Investigating school guided-visits to an Aquarium: what roles for science teachers?

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Abstract

The main goals of this study were to understand the different roles played by teachers and students during a school guided-tour to an aquarium and to analyse their different perspectives about the visit. The study focused on: students' and teachers' behaviour during school guided-visits to an Aquarium; students' and teachers' perspectives about this type of school visits; and the reasons held by teachers to engage in a guided-tour to a science museum. Direct observations of 39 guided-tours were performed in order to describe the structure of the visit and the participants' behaviour. A questionnaire was applied after the visit to 145 teachers and 191 students in order to describe their perspectives about the visit, and an online questionnaire was applied to a sample of 11 teachers, in order to understand their major ideas about school visits to science museums. Data analysis showed that the guided-visits, although well evaluated by both students and teachers, were mainly guide-directed and lecture-oriented, giving students and teachers very little choice and control over the learning agenda. Moreover, teachers showed a very passive role during the visit, and reported limited plans for preparation and follow-up activities that would support the visit. Despite this scenario, the teachers questioned preferred guided-visits instead of non-guided visits, and recognized the potential of museums for learning. The possible role of teachers in establishing the

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necessary connection between guided-tours and school science, helping to bridge school curriculum, museum content and student inquiries is discussed.

Running-head: School guided-visits: the teachers' roles

Introduction

There is a worldwide consensus that modern societies need scientifically literate citizens (EC, 2007; Osborne & Dillon, 2008). Citizens' scientific literacy enhances the understanding of science, provides competences needed in everyday life, develops a climate for public decision-making based on arguments, and establishes a basis for more science-oriented career choices (Holbrook & Rannikmae, 2002; OECD, 2006). In order to accomplish the development of active citizens, able to take an action in everyday situations that concern present and relevant scientific issues, it is essential to develop innovative science teaching approaches, involving inquiry and problem-based activities. In addition to knowledge acquisition these approaches could be more effective in the promotion of students' interest in science and the use of intellectual skills, curiosity, critical thinking and reflection. Additionally, they encourage the use of a range of complementary skills, such as autonomy, collaboration and communication competencies (Osborne & Dillon, 2008).

However, according to international reports (e.g. EC, 2007; OECD, 2006), in most European countries actual science teaching practices do not follow such an innovative approach, and the traditional formal science education strategies, ones that are been developed in our schools, seemed to affect negatively the development of students'

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positive attitudes towards science learning. According to these reports, in order to reverse the situation, it is important to encourage collaborative actions involving both formal and non-formal education stakeholders, aimed at accelerating the pace of change by know-how sharing. School science agenda must extend beyond the walls of the school to the resources of the community.

Certainly, science museums can contribute greatly to the science literacy goals stated above. The mission of many non-formal institutions, like science museums, beyond scientific research and heritage conservation, is to support public engagement with science (ICOM, 2007), contributing to the development of a scientifically literate public. Although the work with schools constitutes only a part of this broader mission it is, nevertheless, a critical part. Science museums have potential advantages in which concerns nurturing curiosity, improving motivation and positive attitudes towards science, and generating a sense of wonder, interest and enthusiasm to learn (Anderson, Lucas & Ginns, 2003; Falk & Dierking, 2000; Ramey-Gassert, Walberg & Walberg, 1994). These institutions are learner-centered, enabling self-regulated and situated learning as well as peers active involvement in social interactions (Bell, Lewenstein, Shouse & Feder, 2009; Hofstein & Rosenfeld, 1996; Ramey-Gassert et al., 1994). The learning environments they generate are ideal to promote active science learning, in which students are engaged in inquiry and problem-solving while investigating and experiencing science, technology and society relationships (Bybee, 2001; Hofstein & Rosenfeld, 1996; Jarvis & Pell, 2005). The association of scientific thinking with engaging, enjoyable events and real-world outcomes can create important connections on a personal level (Bell et al., 2009) with an impact in science learning. In this sense,

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non-formal settings occupy an important and distinctive place in science learning, presenting strengths that are unique and complementary to the strengths of schools (Bell et al., 2009; Jarvis & Pell, 2005; Ramey-Gassert et al., 1994).

However, years of research indicate that school visits to science museums are often conducted in a manner that does not maximize the learning opportunities they could afford (Griffin, 2004; Griffin & Symington, 1997; Tran, 2006). In general, there is little or no preparation or follow-up to the visit, in spite of the fact that many studies have shown that these aspects generally improve the learning potential of a school fieldtrip (Griffin, 2004; Kisiel, 2006; Kubota & Olstad, 1991).

Kisiel (2005) conducted an extensive study about teachers' objectives when planning and implementing school visits to science museums. The author identified eight different motivations, which can be superimposed on the same teacher: (i) as an opportunity to strengthen and expand the curriculum worked in the classroom; (ii) as an opportunity to provide rich and entirely new learning experiences; (iii) to provide an overall learning experience that is memorable; (iv) to promote students' interest, motivation and willingness to learn; (v) to provide a break in the routine; (vi) to promote lifelong learning showing to students that learning is possible beyond the school; (vii) to promote the pleasure and reward since teachers recognize that school visits can be a positive and pleasant experience to students; (viii) to satisfy the requirements of the school since teachers are expected to conduct study visits. According to Kisiel (2005), the objective more often referred by teachers for a school visit to a museum, is to strength the curriculum worked in school. However, the study of

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Kisiel also showed that teachers seem to have very different views about the nature of this connection to the curriculum. For some of them, the connection to the curriculum involves explicit efforts, such as the development of specific activities and the exploration of selected concepts about specific curriculum topics. But there is also what the author describes as mere opportunistic links, when the teacher asks students to check how different aspects of the exhibition relate to the curriculum (Kisiel, 2005). Other studies (e.g. Gottfried, 1980; Lucas, 2000; Tal, Bamberger & Morag, 2005), report that in general, teachers consider personal enrichment and social interactions as main objectives for school visits to museums.

Indeed, numerous studies have revealed that most teachers when conducting school visits to museums do not plan the visit, do not know the proposed program of the visit (in the case of guided tours) and do not seem aware of the relevance of their role for the success of visit. In general they play a completely passive role limited to ensuring the logistical issues of the visit (e.g. Griffin, 2004; Griffin & Symington, 1997; Kubota & Olstad, 1991; Tal & Morag, 2007; Tal et al. 2005). Moreover, strategies appropriate to formal settings are often imposed on museums (Griffin, 2004), in spite of the studies showing that the resemblance of museum lessons to school lessons, without considering the unique learning opportunities that museums offer, is an obstacle to nurturing interests in science and learning (e.g. Tran, 2006).

The literature thus shows that a gap seems to stay between school-based and museum-based activities as a major impediment for students' learning in a visit. Teachers are well situated to meet challenges and capitalize on the opportunities inherent to non-

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formal environments, making the adequate bridge between learners' knowledge and understandings. In order to exploit these opportunities, and to optimize students' attitudinal and cognitive gains, it is crucial that, as part of their planning and implementation procedures, teachers assume an active role during the visit, in a way that provides support and "scaffolding" between students' existing concepts and the exhibits (Anderson et al, 2003; Griffin & Symington, 1997; Jarvis & Pell, 2005; Price & Hein, 1991). Assuring this kind of active involvement on the part of teachers implies helping them to understand their own role as promoters of students' engagement during the school visit.

According to DeWitt and Osborne (2007), the current perspective of many museum educators, supported by the data reported in the literature, is that although science centers and museums are important resources for learning, there still exists a need to improve the way teachers utilize these learning institutions. How to effectively link formal and non-formal learning experiences, enhancing the learning of science is a current issue in science education research (Bell et al. 2009; Hofstein & Rosenfeld, 1996; Tal & Morag 2007).

This study is part of a wider research focused on the promotion of partnerships between formal and non-formal science education institutions (e.g. schools and science museums) in order to improve students' scientific literacy. This research is based in two major assumptions: the need to develop new science teaching approaches more effective in increasing students' interest and achievement; and the enormous potential of non-

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formal environments given the uniqueness and wealthy of resources they present, ideal to promote good practices in science teaching.

The main purpose of this study was to describe the dynamics during a guided-visit, specifically the different roles played by teachers and students, and to analyse their perspectives about the visit itself. The research questions of the study were: i) what kind of interactions (for all participants: teachers, students, guides) occur during a guided school-visit to an aquarium? ii) What are the teachers' and students' perceptions of the guided-visits? iii) What are the teachers' intended outcomes for a guided school-visit?

Methods

Exhibition context

The study was conducted in an Aquarium located in Lisbon (Portugal). The Vasco da Gama Aquarium is a scientific and pedagogical institution, which opened its doors to the public in 1898, during the 4th centenary celebrations of the discovery of the sea-route to India by the renowned navigator Vasco da Gama. Yearly it receives about 60 000 visitors, of which 38% are school visits. All through its 100 years of existence the Vasco da Gama Aquarium has been playing a fundamental role in the divulgation of Aquatic Biology in Portugal throughout a Museum and an Aquarium, complementing each other, and allowing the visitor to receive an enlarged view of the Aquatic World. This institution has been involved in research projects aimed at promoting and strengthen relationships between schools and the aquarium, namely in the development and implementation of innovative activities, embedded by history of science, directed to schools (Faria, Pereira & Chagas, 2010).

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Two types of school-visits are possible. Non-guided school visits, in which teachers take the responsibility for monitoring and guiding students during the visit. In this case, teachers are encouraged to prepare the visit in advance, either contacting the educational service of the aquarium, or consulting the information available in the website. Guided school-visits, in which an aquarium guide conducts the group throughout the tour centered on a specific thematic, according to the students' school grade. In general the guided-tour includes a visit to the live-exhibition of the aquarium and the visualization of a small multimedia presentation centered on the thematic of the visit. The guided-visits last about one hour.

Data collection

The study was focused on the behaviour of students and teachers while doing a guided-visit to the Aquarium. The main objective of the observation was to obtain first hand information about how the study visits were taking place, what was the behavior performed by each participant and what type of interactions they established with each other (first research question). Non-participant and structured observations were the major data collection procedure. First, *ad libitum* observations were carried out in order to identify the type of behaviours each participant (student, teacher, and guide) could perform and to establish the observation protocol to be followed in each observation session.

Based on the *ad libitum* observations the behaviours of students and teachers were organized into the following categories:

1) Students' behaviour

- "With the guide": this category included all behaviours in which students were close to the guide, observing what he/she was indicating;

- "Observing other aquarium": this category included all behaviours in which students were observing other aquaria than those indicated by the guide, and seeking information about it;

- "Playing": this category included all behaviours in which students were not observing any aquaria at all. They may be playing with others in a nonconformity way with the visit (knocking on each other, talking about something not related, taking photos on each other, doing nothing in particular).

2) Type of interactions

- Student-student: when a student asked or said to a colleague something related with the visit;

- Student-guide: when a student asked or said to the guide something related with the visit;

- Student-teacher: when a student asked or said to the teacher something related with the visit;

- Teacher-guide: when the teacher asked or said to the guide something related with the visit.

3) Students' and teachers' relative position

- In the vicinity of the aquarium where the guide was

- In an aquarium apart from the guide

Secondly, structured observations took place according to the protocol previously designed. At the beginning of a school visit, when a group first entered the Aquarium, the observer joined the group and initiated an observation session. In each observation session, which lasted until the end of the visit, the number of all types of interactions that took place (student-student, student-teacher, student-guide and teacher-guide) during each visit was recorded. Additionally, every 5 minutes a scan was performed, in order to record the relative position of each student and teacher in relation to the guide's position (students' and teachers' relative position categories), as well as to record the behaviour of each student (students' behaviour categories). Finally, the scientific content of the tour was also recorded, namely the nature of the questions made by the guide during the visit. For this analysis, the questions were coded as open-ended questions, related with overarching biological concepts, or closed-ended questions, related with specific aspects of the specimens or which have pre-determined and brief correct answers.

However, given that human behaviour can never be understood without reference to the different aims and objectives that actors give to their own actions, the observations were complemented by questionnaires in order to understand how the different intervenient viewed the study visits. In order to understand teachers' and students' perceptions of the guided-tours (second research question) a questionnaire was given to each teacher and student at the end of all guided-visits that occurred during the study period (six months), regardless of the group was accompanied by the observer or not. Moreover, in order to gain a deep understanding of teachers' ideas about school visits

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to science museums, namely their intended outcomes (third research question), this questionnaire included items about the learning objectives of the school visit and the pedagogical value of the tour. This data was complemented with data collected with an online questionnaire that was applied only to teachers, who took part in a guided-visit and who agreed to collaborate with the research providing their e-mail contact.

The purpose of the students' questionnaire was to describe their opinion about the interest of the visit, in terms of the scientific subjects covered by the tour guide in connection with class work, the promotion of scientific understanding and their enjoyment of the visit (five yes/no questions). Additionally, they were asked to give suggestions in order to improve the visit (four open questions) and they were asked to make a global evaluation of the visit (five likert scale, from very bad to very good).

The main objective of the teachers' questionnaire was to get their appreciation about the quality of the visit concerning the topic presented and the strategies used by the tour guide in order to promote students' learning (five likert scale, from very bad to very good). The questionnaire also included items about the learning objectives of the school visit, the pedagogical value of the tour and its suitability for students, teachers' working plans concerning the integration of the visit in the school work (pre- and post-visit activities) (multiple choice questions) and an item for teachers to give suggestions for the improvement of the visit (open question). In the online questionnaire, teachers were asked about their opinion about the potentialities of school visits to science museums, to contrast the non-guided with guided visits, and to explain if and how they usually establish connections between class and museum learning (ten open questions).

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Sample

A total of 39 guided-tours were observed: 13 for grades 1 to 4, 12 for grades 5 to 6, two for grades 7 to 9, and two for grades 10 to 12. The teachers' questionnaire was applied to 145 teachers: 17 kindergarten, 63 elementary, 40 middle, 10 low secondary (grades 7 to 9) and 15 high secondary (grades 10 to 12). From this sample, 11 teachers accepted to answer to the online questionnaire: five were teaching grades 1 to 4, five were teaching grades 5 to 6, and one was a secondary teacher. The students' questionnaire was applied to 191 students (100 males and 91 females): 114 elementary, 59 middle, two low secondary, 14 high secondary.

Results and Discussion

This section is organized in two sub-sections: analysis of data related with the observations made and analysis of data related with the questionnaires. In the first one, the behaviour of students and teachers was analysed during a guided school-visits to the Aquarium (first objective) and in the second one, the perspectives of both students and teachers about the guided-school visits were described (second objective) and the reasons held by teachers for engaging in guided-tours to science museums with their students were identified (third objective).

Observation data

Structure of the guided tour

A usual guided-tour was a structured, guide-directed experience in which students, teachers and guide moved together as a whole group. The vignette bellow provides a

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description of a tour based on observation data collected from a tour with elementary school students, focused on the thematic “The diversity of life”.

Vignette: Twenty-three students and two teachers arrive at 9:45 a.m. for the 10:00 a.m. tour. At 10:00 a.m. students enter the Aquarium hall, where guide M. introduces herself. She gives students some guidance about the rules of conduct during the visit, such as staying together throughout the tour, asking questions one at a time and not making too much noise during the tour. She tells, “I will give you information about the aquarium but I will also give you some time to touch when possible and to see all animals.” She leads the group to the tank of the marine turtles and she asks a variety of questions about turtles: “what do we have here?”, “do you think they are marine or freshwater? Why?” She calls students’ attention to the morphology of the turtles and attempts to relate it with their functions. She also asks students “how do you think the turtles breathe?” Students ask some questions related with the food and reproduction of the turtles. Both teachers are distracted. The group moves to the freshwater gallery to see some river fish. The guide asks students to observe one group of fish and to pay attention to the “the position of the eyes and mouth” and relates it with the fact that they eat insects. After about 15min, they walk to the Portuguese marine fauna gallery. The guide asks “what is the difference between the ocean and the rivers?” and “is the water in Portugal cold or hot?” Teachers remain distracted, talking to each other. The group sees some marine fish typical of the Portuguese coast and stops in front of an aquarium with sea stars. The guide asks “what do you think: a sea star is a plant or an animal?” Some students answer that they are plants. The guide explains what a sea star is, and one student asks if they have eyes. After that, one of the students who saw a jellyfish

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asks if it is a plant or an animal. While watching the tank for some time a flatfish appeared and the guide asks “why is it flat?” Many students answer that it is flat to camouflage in the sand. The guide moves to another tank with the group, but four students are left behind. One of the teachers picks them. The guide asks: “What do we have here besides fish?” Students discover a spider crab. The guide asks students to observe the shell of this animal and tell if it is smooth or rough, and talks about its camouflage with algae. In another tank, the guide asks “what is the name of a group of fish?”, “why do you thing they live in groups?” and so on. Students begin to get restless (10:30 a.m.) and the guide has to ask them to pay attention. The group continues moving along different aquaria, toward the tropical gallery, observing the organisms and talking about them, about their morphology and colors, asking and answering questions such as: “what does the fish use to swim?”, “why there is a spot like an eye in the back of that fish?”, “why fish change colors?”, and so on. Teachers remain distracted, standing many times outside the group. After a while, students begin to talk to each other loudly and one of the teachers tells them to keep quiet. At 10:45 the group moves to two touch tanks, one representing a sand beach and one representing a rocky beach. At this place, the guide separates the group in two smaller ones and asks students to observe the animals in each tank, to touch some of the animals, and to answer to some questions, such as “In which tank there is a higher diversity of animals? What are the reasons for that?” and so on. Students are very excited because they can get their hands into the water and they talk very loudly. Teachers are now very focused on controlling students’ behavior. At 11:00 the guide leads teachers and students to a brief media presentation about the specimens seen during the visit.

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Analysis of the tours

The tours observed in this study could be guided by three different museum educators. However, although there were some differences between the tours according to the personal characteristics of each guide, the basic structure of each tour was the same between all guides. The vignette presented is a typical example of how the tours observed were developed and it will serve as a basis for the tour analysis.

All tours observed (n=39) were guide-focused, lecture-oriented, and often patterned with guide providing content information (e.g. “I will give you information about the aquarium…”), guide asking some questions (e.g. “She (the guide) leads the group to the tank of the marine turtles and she asks a variety of questions about turtles…”), and then group moving to another area. Students have never been asked to search any kind of information on their own nor had a period of free exploration of the aquaria. Analysis of observation data revealed the following:

– Although there was some concern to be focused on some big ideas or overarching concepts (like calling attention for different strategies of surviving, like predatory defenses, or interdependence between species) (5% of the guide questioning), the guide rarely made the connection between the different observations undertaken in each aquarium. Usually, he highlighted different facts related to the specimens present in each aquarium, while guiding students throughout the exhibit, and didn’t challenge students to reflect about what is common to some of them and what is not.

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The following excerpt of the field notes could exemplify the type of questioning the guide could follow to promote some reflection from students about more overarching ideas:

> "(…) one representing a sand beach and one representing a rocky beach. (…) [the guide] ask students to observe the animals in each tank, (…) and to answer (…) in which tank there is a higher diversity of animals? What are the reasons for that? (…)"

– Closed-ended and/or factual questions that do not require complex answers from students were usually observed (e.g. "what is the name of a group of fish?"; "what does the fish use to swim?") (about 95% of the guide questioning). Questions were asked without follow-up, elaboration or probe.

Concerning the interactions observed during the tours (table 1), there were an average of 60 interactions observed per tour, from which the majority of them were interactions of the guide directed to students (67% in average, ranging from 22% to 95% of all interactions observed in each tour). Students and teachers showed very few interactions (17% in average for students and 15% in average for teachers), usually assuming a very passive role during the tour.

- Insert table 1 -

Concerning the type of the interactions observed, the majority of the guides' interactions were related with the thematic of the tour, although there were also some

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few interactions related with disciplinary aspects (about 20% of the guides' interactions). On contrary, teachers seemed to intervene only for disciplinary reasons (63% to 100% of all teachers' interactions). In only one of the tours observed, the teacher asked questions to students, related with what they were observing ("how can fish swim?", "observe the different colors of fish"), or making connections with some aspect already studied in science classes ("do you remember what we've talked in class about that?"). In this tour, students seemed very engaged with the visit, taking a lot of notes, paying attention and always keeping track of the group. However, in the majority of the tours observed, teachers seemed very distracted about the visit, talking to each other or watching tanks or exhibits other than the ones the group was observing. In only two of the visits, the respective teacher was observed taking notes during the tour.

The majority of the students' interactions were directed to the guide, asking questions related with the specimens observed (72% to 100% of all the students' interactions). Students never or almost never interacted with peers about the topics studied in the tour, except for playing purposes. With the exception of the first 10 or 15 minutes of the tour there were always two or three students playing with each other. This number usually increased along the tour, reaching its largest number (nine to ten students) at about the middle of the tour (30 to 40 minutes), and decreasing until the end. In only 18 times, students were observed calling each other attention to what they were watching, and only in three times, in different tours, students were observed explaining to other colleagues something about the specimens they were watching.

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The results of this study showed that the guided-visits analyzed were mainly guide-directed and lecture-oriented, providing limited interactions among teacher, students and even the aquarium resources. Moreover, teachers usually assume a very passive role during the visit, becoming mere spectators, and intervening only when needed for disciplinary reasons. In this kind of visit, both students and teachers seemed to have very little choice and control over their learning agenda, since choices are typically taken for them and not with them, although students are considered the learners in the visit.

However, many studies have already emphasized that the visitor choice and control are important aspects of the museum-learning context (e.g. Bell et al., 2009; Falk & Dierking, 1992, 2000; Hofstein & Rosenfeld, 1996; Ramey-Gassert et al., 1994). According to Cox-Peterson, Marsh, Kisiel & Melber (2003), there are pedagogical standards for a guided tour environment, namely: (a) meeting the interests and experiences of the students, (b) focusing and supporting students' inquiries, (c) challenging students to accept responsibility for their own learning, (d) encouraging discourse among students about scientific ideas. Indeed, according to several authors (e.g. Falk & Dierking, 1992, 2000; Griffin & Symington, 1997; Paris et al, 1998; Rennie & McClafferty, 1996), museums are environments that provide key conditions for the visitor to build a personal meaning, make their own choices and take control of their own learning.

However, to accomplish these purposes, students need time to talk and explore, thereby time for personal reflection and connections, and acknowledgement of the personal

context of the visit. Small group activities provide social interactions among teachers, students and the guide, thereby enhancing the socio-cultural context of the visit. Time is also needed for students to become acquainted with and explore the physical aspects of the exhibits in greater depth (e.g. Cox-Peterson et al., 2003; Gibson, 2004).

Moreover, the activities performed during the visit should help to bridge connections between the formal science curriculum, explored in classroom, and the unique resources and exhibits of the museum. Probably, teachers are the key to make this link between guided-tours and school science, helping to bridge connections among school curriculum, museum content and student inquiries. To accomplish this, they should assume a more active role during the visit, using, for instances, collaborative strategies, such as facilitation (when teachers allow students to direct their own explorations, while providing questions that facilitate the process), interpretation (when teachers direct students' attention toward a particular display) and label reading, which in turn would give students a much more active role in the learning process (Cox-Peterson et al., 2003).

Questionnaire analysis

Teachers' perspective

The analysis of the answers to the teachers' questionnaire (n=145) revealed that the main objectives given by teachers for the school visit to Aquarium were:

- Raising awareness about nature and life beings
- Contact with reality, observing different aquatic organisms integrated in their habitat
- Consolidate knowledge

– Provide opportunities to extend knowledge
– Promote different ways of learning
– Promotion of scientific culture
– Raising interest in natural sciences
– Raising interest for research

Globally, the majority of teachers (96%) considered the thematic interesting, allowing the acquisition of new knowledge (97%), working as a complement to the school learning (97%) and promoting students' motivation to learn more (97%). Additionally, they considered the visit enjoyable (85%), with an adequate duration (95%) and the language used by the guide adequate for students' age (99%).

In which concerns the integration of the visit in school work, 81% of teachers answered positively to the question "the visit was previously prepared with students" and 88% stated their intention to carry out a strategy for students' assessment after the visit. Such a strategy may be a debate (38%) or a written assignment (36%). In the case of lower grades, students' assessment may involve the use and interpretation of illustrations or any kind of arts work (less than 11% of respondents).

Teachers suggested three types of improvements concerning the visits: i) logistics – related with the need to improve the information in the textboxes of the exhibits, to get a better accessibility of aquaria (too high for younger students), and the reduction of the number of students in each group; ii) complementary materials – involving the need for such kind of materials provided by the institution, like some scientific-didactic

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resources (e.g. books, models, videos); iii) resources specifically related with the visit itself – increasing the direct contact with organism artifacts (like shells, fish scales), increasing the interactivity of the exhibits, promoting exploration games at the end of the visit and providing observation recording-sheets to complete during the visit.

Regarding the online questionnaire (n=11), all teachers questioned stated that science museums should function as a complement to school learning, instead of overlapping scientific knowledge or being independent. Only one of the teachers pointed out the possibility of these institutions to serve as a starting point for new learning in school (observation – research new things – build new learning). Every respondent indicated that they usually organize school visits to science museums. When asked about what they think science museums have as unique in relation to schools, they referred the following aspects:

- Allow the contact with reality (6 teachers).
- Promote the consolidation of school learning through the observation of phenomena (5 teachers).
- Allow the possibility of doing experiments (3 teachers).
- Have different and diverse resources (2 teachers).
- Enable the exploration of aspects related with the history of science and the evolution of knowledge (2 teachers).
- Allow learning through play (1 teacher).
- Encourage to go beyond school learning (1 teacher).
- Promote equal access to knowledge (2 teachers).

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Teachers emphasized the following competences as relevant for their students to develop while in a visit to a science museum: the acquisition of a deep understanding of reality (6 teachers), the capacity to mobilize cultural, scientific and technological knowledge in order to understand reality and everyday problems (2 teachers), and the promotion of science skills, including observation (1 teacher), curiosity (2 teachers), critical thinking (2 teachers), to do research as a way to learn more (1 teacher), and be updated (1 teacher).

All teachers involved in this study seemed to recognize that science museums have unique features that can be explored, namely an easier connection with the real world, and an engaging and enjoyable way to encourage and promote the mobilization of cultural, scientific and technological knowledge in order to understand reality. In fact, according to Bell et al. (2009), the question of how to make this association of scientific thinking with engaging and enjoyable events and real-world outcomes, trying to link science-specific phenomena with emotional and sensory responses, is the key educational challenge for science museums.

The eleven teachers who answered to the online questionnaire preferred the guided-visits in relation to the non-guided ones. The reasons they gave were related with the guides' sound knowledge about the thematic, in contrast with the teacher, promoting a deeper learning (7 teachers), with the fact that students keep themselves more interested and focused on visits because they are guided by someone who is not the teacher (4 teachers), and because of the better organization of the group during the visit (2 teachers). As negative issues of the guided-visit, teachers pointed out aspects mainly

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related with the way the tour guide conducts the visit, such as the low adequacy of the language used or the level of knowledge required regarding students' age (5 teachers), the lack of motivation from the guide (3 teachers), or the lack of pedagogical skills (1 teacher). Only one of the teachers claimed that non-guided visits, in contrast with the guided-ones, promote a greater flexibility for students to explore the museum.

Regardless the rigid format of the guided-visit, as observed in this study, there was a tendency among the teachers questioned to prefer guided-visits instead of non-guided ones. These could be related with the general fear of teachers of losing the leading role of the visit because they don't master the thematic under consideration in the visit, as has been pointed out by Griffin and Symington (1997). Indeed, the main reasons given by the teachers in this study seemed to be related with the idea that museum guides have deeper knowledge about the thematic approached in the exhibitions.

When teachers were asked about how they usually plan the visit and prepare the students for the visit, eight teachers answered that they plan the visit according to the science content explored in class, and the other three mentioned they plan the visit based on a thematic proposed by students. In which regards students' preparation for the visit, they all mentioned activities related to prepare students to what is offered by the institution, and additionally the discussion of students' expectations (2 teachers), the explanation of the objectives of the visit (1 teacher), and the preparation of a handout to fulfill during the visit (1 teacher). Only one teacher referred that she usually prepares the visit with students (what they want to know, what they should observe, and so on). Concerning the follow-up activities, and similarly to the teachers' answers to the

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questionnaire administrated at the end of the visit in the Aquarium, the majority referred that after the visit they assess students' acquisitions using different strategies, namely, a presentation to the class (with the aid of a poster, drawings or photography) (5 teachers), a debate (3 teachers), and a report of the visit (3 teachers). Only one of the teachers referred that she usually discusses with students what they have learned with the visit, what they yet want to know and what would be the next step to learn more.

In general, teachers reported limited plans for preparation and follow-up activities that would support the visit, although they all described plans to briefly discuss it in classroom. These results revealed a lack of connections between the activities performed during the school visit and the classroom activities, probably failing to integrate both learning (Griffin, 2004; Kisiel, 2006; Kubota & Olstad, 1991). One of the teachers even seemed to think that the role of making this connection is for the museum guides, referring that they should know the school science curriculum so they could explore the science content of the visit in a similar way as in school.

Students' perspective

The overall results of the students' questionnaire (n=191) revealed a very positive appreciation of the guided-visits by students. 97% of the students assigned a final evaluation of "Good" or "Very Good" to the visit as a whole (80% of students rated it as Very Good). Furthermore, the majority (98%) enjoyed the visit, and considered they had learned new knowledge and become motivated to learn more. In addition, 95% of the students considered that the visit promoted a better understanding of scientific knowledge related with the thematic. Students highlighted the opportunity to observe

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real organisms and to learn special aspects about their life as the aspects they liked most. Older students demonstrated slightly different ideas at this respect. Only 75 to 88% of them agreed with the statement that the visit promoted new learning and the willingness to learn more. Regarding the relationship of the science content covered in the visit with the content studied in the classroom, some students (29%) considered that they are not connected. This idea of no interaction between the visit and school was even more pronounced in elementary students (45% considered they are not connected). As negative aspects, the majority of them reported the inadequate dimension of the groups (too large) that hinders the observation of aquaria.

As suggestions regarding the improvement of the visits, students referred aspects mainly related with their autonomy during the visit, specifically having more time to observe the aquaria, having time to walk alone in the Aquarium halls, the possibility to play games during the visit while observing the organisms, and to play a game at the end of the visit about what they have learned during the visit. Interestingly, students' expectations, revealed in this work, seemed to be in harmony with the theoretical pedagogical principals concerning the use of science museums as learning environments (e.g. Bell et al., 2009; Hofstein & Rosenfeld, 1996; Ramey-Gassert et al., 1994).

Final Remarks

Teachers' agenda for the exploration of non-formal educational resources such as science museums and Aquaria, according to the results of this study, seem very meager taking into account the potentialities of non-formal approaches for students' science

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learning and the perspectives and positive attitudes of both teachers and students toward their use as a complement and enhancement of formal strategies in the classroom.

Since these institutions have special environments and resources that are unavailable elsewhere, science museum and school staffs need to review their practices and introduce more student-centered approaches that allow more active learning and choice opportunities, in order to meet science education new trends (MacLeod & Keistead, 1990; Tal & Morag, 2007). By strengthening school science, these institutions contribute towards the creation of a more interested and receptive audience for future and lifelong science learning, playing an important role in the reform of science education nationally (Chin, 2004). However, to achieve success in this mission is crucial to reinforce the collaboration between the non-formal science institutions and the formal educational system.

The discomfort shown by teachers with regard to their scientific preparation on the issues explored during the visit, the absence of a suitable planning of the visit itself including pre and post tasks framed in the topics under study in science classes, and teachers' alternative conceptions regarding the role of non-formal institutions claim for up-to-date and appropriate both initial and in-service science teacher education programs, helping them understanding their own role as promoters of students' engagement during the school visit, providing support and "scaffolding" between students' existing concepts and the exhibits.

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Table 1. Number of interactions observed during the tours (n=39)

	Average	SD	Minimum	Maximum
Total number of interactions	60	18.72	15	98
Guide versus students	40	20.89	7	91
Teacher versus students	9	11.67	0	29
Students versus other intervenient	10	13.32	0	34

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