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Exploring marine biodiversity through inquiry with primary school students: a successful journey?

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ABSTRACT

In this work, we present a marine ecology inquiry-based activity, implemented with 164 primary school students. The main goal was to evaluate the activity's impact on students' understanding about biodiversity and scientific procedures. We also aimed to analyse the potential use of personal meaning maps (PMMs) to assess the impact of the activity on students' ideas about the topics explored. The results revealed that fieldwork and the exploration of real data were the aspects most emphasised by all intervenient. Finally, the PMMs proved to be a good tool to evaluate the impact of activities developed outside classroom, with primary school levels.

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Primary education; IBSE; out-of-school work; fieldwork; science centres

Introduction

From the profound changes that society has suffered in the last century due to scientific and technological innovation, science education became a priority for today's society (BSCS 2008; ICSU 2011; Millar 2002). Citizens are often forced to make choices that should rely on scientific knowledge of issues affecting their personal lives, such as health, consumer habits or environmentally sustainable practices (Hodson 2010; ICSU 2011). Indeed, a modern citizen must be actively engaged in current societal challenges. And in order to do so, one needs not only to have a deep understanding of scientific concepts but also to develop some scientific competences, such as questioning, researching, reflecting, analysing data, solving problems and making informed decisions based on evidence (Harlen 2006; Longbottom and Butler 1999). To achieve these goals, science education needs to: (i) help students to develop science process skills; (ii) create meaningful connections with science, technology, society and environment; (iii) develop values and positive attitudes towards science and (iv) promote a better understanding about the nature of science (Osborne and Dillon 2008). The increasing demand in these goals has been especially evident at primary school grades (Bell 2001; EC 2007).

Currently, there is a general consensus between science educators and researchers, that one important dimension to be considered is the involvement of the local community resources in science teaching, through the exploration of natural places and non-formal learning contexts as learning environments (Bell et al. 2009; Braund and Reiss 2004, 2006; EC 2007; Eshach 2007; Harlen 2006; Jenkins 2000). Indeed, many authors have already pointed out that the use of out-of-school learning contexts can provide a larger diversity of experiences and activities that can foster more active learning styles, helping students to be successful by stimulating their interest and curiosity in learning and by enhancing their self-esteem (Braund and Reiss 2004, 2006; Eastwell and Rennie 2002).

This study aims to contribute to this discussion, providing some evidence about the potentialities of developing inquiry-based science activities, focused on out-of-school resources, for supporting a

deep understanding about science and scientific processes at primary school. For this, we investigate how primary school students engage in a scientific research, when they are involved in an inquiry activity related to direct field observation and biological inventory on a natural wetland area. The main goal was to evaluate its impact on students' understanding about biodiversity and some scientific procedures. Furthermore, we sought to understand how students and teachers evaluate the activities implemented. Finally, we also intended to analyse the potential use of a personal meaning map (PMM) to assess student's learning, namely concerning their understanding about the scientific concepts explored in this kind of activities.

Theoretical background

Nowadays, many international reports on science education stress the need of science curricula to reveal a more authentic picture of science (e.g. Anderson 2007; Duggan and Gott 2002; Schreiner and Sjøberg 2004; Singer, Hilton and Scwiengruber 2005). Aligned with this major goal, and within the context of student-centred learning, inquiry-based teaching methods have become increasingly prominent, namely in the first years of schooling (Bybee 2000; EC 2007; Osborne and Dillon 2008).

According to Linn, Davis, and Bell (2004), the inquiry approach is defined as the 'intentional process of diagnosing problems, criticizing experiments, distinguishing alternatives, planning investigations, researching conjectures, searching for information, constructing models, debating with peers, and forming coherent arguments'. In fact, inquiry activities seem to help students to develop not only scientific knowledge but also a better understanding about the processes that scientists use in their research (Maaß and Artigue 2013; Mohrig, Hammond, and Colby 2007; NRC 1996), giving students an active role in their own learning (Fradd and Lee 1999; Maaß and Artigue 2013), and helping them to improve autonomy and self-confidence (Fradd and Lee 1999).

On the other hand, inquiry activities, in general, help to contextualise the learning in real life, which in turn reinforce its relevance and, consequently, could promote a greater interest in science (Barell 2007). Indeed, in an authentic inquiry activity, 'learners can investigate the natural world, propose ideas, and explain and justify assertions based upon evidence and, in the process, sense the spirit of science' (Hofstein and Lunetta 2003, p. 30). Consequently, scientific inquiry that enables students to apply both substantive and procedural knowledge in order to perform investigations in a way that mirrors actual practices of scientific communities, has re-emerged as the emphasis of new curriculum approaches (Atkin and Black 2003; EC 2007).

Finally, inquiry activities based on out-of-school contexts, when developed with primary school levels, can highlight opportunities for building onto children's innate curiosity about their natural environment and the world around them (Milne 2010; Murcia 2007). Young children are intrinsically interested in science. This natural curiosity could be a motivation for learning important foundational habits such as investigating, observing, measuring, reasoning or using scientific language to describe experiences and making informed decisions based on scientific ideas (Milne 2010).

However, despite the evidences about the potentialities of developing authentic inquiry activities with primary school students (Boaventura et al. 2013; Guilherme, Faria, and Boaventura 2015; Michaels, Shouse and Schweingruber 2007; Nowicki et al. 2013), it is known that many schools do not develop this kind of approach (DeWitt and Osborne 2007; Geist and Baum 2005; Kisiel 2005; Pearson 2007; Windschitl 2003), which provides a renewed urgency to the long-running debate on how best to support schools and teachers in changing their practices accordingly.

Methods

Activity description

The activity was developed through a collaboration between an Institute of teachers' education and a Science Centre and was integrated in a research project, 'Between tide-marks: Integrating literacies' (PTDC/CPE-CED/117923/2010). The major goal of the project was the development of inquiry

research activities, based on the exploration of local marine resources, providing 'real-life' situations as the learning context.

The activity was focused on the theme of biodiversity and was directed to primary school level. It involved a pre-visit task, a field trip and a post-visit session. In the pre-visit task, in order to contextualise the activity, students viewed a short animation video, created for this purpose, focused on the work of two marine scientists who were developing a research about the biological diversity of a local wetland natural area (Ria Formosa, in south of Portugal). Through this video, students were introduced to the main characteristics of the wetland area (that was in the vicinity of the involved schools), and to the concept of biodiversity, and were asked to assume the role of a marine biologist responsible for monitoring the biological diversity of the natural area under analysis.

In the field trip, students were asked to make an inventory of the living organisms present in the sediments. Since the wetland area under study was formed by two main type of sediments, with different relative percentages of mud and sand, in order to promote the possibility of a deeper exchange of data and ideas, each student was assigned to the exploration of only one type of the sediments present (so, half of the class was responsible for one type of sediment, and half for the other). The sampling of the sediments was made with the help of a monitor (from the science centre), and students sorted and identified the living organisms collected (plants, algae and marine benthonic macro-invertebrates) in the sampling, with the help of a species identification guide. All the work was performed in groups (4–5 elements), chosen by students.

In the post-visit session, students shared the data obtained by the different groups, confronting the observations made in both type of sediments, and discussed the differences obtained.

During the activity, students had the opportunity to work collaboratively, to question, discuss and confront ideas, to analyse data and to make conclusions based on evidence and, to learn some procedures about data collection in the field.

Participants

The activity was carried out with three primary schools, located in the vicinity of the wetland area under study. The participants belonged to the 2nd grade (6 students), the 3rd grade (89 students) and 4th grade (69 students), in a total of 164 students, 87 boys and 77 girls, aged between 7 and 10 years, and 9 teachers (1 for each class). These students belonged to nine classes: one class of the 2nd grade; one class of the 3rd and 4th grade; four classes of the 3rd grade; and three classes of the 4th grade. Only one class (of the 3rd grade) had previously experienced a field trip centred on freshwater benthonic macro-invertebrates identification.

Data collection and analysis

Data were collected through different instruments, namely, two PMMs, a students' opinion questionnaire, a teachers' implementation note, and two semi-structured interviews, one directed to students and one to teachers. The two PMMs were used before and after the field trip (pre- and post-PMM). The remaining instruments were used only after the end of the whole activity.

Considering PMMs, there was a small session in the beginning of the activity, where one example of PMM was shown to students, together with a basic explanation on the use of this technique. After that, students were asked to write (or draw) on an empty page, only with a key word in the centre, all the ideas that occur to them from this word. The two key words used were 'Biodiversity' and 'Doing science'. In the post-visit session, students were asked to create a new PMM and not to reformulate the one already created in the pre-visit session. The PMM about 'Biodiversity' aimed to reflect the impact of the activity on student's ideas about this concept. The PMM about 'Doing Science' aimed to reflect the activity impact on students' ideas about scientific procedures. Both PMMs were subject to content analysis, considering the following dimensions: number of related or unrelated items and number of concrete examples given (according to each key word in analysis)

(adapted from Evrekli, Inel, and Balim 2010; Falk and Storksdieck 2005). A total of 149 students completed the pre- and post-PMM (15 students missed the last session for personal reasons).

The students' opinion questionnaire had the main objective of identifying students' perceptions regarding the activities developed, along three dimensions: general appreciation of the activity; aspects they liked most; aspects in which they had more difficulties. The items of the questionnaire (52 questions of yes or no) were mainly centred on the main scientific procedures involved in planning and performing all the work (e.g. working in groups, using real data, arguing, analysing data, presenting to others). The data collected in this survey ($n = 164$) were submitted to a descriptive statistical analysis.

The students' interviews were conducted aiming at deepening and clarifying their perspectives on the impact of the activity for: science learning, understanding about the importance of science learning, and understanding about scientific procedures. For the interviews, a student from each group, in each class, was chosen by the group. A total of 41 students were interviewed.

The teachers' opinion about the activity was obtained through two different, but complementary instruments: the teachers' implementation notes, in which they were asked to explain how they conducted the activity, the main difficulties they had and their general opinion about it; and the interviews, in which they were asked to deep explain their perspectives about the impacts of the activity on students. A total of nine interviews (and nine implementation notes) were analysed. All interviews were audio-recorded, transcribed and subjected to content analysis, based on categories that emerged from the responses given by the participants. Through an iterative process of reading and re-reading data, we assigned meaningful pieces of text to categories (Miles and Huberman 1994). The inductive analysis of the interviews was performed independently by two researchers, who discussed and reviewed the analysis to ensure greater reliability.

All used instruments for data collection were developed by the authors for the evaluation of the activities created under the project 'Between tide-marks: Integrating literacies'. The Questionnaire was previously tested with a different class of students of the same age in order to verify if the questions were suited to the age of the participants. Data collected using different methods (PMMs, questionnaires, teacher and students' interviews) were crossed to ensure the reliability of the analysis and to get a deeper understanding of the activity impacts.

Results

Students' perception about the activity

Overall, students expressed that they liked performing all tasks, feeling motivated during the whole activity 'it was always fun' (4th grade), and that they have learnt in all stages, 'I've been learning step by step to the end' (3rd grade). The analysis of the questionnaire revealed that all of them (100%) enjoyed the activity.

The aspects most appreciated were the 'group work' (96%), the 'use of research equipment' (96%) and the 'use of scientific knowledge' (93%), whereas the aspects underappreciated were, 'have to think a lot' (30% do not appreciate), 'argue to defend my own ideas' (30% do not appreciate) and 'planning and performing my own experiences' (29% do not appreciate) (Table 1).

In the interviews, students highlighted the field trip, and one of the most referred aspects was the experience of collecting, observing and identifying living organisms in the field, as expressed in the following excerpt:

I enjoyed being ... hmm ... trying to find crabs and other living beings and things and animals that exist ... that exist ... there at the sea and ... hmm ... to know the names of the plants that are in the water. (2nd grade)

Concerning the difficulties, six aspects were highlighted by more than 40% of the students: (i) to analyse relevant information (40%); (ii) to carry out observations (43%); (iii) to ask questions (48%); (iv) to interpret results (43%); (v) to make conclusions (44%); and (vi) to use their own learning to

Table 1. Most appreciated aspects of the activity ($n=164$).

Aspects that you liked most:	Yes	No	N.A.
Having to think a lot	114	50	0
Presenting my own results	145	19	0
Arguing to defend my own ideas	114	49	1
Using scientific knowledge	153	9	2
Taking decisions on how to organise the work	142	22	0
Planning and performing my own experiences	117	47	0
The opportunity to answer to my own questions	137	25	2
Working in groups	157	6	1
Using real data	143	19	2
Doing the field trip	144	20	0
Using research equipment	157	7	0

make decisions (45%). On the contrary, the two aspects less mentioned were to search information in books and other sources (29%), and to plan their own experiences (27%) (Table 2).

Regarding their understanding about the relevance of science, students reported that the activity increased their interest in science themes, as illustrated by the following sentence: 'I liked it before but now, I manage to like a bit more' (3rd grade), and helped them to realise the important of science, although, in general, they revealed some difficulty to explain the reasons for that. Those who managed to explain it highlighted the importance of acquiring scientific knowledge and of sharing it with others, as illustrated by the following excerpt:

Yes, it helped me to realize, because science will be part of our life and we have the knowledge, so we can learn better and better ... and afterwards we can explain to our children and grandchildren and that's it. (3rd grade)

Finally, concerning the impact of the activity, the analysis of the questionnaire revealed that most students considered that the activity promoted a better understanding of scientific concepts (88%) and of knowledge about 'how to do science' (82%). Moreover, most students agreed that the activity helped them to understand the need of studying science (91%) and to learn that scientific knowledge is useful for their daily life (88%).

Teachers' perception about the activity

In general, teachers' opinion about the activity was quite positive. They considered the activity as very interesting, integrated in the curriculum and appropriate to students' ages, as highlighted in one of the teachers words: '[...] gives an idea of what surrounds them in terms of the study of very concrete aspects and I think that is very well suited to the curriculum' (Teacher of the 4th grade). All of them

Table 2. Most difficult aspects in the activity ($n=164$).

Aspects that you felt as most difficult:	Yes	No	N.A.
Taking decisions on how to organise the work	65	97	2
Analysing relevant information	66	96	2
Carry out observations	71	91	2
Asking questions	78	84	2
Identifying a problem	63	100	1
Searching information in books and other sources	47	113	4
Raising hypotheses and making predictions	63	101	0
Planning my own experiences	45	119	0
Performing my own experiences	56	108	0
Using tools to analyse data	59	105	0
Interpreting results	70	94	0
Making conclusions	72	92	0
Having to use my learning to make decisions	74	88	2

refer that the activity was well received by students, and kept them highly motivated, as illustrated by the following excerpts:

[...] They [students] were always saying 'we must do, we must do, we have to prepare [something] for the activity', so the motivation was achieved since the first moment [...]. (Teacher of the 3rd grade)

They expressed that they were always enjoying it. I think that what they liked even more was the field trip [...] a field trip for them was the highlight. Then at the end of the year, when they saw the pictures they still said: I loved, I loved! I loved doing that. (Teacher of the 4th grade)

[...] To catch ... the proper tools, registers and go out looking for little things as they did, I think it is a fabulous motivation. I think they were more motivated [for learning science]. (Teacher of the 4th grade)

All participant teachers considered that the activity brought something new to students, namely through the introduction of a practical component based on real data, which is not always held at primary school classrooms, as can be seen by the following answer:

It is an activity which has a practical part, obligates us to collect field data and to work with those data and that is something we don't do much in our daily routine. Therefore, this activity filled that gap. (Teacher of the 3rd grade)

Overall, most teachers stated that the activity contributed not only to develop conceptual knowledge, but also helped students to develop diverse collaborative and social skills, as well as positive attitudes for environmental protection, as illustrated by the following opinion:

Feelings respect towards nature, both concerning flora and fauna [...]; group working was also very helpful to them, although it is a common procedure [...], skills about knowing how to organize work in different stages, respecting and following certain items [...], learning how to be with each other, knowing other teachers [monitors] and functioning with other people besides those who they already known [...], and regarding the learning of new scientific concepts, as I said in my teachers' implementation note, ecosystems, biodiversity and more. (Teacher of the 4th grade)

Concerning the main difficulties, some teachers referred the use of somehow complex scientific vocabulary, 'Clearly, in the beginning, there was the vocabulary that they were supposed to use and that they didn't dominate, many didn't know the meaning of some concepts [...]' (Teacher of the 4th grade)

The time needed for performing all the activity was one of the main difficulties that teachers felt in the implementation process, '[...] the period for developing the activity has to be longer, it can't be a short activity, you have to spend more time with the activity than just 3 sessions, before, during and after, it is very short [...]' (Teacher of the 3rd grade).

Finally, six teachers assumed that the activity might have contributed to enrich their own pedagogical practices, as shown in the following quotes:

[...] For me it was very useful because it enriched my job, because I could contact with new ways of approaching certain topics, that I never had the opportunity to do so, like collecting samples in the water, in the sand, by using those tools [...]. (Teacher of the 4th grade)

[...] It also taught me the experimental practice and how to continue this type of didactic exploration. (Teacher of the 3rd grade)

Finally, all teachers claimed to have interest and willingness to undertake this type of activity again.

Learning outcomes about Biodiversity

Concerning the analysis of the PMMs related to the 'biodiversity' concept (Figures 1 and 2), in general, there was some progress in the complexity of the PMMs made at the end of the activity. In fact, in the second one (post-visit), there was an increase in the number of related items, namely, with reference to general groups of living organisms (like plants, animals, marine animals and terrestrial animals), and more specific animal groups (like fish and birds) (Figure 2), and a decrease in the number of

Figure 1. Analysis of the PMMs concerning “Biodiversity” ($n=149$). (a) Related items; (b) unrelated items; (c) examples of organisms.

unrelated items (Figure 1(b)). Furthermore, the post-visit PMMs included much more concrete examples of organisms (like eremite crab and spider crab) than the pre-visit PMMs (Figure 2). For example, there are only 3% of pre-visit PMMs with three or more related items, in contrast with 42% of the PMMs of the post-visit (Figure 1(a)). Moreover, although in both PMMs (pre and post-visit) students included unrelated terms, the differences are also very clear, with 20% of pre-visit PMMs with three or more unrelated items, in contrast with 14% in the post-visit ones (Figure 1(c)).

Regarding the analysis of the progression of individual students through the comparison of both PMMs made by each student (see an example in Figure 2), it was found that, although not all students revealed a progression in the PMMs created, 87% created a more complex one, with a larger number of related and/or smaller number of unrelated items, as well as a greater number of references of

Figure 2. Example of a PMM concerning "Biodiversity". (a) Pre-visit; (b) post-visit.

distinct living organism, compared to the PMM made in the beginning. Nevertheless, around 11% of the students did not show any difference in their PMMs, and 3% of them revealed even a regression in the complexity of their post-visit PMM.

Considering this entire pattern, it seems that the understanding of the biodiversity concept was somehow improved by the majority of students after the conclusion of the activity. Indeed, in the interview, 8 students (out of 41) said that they have learnt the meaning of biodiversity, as it is illustrated by the following quote: 'I learnt that biodiversity is living beings and plants and also animals, they aren't all the same and there are different ones' (3rd grade).

One of the main difficulties of this PMM could be the fact that students did not understand the biodiversity concept at the beginning of the activity, as highlighted by them: 'Before we went to the beach and your explanation about the meaning of the word biodiversity, I felt some difficulty because I didn't know the meaning of that word and I wouldn't be able to make the task' (4th grade); and by teachers:

I think that in the part of the PMM they had some difficulty [...] they didn't know the word and it brought them some difficulties, some pass it beyond inventing things that have nothing to do, but the fact that they didn't know the meaning or a synonym of the word increased its difficulty [...]. (Teacher of the 3rd grade)

Learning outcomes about doing science

Regarding the analysis of the PMMs related to the expression 'Doing Science' (Figures 3 and 4), and contrary to the biodiversity concept, students already revealed some knowledge about what could be involved with that expression. Indeed, 25% of the pre-visit PMMs already presented one or two related items (21% and 25%, respectively) (Figure 3(a)). However, there was also a tendency to create richer PMMs in the post-visit, with a slight increase in the number of related items, associated with persons (scientists) and spaces, with a reference to field work, instead of only laboratory work. The post-visit PMMs also included more items associated with scientific procedures, some very important ones (like experiments, exploration, discover, observation, learning, studying, thinking and discussing) (Figure 4). For example, at the end of the activity, 21% of the PMMs presented four or more corrected items, in opposition to 11% at the beginning (Figure 3(a)). The same applies to the number of examples of scientific research equipment (mainly laboratory equipment, like tweezers, chemical products, test tubes and books) indicated in each type of PMM: 7% with 3 or more examples at the end, in opposition to only 2% at the beginning (Figure 3(c)). In this case, a reduction of unrelated terms from the pre to the post-visit PMMs was also found (Figure 3(b)).

Moreover, the analysis of the pre-visit PMMs revealed that most children related science essentially with chemistry and laboratory work, and some of them had a somehow 'romanticised' idea about it, using words like 'explosion' (11% of PMMs), 'magic' (4% of PMMs) and 'potions' (2% of PMMs).

Regarding the analysis of the individual progressions (see an example in Figure 4), 46% of the students revealed some progression in their PMMs, showing a greater number of related and/or fewer unrelated terms in the post-visit mind map than in the first one. However, about a third (34%) revealed neither progression nor regression, showing similar PMMs in both phases, and some of them (20%) revealed even a regression, creating post-visit PMMs with a smaller number of related terms.

Therefore, it appears that, although it is evident that some students developed some knowledge about what is 'Doing Science', this concept was not as effectively apprehended through the activities carried out as the biodiversity concept. During the interviews, students claimed that the activity helped them to understand better how to 'Do Science', but they 'had a hard time' explaining it. Some students said that it is necessary to use special equipment, as referred in the following answer: 'You can work with multiple tools, binoculars, tweezers and with that thing of taking sand and you can work with several portions and other stuff as well' (4th grade). Other students said that it has to do with research, something you want to learn a little bit more, as the following answer shows: 'Science is done ... first ... hmm ... say anything to discover and then go study to see whether it is truth or false' (3rd grade).

Discussion

The results obtained in this work revealed that young children are perfectly capable of engaging in scientific field research activities involving planning, data collection in the field, and explanation. Many of them were highly motivated during all the different tasks of the activity, having developed a better understanding about the subject under study (biodiversity) and about the scientific procedures. The fieldwork, and the consequent exploration of real data, seemed to be the aspects most emphasised by all participants (teachers and students).

Considering the impact of the activity on students' understanding about the thematic explored, the analysis of the PMMs revealed that, in general, there was a progression in their complexity at

Figure 3. Analysis of the PMMs concerning "Doing science" ($n=149$). (a) Related items; (b) unrelated items; (c) examples of research equipment.

the end of the activity, considering both the biodiversity concept and the 'doing science' expression. Considering the entire pattern, it seems that the implemented activity promoted not only the understanding of the biodiversity concept but also the development of a greater understanding about the scientific procedures in the majority of students.

Recently, many primary science reform documents advocate the need to develop children's views about scientific activities, through the use of an inquiry-based approach in a real-world context, as early as possible (e.g. EC 2007; Johnson 2012). Young children are intrinsically interested in science. They are curious about their surrounding world and about the causes, processes, and mechanisms that underlie biological and physical phenomena (Brown 1997). When the relevant content

Figure 4. Example of a PMM concerning “Doing Science”. (a) Pre-visit; (b) post-visit.

comes out from children’s inquiry into a specific real context, it places them at the centre of the learning process, providing opportunities for children to construct ideas and to shape prior knowledge and understanding (Murcia 2007). The involvement and enthusiasm demonstrated by all students in this work reinforce the idea that these opportunities could, and probably should, begin early in the educative process, taking advantage of children’s curiosity and willingness to understand the natural world around them.

Quite interesting was the fact that working with peers, in groups, was referred by students as being one of the aspects they liked most. This results contradicts the results obtained in other studies involving older students (e.g. Pepper 2010), which did not always appreciate group work. This may mean that younger students appreciate more the helpfulness and cooperation provided by their peers, which may be an aspect to take advantage in the future. In view of this, probably, it should be important to give more attention to the formation of the groups, to monitoring the functioning of each group and to support its progression, thus ensuring an effective collaborative process by all.

The results obtained in this study highlight the importance of developing inquiry-based approaches and exploration of out-of-school settings with primary school students. Using learning contexts that allow children to explore real-world contexts and real data seems to be a relevant way to provide opportunities that enable them to be engaged and motivated to learn science and to deepen their understanding about scientific procedures.

Conclusion

One aspect that was reinforced by this study is the importance and usefulness of developing partnerships between schools and non-formal education institutions, like science centres, to promote a better understanding of science, namely of scientific procedures. Faria, Pereira and Chagas (2010), in a study about the effects of infusing the history of science in science teaching, have already stressed that science museums can constitute a compelling context for learning about scientific practices and concerns over time. Our belief is that this kind of non-formal educational institutions can be an excellent complement to the work developed in the classroom because they can provide unique resources and expertise, through the involvement of other experts, like monitors and scientists, that could support and complement the work of teachers.

Finally, it seems that PMMs are good tools to evaluate the impact of activities performed outside the classroom on students' ideas about the thematic explored, at least at primary school levels. This is a major result, since the assessment of school fieldtrip effectiveness on the learning process, although being a major objective of any work performed in the context of the schoolwork, is rarely made or it is made in a too simplistic way (Kisiel 2005). So, there is an urgent need to develop practical and efficient tools to assess this type of learning. The PMM analysis could show the progression of students towards conceptual understanding and help to diagnose student's previous ideas on a particular subject. One interesting way to complement the analysis of these data would be to promote the confrontation of both PMMs (pre and post) by each student, to deeply understand the changes undergone by them.

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