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Field trip activity in an ancient gold mine: scientific literacy in informal education

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Considering informal education and field trips as important didactical elements that promote science and scientific literacy (to know, to understand, to apply science), this article presents the work carried out in the gold mines of Castromil (city of Paredes, Portugal), a region with an unquestionable richness in terms of geological heritage. The field trip involved 166 students, ranging from 10 to 21 years of age, and was organized according to Orion's model. The evaluation of the field trip was observed in three aspects: i) the construction of scientific knowledge; ii) the quality of the activities performed; and iii) the promotion of environmental education. The results were obtained through a questionnaire applied to the participants, and interviews of the two monitors responsible for the field trip. The results allow us to conclude that Orion's model was successfully applied in an informal field trip activity promoting scientific literacy.

Keywords: field trip activity, public understanding of science, science education, scientific citizenship, scientific literacy

1. Introduction

Literacy in science is concerned with the capacity to perceive and deal with science and its applications in daily life (particularly in the context of knowledge transfer, communication of science through the media and science-based political decision-making). At its simplest level, scientific literacy is a shorthand for "what the general public ought to know about science" (Durant, 1993: 129). This research project was interested in informal education (that is, education outside the school or university). Considering the importance of scientific literacy in the education of citizens, the research team carried out a project in Portugal on the "Public Understanding of the Science of the Castromil Gold Mines." The main objective was to broaden knowledge of important geological and mining issues, and related aspects of flora and fauna. The Castromil region contains gold deposits that have been intensively exploited, at least since the Roman occupation of the Iberian Peninsula. It should be mentioned that this is a very relevant spot for geology and mining; further, it bears witness of the importance that the mining industry once had in Portugal. Castromil displays innumerable vestiges of Roman mining, largely as a consequence of recent research work. As a result of recent exploration

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and exploitation, the mining heritage can be viewed in the open-pits, underground galleries and shaft (Vasconcelos et al., 2006).

2. Scientific literacy and informal education

Science educators are facing rapidly changing demands in the postmodern era of science and technology which brings new goals for scientific education. Perhaps the major goal for science education is to develop a scientifically literate population. Nevertheless, this goal is seldom achieved (Rutherford and Ahlgren, 1990). According to official policy documents (GAVE, 1996), students should have opportunities to develop a scientific literacy that enables them to use their scientific knowledge with competency in the everyday world. Scientific education must adapt itself to the requirements of the twenty-first century, teaching individuals to think and act independently and accept social responsibilities, and to create information about science and technology.

Scientific literacy involves learning "science," learning "about science" and learning "to do science" (Hodson, 1998). For Wellington (2001), such comprehensive literacy is essential for people in a democracy. Education for an active and involved populace, giving the average citizen knowledge and opportunities that make them capable of dealing effectively with the problems and situations of life, has inevitably to involve scientific literacy. It is intended that citizens develop an adequate perception of science and understand its role and regulation, as part of our common culture. Thus education should make school knowledge become day-to-day knowledge. Just as Jenkins (1994) states, most people think that conventional scientific knowledge has little or no use when taking actions in a social context, except if it is reworked, restructured and recontextualized. Despite the increasing importance of science and technology in people's lives, public understanding of science globally is generally weak.

Informal education for the populace has acquired increasing importance as an element of promoting activities which enhance the scientific literacy of the citizen, as a complement to formal learning. The Council of Europe (2004) refers to informal education as what, in the past, was called "education out of school." This type of education is developed essentially in places such as museums, science institutes and other institutions that organize events, such as free courses, conferences/seminars or expositions. Many researchers have referred to the importance of learning in out-of-school settings, especially in museums (Griffin, 1998; Anderson et al., 2003; Kisiel, 2005). This education has not been evaluated: it was focused on the student and was highly variable—in length of time, place, number and type of participants, dimensions of the learning and field of application of the results (for example, community or social work, or non-profit organizations). Through this type of education the deficiencies and contradictions of the traditional school education are successively resolved and then an effort can be made to answer the immediate needs, those unsatisfied by *formal* education. This, in fact, explains the interest of local communities in this form of education, since it adjusts itself better to their own requirements.

3. Field trip activities

Fuller (2006: 215), mentioning the work of Dando and Wiedel (1971), clarifies the concept of fieldwork which "may incorporate field teaching, field trips, field research or field camps." This project's concern is a field trip whose educational quality is determined by structure, learning materials, teaching methods and its ability to take the learning to real interactions with the environment. Furthermore, it must be developed in a context and set a group of connected activities (Orion and Hofstein, 1994).

Considering the need to find a theoretically supported alternative to the kinds of field activities generally put into practice, the research team decided to organize field trips based on the model proposed by Orion (1993) (although some necessary adaptations were made, so as to promote the activity in an informal education context). As a result of some successful field trips (following Orion, 2003, 2007), it was decided to choose Orion's model to carry out this project.

The difference between this school field trip and a typical school trip was the intention to stimulate greater interest in protecting geological heritage. It is necessary to promote such field activities so that geology is learned through practice and not only from books, and to help conserve geological heritage (Van Loon, 2008). Nevertheless, as this is informal activity, the points of study at the mine were not selected according to the potential concepts that could be taught (curricular criterion), but because specific geological features could be well observed. According to Van Loon (2008), diminishing field experience is a threat to the capacity of future generations to optimize exploitation of all natural resources. The required role of the teacher is to facilitate students taking an active role in the field. On other hand, as in all field trips, it was intended that this one should promote geology learning and generate awareness in all participants so as to cultivate responsible stewardship of the environment.

The field trip model (Orion, 1993) is presented as an alternative to traditional activities, which were focused on the teacher and the information s/he communicates, where the natural context and phenomena were used only to illustrate and confirm the geological data. According to Orion (1993, 2007), the concepts to be learned in the field are classified according to their level of concreteness or abstraction. The appropriate times for teaching—before, during and after the field trip—are also determined according to this classification.

In formal field trip activity, the stage of preparation for a field trip takes place in the classroom or laboratory and can be of variable duration. During this phase, some tasks will have to be developed, with the main objective of preparing the students for field activity. Orion (1993) points out the importance in this stage of reducing the "novelty space" (psychological factors, geographical factors and cognitive factors) to the minimum, related to how familiar the student is with the place to be visited. In this informal activity this preparation cannot be made in the classroom prior to the visit, although an Internet site was provided so that students could make a virtual visit. The preparation unit was given by the monitors (geology graduates) when students arrived at Castromil. Thus, this pre-visit preparation was the first part of a two-part field trip, but the team decided to maintain the name of Orion's model: pre-visit unit.

The second stage of the field trip is the core of the module, since most attention is focused on it, during either the preparation ("pre-visit unit") or the post-trip work ("summary unit"). In the core stage, although the students are absorbing the information given by the teacher, there is a constant interaction between them and the environment: from this they start building up information. The materials created for the use of students and teachers—a trip guide, posters, models, elements of orientation, etc.—are employed at this stage. The lack of relevant educational materials for such activities is a factor that often inhibits the teacher wishing to organize a field trip (Hickman, 1976; Mirka, 1970).

The field trips to the old gold mines started in 2006 and are still going on today. Nevertheless, the field trips of this project took place during a six-month period of one school year (2006/7). The project's chosen seven study points at the Castromil Gold Mine were along a route approximately 3000 meters in length. At each point, students could find a mini-poster to help them to better understand specific geological aspects (for example, geological structures such as faults). The monitors gave explanations, helped students to observe and understand visible geological features and stimulated them to give answers to the questions in the field trip guide. In the classroom and before the field trip, teachers needed to share knowledge and teach some data (they were helped by the Internet site specifically made for this project). In the field, students needed to guide their own learning, work in small groups and teach one another. At this stage, teachers have an encouragement role, by their intervention, correcting basic misconceptions that might lead individuals astray, and remaining alert during group discussions.

The post-trip stage takes place in the classroom and/or the laboratory. In this stage, debates take place (bringing up new questions or going over those that remained unresolved in the field), leading to analysis and reflection, and an articulated and structured approach to the information and knowledge obtained. The new knowledge will be reused or recycled. Matters relevant to the students' attitudes towards the field activity will be evaluated in this stage.

As "learning is a process and a product so we need to investigate the process of learning as well as the product" (Rennie et al., 2003: 116). As important as the preparation of the trip, says the model's author, Orion, is the need to evaluate the work undertaken, in terms of products (knowledge and competencies developed by the student) and in terms of process (the way learning evolved). The assessment required is less to evaluate students (especially because it was an activity in an informal context) but more to evaluate the field trip itself ("do some changes need to be made, did the participants understand the geology, did the field trip help the development of competencies?").

Orion et al. (1997: 161) state that "because outdoors is regarded as a unique instructional setting it deserves a unique inventory for assessing students' perceptions." Marques et al. (2003) made an investigation in Portugal designed to enhance the effectiveness of fieldwork activities by Portuguese teachers. It demonstrates: i) that teachers often fail to put theory into practice, probably as a result of a lack of confidence to implement novel procedures; and ii) that students seem to enjoy the social interaction with other students and the opportunity to work independently of teachers. Marques et al. also indicate that the lack of confidence is probably because the translation of the theory into practice requires time for teachers to develop the confidence to adopt, and successfully engage in, practices that they have previously not pursued. According to Fuller et al. (2003), students perceived fieldwork to be beneficial to their learning, because through it they develop subject knowledge, acquire technical and transferable skills and interact socially with their lecturers and peers. Fuller et al. say that the value of field trips lies particularly in providing students with a better sense of the real world and direct experience with concrete phenomena. Similar and other statements about field trips are mentioned by authors, such as McKenzie et al. (1986), Orion and Hofstein (1994), Tal (2001), Rennie et al. (2003), Orion (2007), and Van Loon (2008), that have published on the topic of out-of-school field trips. Nonetheless, the outdoor environment still is one of the most neglected by teachers and researchers.

Purpose of the study

The purpose of the study was to evaluate whether a field trip carried out in an informal context could be successful, or not, if organized in accordance with Orion's model. The team believed that an informal field trip organized as such could help students, and others, lacking in geological knowledge (for instance, older people living near the mines) to develop geological literacy.

The success of the project, in terms of the promotion of scientific literacy, was measured by three parameters. All three were measured in a questionnaire (given to all participants) and in the interviews of the monitors. The three measured topics were:

i) construction of scientific knowledge—measuring understanding of geology and the ability to apply it in daily life situations;
ii) quality of the field trip activities—measuring the monitor's scientific ability, the quality of the educational materials and the quality of pedagogical sessions (thematic exposition, multimedia session, etc.);
iii) promotion of environmental education—understanding the impact of mining, related environmental problems and measuring the educational potential of the place.

4. Method

The most basic form of evaluation is simply to measure what is happening (Anderson, 1999). The summative evaluation that was carried out in this project was intended to provide judgments about the field trip's worth or merit measured in terms of its success for the user. In an attempt of triangulation of data the evaluation used two instruments: i) a questionnaire to be answered by the participants; and ii) interviews of the two monitors. Before all of this, preparation for the field trip took place, in order to diminish the "novelty space."

Preparation for the field trip

This first unit was carried out with the intention of diminishing the "novelty space." It took place in the facilities provided by the City Hall of Paredes, where most of the thematic expositions and multimedia sessions took place.

Some adjustments to Orion's model were considered in the first unit, the preparation of participants for the field trip. The two monitors (geology graduates of the Faculty of Sciences, University of Porto) helped to plan the activity and to prepare the educational materials. Basically, their role was to explain the geological and biological aspects of the region when they accompanied the field trip.

The thematic exposition of the first unit involved: i) posters; ii) experimental models (explaining the creation of terraces, fossils, folds, geological faults); iii) three-dimensional virtual models (explaining the formation of ore deposits and other complex processes); iv) posters on local biodiversity; and v) complementing the exhibition, interactive guides, based upon previous scientific-educational studies. The multimedia sessions employed the presentation of a DVD compiling all the information. As said, both thematic expositions and multimedia sessions were developed by the two monitors. Furthermore, in order to reduce the "novelty space" of the participants, the Internet website (http://www.fc.up.pt/pessoas/allima/Castromil) allowed consultation of the materials, and made the place to be visited familiar before the field trip. The teachers taking part were responsible for the organization and timing of the field trip, for a visit to the exhibition, and attendance of the multimedia presentation.

Seven study stations were chosen for the field trip. Each location was selected according to the known scientific and educational characters: 1) slag; 2) faults and different rock types; 3) vein and fault; 4) contact between igneous rocks; 5) mine gallery visit; 6) tailings; and 7) fossils (graptolites). Given that this was a trip with specific scientific aspects, the monitors were prepared to carry out their roles acting as guides during the field trips. Being geology graduates, the monitors already had scientific information about the region. Their performance was essentially educational.

Sample

The participants, 166 students, belonged to five schools in northern Portugal. They were mostly from middle and secondary schools, between 10–21 years old and the majority were boys (58.5%, $n = 97$). The ages of the participants varied a lot, but informal teaching activities in outdoor environments are usually directed to a very wide public (note, for instance, the diversity of people who are museum visitors). Nonetheless, in spite of the difference in attitudes, goals and experiences of the participants, the team was certain that the participants' knowledge about the mine and geology was almost the same. This was so because of the limited number of such experiences, in both formal and informal teaching in Portugal. Nonetheless, the variety of ages was taken into account when planning the field trip and preparing educational materials. The two monitors were also prepared to deal with the pedagogical needs of this range of ages.

5. Data collection

As previously said, the evaluation carried out consisted of a user questionnaire and an interview with the monitors. The team decided to use a questionnaire prepared for the specific trip following Orion's suggestion that this kind of tool (in which we include inventories, scales etc.) can be useful for studies carried out in informal settings (Orion et al., 1997). Also, since it was expected there would be a huge number of participants, it would not be practical to carry out interviews of them all.

Firstly, the questionnaire was content-validated. Afterwards, the questionnaire was re-validated by a jury of three specialists (a secondary school teacher—a geology graduate, a university professor of geological education and a professor of geology). All had previously participated in field trip activity. The three were asked to evaluate the quality of each item and to suggest any relevant revision. Validation was also applied to a pilot sample (23 secondary school students) so as to identify motivations and linguistic issues.

The questionnaire was organized in four sections. Section I (six questions) allowed us to characterize the participants, at both a personal and academic level. Section II (13 questions) aimed at evaluating preexisting scientific knowledge as well as that acquired during the field trip. Section III (12 questions) evaluated the visit, in terms of the materials used, ability to deal with any doubts, and the performance of the monitors. Section IV (29 questions) dealt with environmental education (most of the questions presented in a Likert format). These questions were intended to diagnose attitudes and values related to environmental preservation. Of the questionnaire's 60 questions, only three involved long answers. The time available to produce answers was not restricted, but 30 minutes was enough.

The first section, called *Personal Characterization*, included six items, for example, "Age?" The second included questions about *Scientific Knowledge,* such as, "Which is the mineral exploited in these mines?" The concern of the third section was the *Developed Activities* and included questions like "The quantity of materials used for the visit was: insufficient, sufficient or excessive?" Finally, the fourth section dealt with aspects of *Environmental Education* and included questions such as "Do you consider it important to perform this type of activity in the field of geology and/or environment?" After the field trip, the monitors gave the teachers an envelope containing the questionnaires. These were confidential. The questionnaires were filled out in the classroom, during the first lesson after the field trip. The completed questionnaires were then posted to the research team, by the teachers. The items of the questionnaire were statistically treated, but long answer questions required a content-analysis.

The first contact between the monitors (as members of the project team) and the participants was only on the day of the field trip, making it impossible to take pre-visit measures. An evaluation study can be made without using such preliminary preparations, and these would be very difficult to get since the field trip was informal. One of the reasons leading us to decide to conduct an evaluation study was that the project team had no previous contact with the students until they arrived at the study area. With no pre-measures the evidence gathered in this research does not allow one to make substantial conclusions, but the outcomes are strong indicators of the benefits of the fieldwork in helping the development of scientific literacy.

The interviews of the monitors took place after the field trip. They were conducted individually by one trained researcher involved in the project. The questions included the major subjects tackled in the questionnaire: the first part explored scientific knowledge developed during the field trip and how it could help to improve scientific literacy; the second part asked the interviewees about the quality of the field trip (thematic exposition, multimedia presentation, mini-posters, organization, etc.); and the third part addressed the relevance of the study to environmental education and its connection to this specific field trip. The guiding interview questions are presented below:

1) Which geological and biological content was explored? What connection was perceived between these and scientific literacy?
2) Do you consider that the preparation provided before the field trip (exhibition and multimedia session) was able to reduce the “novelty space”? How? How do you evaluate the pedagogical relevance of the mini-posters and the field trip guide?
3) Was the activity also directed to environmental education?

The interviews were tape-recorded and fully transcribed for further analysis.

6. Results and analysis

Results and analysis of the questionnaire

The results took into consideration the three last sections of the questionnaire (II: Scientific Knowledge; III: Developed Activities; and IV: Environmental Education). Section I of the questionnaire (Personal Characterization) was used to characterize the sample.

Part II of the questionnaire

This section comprises 13 multiple choice questions, all of them related to geological or biological scientific knowledge. Analysis of the results led us to the conclusion that biological knowledge had been assimilated less than geological. Indeed, the questions related to biology (flora and fauna) show a very low percentage of correct answers (less than 12%). In general, the questions relating to geology obtained higher percentages of correct answers. Such results are probably due to the fact that the monitors’ academic knowledge was geology and not biology. Although they were prepared to act as guides in biologically related subjects, their preparation seems to have played little part in their performance, a fact that was echoed in the

Table 1: Descriptive information of the questionnaire

Sections	No. of items	Description	Sample items	Type of item
I	6	Characterization of the participants	Age?	Open question
II	13	Evaluation of pre-existing scientific knowledge.	What type of weathering is it possible to observe in the rock mention in the previous question?	Multiple choice question
III	12	Evaluation of the visit (monitors, materials…)	Concerning the material used during the visit, what is your opinion about the visual quality of each?	Multiple choice question
IV	29	Relation between the field trip and Environmental Education	Do you consider important performing this type of activities in the field of Geology and/or Environment	Multiple choice question

participants' answers. The analysis of these results leads us to reflect upon the importance of academic formation, not only in terms of scientific preparation. On the other hand, the geological/mining aspects of the region were understood better than biological.

Part III of the questionnaire

This aimed to assess the quality of the "Developed Activities." Of its 12 questions, only two required long answers.

The quantities of the educational materials (films, field guide, mini-posters etc.) were mostly rated as "very good" (60%). The quality of those materials was mostly classified as "good" (84%). In general, most of the educational materials were classified as "clear/good" (73%). In the "clarifying doubts section," 51% of the participants classified the explanation session held by the monitors as "good," and 42% as "very good."

The language used in the presentation of the educational materials obtained a higher percentage of answers in the "reasonable" category (more than 87%), reminding us of the difficulty of communicating in science. The course of the visit was mostly classified as "very good" (48%), owing to the monitors' scientific quality, the quality of the educational materials and the importance of the activity as a promoter of environmental education.

Part IV of the questionnaire

The fourth part of the questionnaire comprised questions referring to environmental education; only one question compelled a long answer. Although the questions of this section were focused on environmental education, all of them were specific to one subject of: i) usefulness of the region in terms of geological heritage; ii) link between geology and environment; iii) evaluating the development of competence; iv) evaluating the geology–society link; and v) establishing links between the scientific promotion of the region and the teaching of geology.

Most of the participants (95%) answered that it was positive to carry out these activities in the geological/environmental area, referring their importance to: i) environmental protection; ii) social contact; and iii) the spread of geological knowledge. The participants also mentioned the importance of conserving the geological heritage in this mining region. The answers related to the importance of preserving the geological, had the highest percentages in the "agree" category (more than 59%). These results reinforce the effectiveness of the field trip in helping preserve the geological and mining heritage of Castromil. This is indicated by the following finds: i) students considered the didactic use of the geological-mining heritage important; and ii) that an important historical-social resource is destroyed with the degradation of this heritage.

Stressing both the relevance of the link between geology and the environment and the relevance given by students to scientific literacy as an essential part of the role of the people, the questions in the thematic gave the highest percentages of answers in the "agree" category (more than 59%). Note that the questions in this group refer to the field trip activities' contribution to citizenry and the preservation of the environmental and geological heritage.

In questions addressed to the ability to develop competence, again the majority of answers were in the "agree" category (more than 63%), demonstrating that this type of activity favorably affects people's attitudes and benefits the environment and geological heritage.

In general, the participants considered that the activity contributed to the promotion of environmental education, encouraging understanding of the link between science, technology and environment, and the development of competencies.

In terms of the relevance of the activity to the understanding of geological issues and knowledge transfer, the affirmative answer was predominant overall, indicating the positive impact of the field trip as a help in preservation of the geological heritage and environment (more than 81%), scientifically and educationally (more than 90%) and socially (more than 68%). We also considered that the project activities probably helped the participant to learn geology, because the content explored during the field trip was not part of the normal curriculum and students were unlikely to have encountered it elsewhere. The answers also seem to indicate that they have the intention to apply that knowledge in day-to-day situations.

Summing up, the majority of the participants considered the fulfilment of this project's activity to be important for the preservation of mining-geological patrimony, for example, for the promotion of geology and geo-tourism (80, 7%), the preservation of the environment (86,7%), to promote the social and economic develop of regions involved (76%) and to promote scientific and didactic activities (90%).

Results and analysis of the interviews

To assess the field trip's success, the interviews were subjected to a content-analysis, in accordance with the previously defined three categories: i) construction of scientific knowledge; ii) quality of the developed activities; and iii) promotion of environmental education. Similarly to the approach used by Bardin (1994), the researcher started by pointing out the most significant sentences and underlined some keywords that represented the monitor's views about each one of the three categories. By comparing the sentences and the keywords marked on the monitor's interview transcripts, the content-specific similarities and differences between the interview replies were summarized, as presented in Table 2. As there were only three questions, it was easy to make a direct and clear analysis.

This categorization process was undertaken by a trained researcher involved in the project with further validation by another researcher (the coordinator of the project). Both monitors demonstrated they had clear conceptions of the content and they presented more similarities than differences in their answers.

Both monitors mentioned that students understood geology and the need to protect the environment. The participants demonstrated their development of geological knowledge when giving correct answers to questions from their guide on the trip. In addition, the monitors perceived the trip to be successful because they concluded that the participants demonstrated such knowledge in conversation at the end of the fieldwork. Monitors also noted that

Table 2. Monitors' interview replies in each category

	Category		
	Construction of scientific knowledge	Quality of the developed activities	Promotion of environmental education
Monitor 1	The contents observed were essentially geology related. Biology related contents were also looked into in articulation with the environment component. The students followed up their knowledge competence by filling in field guides and answering questions during the activity. This was a way of becoming aware of the need and dependence of society regarding geology related issues and their everyday applications, which usually are unnoticed by the majority of citizens.	The preparation of the field activity and of the exhibition was undoubtedly a learning booster, and was an element of student motivation. The guide led the students to attentively follow the activities and the mini-posters provided a quick, easy and explanatory resource. They linked theory to the direct field observation.	The students became clearer on the problems related to mining and its environmental impacts. The contact with geology made them think about and question these issues.
Monitor 2	More emphasis was put on geology related contents than on biology related ones (probably because the monitors came from the scientific area of geology). Several of the issues that were addressed during the field trip allowed the visitor to acquire basic geology related knowledge. This will allow a more easy understanding of the presence of geological resources in everyday life, as well as of their potential as a source of growth and the need for their sound management.	All the visits were undertaken after the thematic exhibition and the multimedia session, which allowed a better understanding of the contents. The field guide was fundamental for the field trips, keeping the majority of students concentrated and motivated, trying to understand all the aspects that were pointed out throughout the field trip. In some circumstances the mini-posters allowed a detailed thematic explanation.	The participants also understood the relevance of the didactical potential of this mining area. In general they agreed that this didactical facet may and should be used as a means for preserving patrimonial heritage for future generations.

some group discussions touched on the importance of geological resources in everyday life (for example, applications of gold, silver and kaolin).

In relation to the quality of the project's activities, the preparation of the field trip was said by both monitors to be motivating and useful, in instilling scientific knowledge. On the basis of their own experience in undergraduate courses, where field trips were frequent, the monitors saw the project model and its didactical materials as extremely appropriate in helping students gain a better sense of the real world environment and processes, as well as in recognizing the value of geological heritage. The materials (the thematic exhibition, the multimedia session, the field trip guide and the mini-posters) were user friendly and helped students to focus attention.

According to the monitors, the field trip promoted environmental education by reflecting upon the environmental impacts of mining, and also by educationally exploiting the local features. In fact, in the summary unit, when filling in the questionnaire, the students specifically referred to the fact that they considered it important to preserve the study area for didactic purposes and that the field trip helped them to understand the importance of the part they as citizens should play in preserving the environment. The monitors also noted that students revealed their knowledge and competencies when answering questions about the need to protect and to preserve the environment.

7. Conclusions

Carrying out a field trip involves the observation and analysis of geological aspects in a real environmental context. For the user, it is a strategy that makes it easier to understand concepts that demand some level of abstraction.

The evaluation study described here had no pre-measures phase. This means that the research is not sufficiently robust to make final conclusions, but it is indicative, and it is possible to mention some outcomes that could help further research on the value of field excursions in out-of-school settings. The technique of triangulation of data allowed us to conclude that the two sources of data pointed in the same direction. Both the questionnaire and the interviews allowed us to evaluate the field activity in three aspects: i) the construction of scientific knowledge by the participants; ii) the quality of the field activity carried out; and iii) the promotion of environmental education.

Post-trip information gathering seems to indicate that the activity allowed the participants to better learn "about science" and to "understand science." The field trip seems to have helped students to construct new concepts and to develop competencies that are promoted by the learning of geology and other natural sciences. As stated by Fuller (2006), fieldwork enhances student learning by improving students' understanding of the subject.

The quality of the field activity proved that the guide for the students and the mini-posters helped the teacher to plan the activity and promote the (re)conceptualization of concepts by the students. The quality of the monitors and the thematic exhibition and multimedia sessions helped to diminish the "novelty space" as mentioned in Orion's model.

Environmental education also seemed to be promoted by stimulating the emergence of a more informed citizenry capable of using intellectual resources, so as to contribute to a sustainable environment. The study undertaken demonstrates that Orion's (1993) model makes possible the creation of field trips in an informal setting, encouraging group discussion and team work.

The outcomes of this study are in agreement with the work developed by other researchers (Orion and Hofstein, 1994; Orion, 2003; Fuller, 2006; Kisiel, 2005). The outcomes provide further support for following the recommendations given by many researchers on the value of field trips, and the potential for creating successful school trips. Although the use of fieldwork as a teaching and learning tool is well established, this particular project intended to strengthen the importance of field trips in the enhancement of scientific literacy. Also established was the importance of careful organization of an excursion and of how helpful this type of activity could be for environmental education and the preservation of geological heritage. Considering that the quality of the activity and that the promotion of scientific literacy can be evaluated through the three above-mentioned items, this paper represents an attempt to reinforce the model of Orion (1993) thus leading to more successful field trips in an informal setting.

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