ | AQ |
|----------------|----|----|
| Basalt         | 23 | 9  |
| Granite        | 7  | 20 |
| Do not know / No answer | 7  | 8  |

| Sedimentary rocks | DQ | AQ |
|-------------------|----|----|
| Sandstone         | 19 | 26 |
| Limestone         | 2  | 0  |
| Sand              | 2  | 1  |
| Siltstone         | 0  | 1  |
| Granite           | 5  | 0  |
| Lime              | 1  | 0  |
| Do not know / No answer | 8  | 9  |

| Metamorphic rocks | DQ | AQ |
|-------------------|----|----|
| Shale             | 3  | 17 |
| Marble            | 5  | 3  |
| Granite           | 1  | 1  |
| Gneiss            | 0  | 1  |
| Diamond           | 2  | 1  |
| Do not know / No answer | 26 | 14 |
role of the cooperative working as a catalyst in the interactions between them and between students and the teacher, and therefore crucial in the development of the social skills (Slavin, 1996, 2011; Johnson et al., 1994) necessary to adopt an active and responsible citizenship in their daily lives.

There were significant gains in student learning of concepts and ideas about geology, particularly with regard to the issue of rock deformation in the crust, which highlights the value of educational interventions involving field work in geology which enrich the daily experiences of the classroom (Lock, 2010; Rickson et al., 2004). Student’s perceptions and ideas about geological heritage and geoparks have clearly changed as a consequence of the intervention, and seem to have contributed to stimulate them to adopt appropriate behaviors and attitudes concerning amateur fossil and mineral collecting practices, that may endanger the integrity of these elements of the Earth’s natural heritage (Van Loon, 2008; Figure 5).

Due to the intervention, there were significant changes in student’s ideas about geoparks, notably about its objectives; most of the students could identify properly the Arouca and Naturtejo Geoparks as Portuguese geoparks included in the Global and European Geoparks Networks assisted by UNESCO, and expressed interest in visiting not only the Arouca Geopark, as others in Portugal and abroad. In fact, when asked whether they intended to return to the Arouca Geopark, 31 students answered yes and 6 students said they were not interested in doing it. The same opinions were collected in relation to the intention to visit another geopark. As the Table 4 illustrates, 17 students showed interest in returning to Arouca Geopark in order to participate in educational activities within the discipline of geology, meeting ideas postulated, for example, by Orion and Hofstein (1994) and Orion (2003), that field trips are activities with high educational value and cognitive potential.

Table 4 also emphasizes the interest expressed by some students in performing leisure activities in natural areas, reinforcing the value of geoparks as areas of excellence for the practice of geotourism, where various natural resources (landscape, topography, outcrops, fossils, rocks and minerals) highlight processes that created and create geodiversity, where environmental conservation and cultural traditions are promoted, thus bringing unquestionable benefits to the host communities.

| Activity                          | Number of students |
|----------------------------------|--------------------|
| Visiting museums                 | 14                 |
| Canoeing                         | 13                 |
| Rafting                          | 13                 |
| Rappel                           | 15                 |
| Pedestrian tours                 | 19                 |
| Mountain biking                  | 19                 |
| Geological educational activities| 17                 |
| Camping                          | 14                 |
| Fossil collecting                | 1                  |
communities (Dowling and Newsome, 2006; Dowling, 2011; Arouca Declaration, 2011).

Of the 31 students who expressed interest in visiting other geoparks, 25 indicated the Natu... (Mansur and Silva, 2011; Moreira, 2012). However, understanding geodiversity and the geological value of a geosite, as well as promoting geoconservation based only on the information included on interpretative panels seems to be quite limited (Crawford and Black, 2012). In fact, the education effectiveness of visits to geoparks involves breaking with traditional educational practices setting aside field trips of “voyager-type”, and requires innovative educational interventions, where fieldwork must be articulated with activities integrated in the curriculum developed before and after the field trip, according to the holistic model proposed by Orion (1989; 1993), and addressing cooperative learning in small groups as the best strategy for its achievement (Figure 1).

The present paper reports a research in science education which has followed the above mentioned requirements. The obtained results show that educational interventions using geoparks can contribute to promote significant and relevant learning on geology and on geoconservation, as well as to stimulate curiosity and interest for visiting other geoparks. Moreover, it has contributed to motivate students for learning more about Earth Sciences, as proof the fact that 14 of the 37 students who made up the sample, had decided to pursue studies in geology, and have attended the discipline of geology of the 12th grade in the academic year 2011/2012 (Tomaz, 2011).

The results relate to a study case, and cannot, as such, be extrapolated to other classes and/or contexts, unless if other researchers or readers will recognize their utility (Cohen et al., 2010). So, and in spite of the fact that the national educational systems are different from a country to another, the research design and the resources produced may be useful for inspiring other researches and educational interventions aiming at assessing education effectiveness of visits to geoparks. This further reinforces the idea that the creation of common educational tools within the European and Global Geoparks Networks is a way to help the strengthening of co-operation in educational programmes in geoparks (Zouros, 2004).

Acknowledgements

The authors are grateful to the Arouca Geopark staff and the Executive Board of the Secondary School of Ponte de Sor (Portugal) for the helpful collaboration in the implementation of this research, and to an anonymous reviewer for the constructive comments on the manuscript.

References

Amador, F., Silva, C. P., Baptista, J. P. and Valente, R. A., 2003, Programa de Biologia e Geologia. Componente de Geologia, 11º ano. Curso Científico-Humanístico de Ciências e Tecnologias: Ministério da Educação. Departamento de Ensino Secundário; http://eec.dgidc.minedu.pt/programas/biologia_geologia_11_ou_12_anos.pdf (access 2010.10.10).

Arouca Declaration, 2011, International Congress of Geotourism – Arouca 2011, Associação Geoparque Arouca, http://www.geoparquearouca.com/geotourism2011/index.php?p=congress&l=en (access 2012.06.25). Arouca Geopark, 2012a, The geosites: Arouca Geopark.http://www.geoparquearouca.com/?p=geoparque&sp=osgeositos (access 2012.09.03).

Arouca Geopark, 2012b, Programas escolas: Arouca Geopark. http://www.geoparquearouca.com/?p=programas (access 2012.09.03).
Bruij, D., Zamorano, M., Casellas, R. M. and Bach, J., 2011, Reflexiones sobre el diseño por competencias el trabajo de campo en Geología. Enseñanza de las Ciencias de la Tierra, v. 19, no. 1, pp. 4-14.

Cohen, L., Manion, L. and Morrison, K., 2010, Research Methods in Education: London, Routledge, pp. 1-638.

Crawford, K. R. and Black, R., 2012, Visitor Understanding of the Geodiversity and the Geoconservation Value of the Giant’s Causeway World Heritage Site, Northern Ireland. Geoheritage, v. 4, no. 1-2, pp. 115-126.

Dodick, J. and Orin, N., 2003, Cognitive Factors Affecting Student Understanding of Geologic Time. Journ. Res. Science Teaching, v. 40, no. 4, pp. 415-442.

Dowling, R. S. (2011). Geoheritage: A North American perspective on Geoparks, Episodes, v. 27, no. 4, pp. 415-442.

Eder, W. (1999) “UNESCO GEOPARKS” – A new initiative for protection and sustainable development of the Earth’s heritage”, N. Jb. Palaont. Abh., v. 214, pp. 353-358.

Eder, W. and Patazk, M., 2004, “Geoparks – geological attractions: A tool for public education, recreation and sustainable economic development, Episodes, v. 27, no. 3, pp. 162-164.

EGN (2012a), European Geoparks Network. Education. Education in European Geoparks. http://www.europeangeoparks.org/?page_id=104 (access 2010.10.10).

EGN (2012b), European Geoparks Network. Meet our geoparks. http://www.europeangeoparks.org/?page_id=168 access 2010.10.10.

Fermeli, G., Meléndez, G., Calonge, A., Dermitzakis, M., Steininger, F., Koutsouveli, A., Neto de Carvalho, C., Rodrigues, J., D’Arpa, C. and Di Patti, C., 2011, Geoschools: innovative teaching of geosciences in secondary schools and raising awareness on geoheritage in the society, in Fernández-Martínez, E. and Castaño de Luis, R., Eds., Avances y retos en la conservación del Patrimonio Geológico en España. Actas de la IX Reunión Nacional de la Comisión de Patrimonio Geológico (Sociedad Geológica de España): Léon, Universidad de León, pp. 120-124.

GeoFocus, 2010a. Educational Programs, Arouca Geopark Report, June, 2010, 2, p. 4.

GeoFocus, 2010b. Arouca Geopark Educational Programs Balance, Arouca Geopark Report, July, 2010, 2, p. 4.

Henríquez, M. H., 2008, Ano Internacional do Planeta Terra e Educação para o Desenvolvimento Sustentável e a Geoconservação em Portugal. Lisboa, D.G.G.M., Serv. Geol. da folha 13D – Oliveira de Azeméis: Lisboa, D.G.G.M., Serv. Geol. da folha 13D – Oliveira de Azeméis: Lisboa, D.G.G.M., Serv. Geol.

Henríquez, M. H., Guimarães, F. A., Sá, A. A., Silva, E. and Brilha, J., 2010, The International Year of Planet Earth in Portugal: past activities and further developments, Episodes, v. 33, no. 1, pp. 33-37.

Henríquez, H. H., Pena dos Reis, R., Brilha, J. and Mota, T., 2011, Geoconservation as an emerging geoscience, Geoheritage, v. 3, no. 2, pp. 117-128.

Johnson, R. T, Johnson, D. W. and Holubec, E. J., 1994, The New Circles of Learning: Cooperation in the Classroom and School; Alexandria, Virginia, U.S.A., ASCD, 110 p.

ICNB, 2012, Listagem das Áreas Protegidas da Rede Nacional de Áreas Protegidas, Instituto da Conservação da Natureza e da Biodiversidade, http://portal.icnb.pt/NR/rdonlyres/93929FAD-3779-45B2-B13F474026DD15EC/0/AP_UOA_RNAP_10MAIO2012.pdf (access 2012.06.25).

Lock, R., 2010, Biology field work in schools and colleges in the UK: an analysis of empirical research from 1963 to 2009, Journal of Biological Education, v. 44, pp. 58-64.

Mansur, K. L. and Silva, A. S., 2011, Society’s Response: Assessment of the Performance of the “Caminhos Geológicos” (“Geological Paths”) Project, State of Rio de Janeiro, Brazil, Geoheritage, v. 3, no. 1, pp. 27–39.

Me Keever, P. and Zouros, N., 2005, Geoparks: Celebrating Earth heritage, sustaining local communities, Episodes, v. 28, no 4, pp. 274-278.

Moreira, J. C., 2012, Interpretative Panels About the Geological Heritage—a Case Study at the Iguassu Falls National Park (Brazil), Geoheritage, v. 4, no. 1-2, pp. 127–137.

Nowlan, G. S., Bobrowsky, P. and Clague, J., 2004, Protection of geological heritage: A North American perspective on Geoparks, Episodes, v. 27, no. 3, pp. 172-176.

Orion, N., 1989, Development of a High-School Geology Course Based on Field Trips, Journ. Geol. Education, v. 37, pp. 13-17.

Orion, N., 1993, A model for the development and implementation of the field trips as an integral part of the science curriculum. School Science and Mathematics, v. 93, no. 6), pp. 325-331.

Orion, N., 2003, The outdoor as a central learning environment in the global science literacy framework. From theory to practice, in V. Mayer, Ed., Implementing global science literacy: Ohio, Ohio State University, pp. 33-66.

Orion, N., Gudovich, Y, Cohen, C., BASIS, T., Lernau, H., Gorni, C., Dayan, A. and Blat, M., 2008, Thinking science - Understanding environment. Science Teaching, http://stwwww.weizmann.ac.il/department40/publications/Nir/nir.pdf (access 2010.10.10).

Orion, N. and Hofstein, A., 1994, Factors that influence learning during a scientific field trip in a natural environment, Journ. Res. Science Teaching, v. 31, no. 10, pp. 1097–1119.

Pereira, E., Gonçalves, L. S. and Moreira, A., 1980, Carta e notícia explicativa da folha 13D – Oliveira de Azeméis: Lisboa, D.G.G.M., Serv. Geol. Portugal, Carta Geológica de Portugal à escala 1/50 000, pp. 1-68.

Pena dos Reis, R. and Henríques, M. H., 2009, Approaching an integrated qualification and evaluation system of the geological heritage, Geoheritage, vol. 1, nº 1, pp. 1-10.

Pozu, J. Í., 2000, ¿Por qué los alumnos no aprenden la ciencia que les enseñamos? El caso de las Ciencias de la Tierra, Enseñanza de las Ciencias de la Tierra, v. 8, no. 1, pp. 13-19.

Rixson, M., Dillon, J., Teamney, K., Morris, M., Choi, M.Y., Sanders, D. and Benefield, P., 2004, A review of research on outdoor learning: London, National Foundation for Educational Research and King’s College London, pp. 1-68.

Slavin, R. E., 1996, Research on Cooperative Learning and Achievement: What We Know, What We Need to Know. Contemporary Educational Psychology, v. 21, pp. 43-69.

Slavin, R. E., 2011, Instruction based on cooperative learning, in Mayer, R. E. and Alexander, P.A., Eds., Handbook of Research on Learning and Instruction: New York, Routledge, pp. 344-360.

Stokes, A. and Boyle, A., 2009, The undergraduate geoscience fieldwork experience: influencing factors and implications for learning, in S. J. Whitmer, D. W. Mogk and E. J. Pyle, Eds, Field Geology Education: Historical Perspectives and Modern Approaches, Geological Society of America, Special Papers, v. 461, pp. 291-311.

Tomaz, C., 2011, O Papel do Geoparque Arouca na Educação Científica: uma Investigação com Alunos do Ensino Secundário no Âmbito da Geologia. Unpublished M.Sc Thesis, University of Coimbra, pp. 1-149.

UNESCO, 2005, UN Decade of Education for Sustainable Development 2005 – 2014. The DESD at a glance. UNESCO Education Sector, ED/2005/PEQ/ESD/3, http://unesdoc.unesco.org/images/0014/001416/141629e.pdf (access 2010.10.10).

UNESCO, 2012, Natural Sciences. Environment. Earth Sciences. Geoparks. Members. http://www.unesco.org/new/en/natural-sciences/environment/earth-sciences/geoparks/members/ (access 2010.10.10).

Van Loon, A. J., 2008, Geological education of the future, Earth-Science Reviews, v. 86, pp. 247-254.

Vygotsky, L. S., 1962, Thought and language, E. Hanfmann and G. Vakar, Eds., In Thought and Language. New York, Routledge, pp. 344-360.

Zouros, N., 2004, The European Geoparks Network. Geological heritage protection and local development, Episodes, v. 27, no. 3, pp.165-171.
**Maria Helena Henriques** is Professor at the Earth Sciences Department, University of Coimbra (Portugal) and Researcher of the Geosciences Centre in the same University. Graduated in Geology and Journalism subsequently obtained PhD and DSc in Palaeontology and Stratigraphy from the University of Coimbra. She collaborates with different Working Groups of the International Subcommission on Jurassic Stratigraphy (ICS-IUGS). During the triennium 2007-2009 she coordinated the Portuguese Committee for the International Year of Planet Earth. Presently, she integrates the Portuguese Committee for the International Geoscience Programme (IGCP) and the Scientific Advisory Board of the Associação Geoparque Arouca.

**Carlos Tomaz** is Teacher of Natural Sciences at the Secondary School of Ponte de Sor (Portugal). Graduated in Geology by the University of Coimbra, he received Master Degree on Earth Sciences during 2011 from the same University. From 2001 to 2008 he was cooperating-teacher in the Republic of Cape Verde. Since January 2012 he is Collaborator-member of the Geosciences Centre, University of Coimbra, where he develops research on science education.

**Artur Abreu Sá** is Professor at Department of Geology, School of Life and Environmental Sciences, University of Trás-os-Montes e Alto Douro (Portugal) and Researcher of the Geosciences Centre, University of Coimbra (Portugal). He obtained PhD in Geology at the University of Trás-os-Montes e Alto Douro. He is the Scientific Coordinator of the Arouca Global Geopark, President of the Portuguese National Committee for the International Geoscience Program (IGCP). He was recently elected as Titular Member of the of the Subcommission on Ordovician Stratigraphy.