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Daytime School Guided Visits to an Astronomical Observatory in Brazil

Pedro Donizete Colombo, Jr.
Instituto de Física de São Carlos, Universidade de São Paulo, São Carlos-SP-Brazil 13566-590
Silvia Calbo Aroca
Universidade Federal do Rio Grande do Norte, Campus Universitario Lagoa Nova, Natal-RN-Brazil 59072-970
Cibelle Celestino Silva
Instituto de Física de São Carlos, Universidade de São Paulo, São Carlos-SP-Brazil 13566-590
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Abstract

This article analyzes the activity *Daytime School Guided Visits* at an astronomical observatory in Brazil with pupils from primary school. The adopted research methodology relied on questionnaire applications and semistructured interviews. The objectives were to identify the influences of the visits on learning of astronomical concepts and on pupils' motivation toward science. This study showed that it is difficult for children to understand scale distances in the Solar System and beyond. In order to cope with this problem, this article highlights the relevance of science centers' partnership with schools to achieve the goal of improving scientific education by relying on two main participants for a successful visit to a science museum: Guides and teachers.

1. INTRODUCTION

The International Year of Astronomy (2009) as declared by the United Nations [UN] and sponsored by United Nations Educational and Scientific Organization and the International Astronomical Union was a landmark for teaching astronomy in many countries, and many outreach educational activities were promoted around the world aimed at stimulating interest in astronomy and other sciences. The International Year of Astronomy goals included increasing public scientific awareness, supporting and improving formal and informal science education, and promoting widespread access to new knowledge and observing experiences. With these objectives in mind, the Brazilian government financed several astronomy outreach projects. This was a very important step in a developing country such as Brazil, where few people have access to quality science education. Also, as part of the International Astronomy Year, the XXVII Assembly of the International Astronomical Union took place in Brazilian territory in 2009, thanks to strong efforts of the country's community of professional and amateur astronomers.

Astronomy is a fascinating science subject partly because it enables interdisciplinary approaches and attracts students toward contemporary science. In Brazil, astronomy is part of the school curriculum, but the subject is seldom taught because most teachers do not have the opportunity to study it in their preservice courses. The few teachers who address astronomy topics rarely have enough knowledge and access to scientific tools and practices, such as astronomical observations and other practical activities. In addition, research in science education points out that teaching science only in school settings is not enough to motivate students (Falk 2001; Braund and Reiss 2006). Teaching science in informal spaces like science museums can be an alternative to cope with these problems. Science museums can offer an attractive environment allowing students direct contact with instruments and scientific practices. In an astronomical observatory, it is possible to observe constellations, planets, the Sun, and other celestial objects using simple instruments.

The present article analyzes the activity *Daytime School Guided Visits*, which take place at the Astronomical Observatory of the Center of Scientific and Cultural Dissemination of the University of São Paulo, campus São Carlos, Brazil.

2. THE ASTRONOMICAL OBSERVATORY

Figure 1. Astronomical Observatory of the Center of Scientific and Cultural Dissemination

The Astronomical Observatory (Figure 1), associated with the University of Sao Paulo, has as its main mission the promotion of outreach astronomy education, such as public visits during weekends with the objective of observing the southern sky through telescopes, and fostering guided school visits during weekdays. The activity *Daytime School Guided Visits* lasts two hours including a short lecture about the Solar System and/or a short educational documentary presented in the auditorium, followed by a guided visit through the Observatory settings.

During the visit, students are introduced to the Observatory's main refractor telescope, other telescopes, globes, and celestial spheres. Students are amazed by the refractor's dimensions (3 m focal distance with a 20 cm aperture) and the size of the dome (6 m), while they are informed about its history and function and the care that must be taken when observing the Sun through a telescope. For solar observations, the guide positions a sheet of paper in front of the telescope's eyepiece, showing that solar radiation can burn the paper in a few seconds in order to warn students about the danger of observing the Sun directly. The Sun is then projected through the main telescope onto a white sheet of paper, which enables many people to observe it at the same time. Interesting solar effects can be seen such as sunspots and faculae. Due to unfavorable atmospheric conditions, it is not always possible to observe astronomical phenomena through a telescope. In some visits, students can also observe the Moon, Venus, and/or Jupiter.

3. METHODS

The goals of this research were to identify influences of the *Daytime School Guided Visits* on the learning of astronomical concepts and on pupils' motivation toward science. The participants were fourth- and fifth-year primary school students with ages between 10 and 11 years and were accompanied by their teachers. The choice for this specific public was motivated by the fact that they constitute the majority of visitors during daytime visits to the Observatory.

The adopted research methodology relied on quantitative and qualitative approaches, with questionnaire applications and semistructured interviews. Initially in a planning phase, in order to access the students and

teachers profiles, a database containing school information was build and updated. In a second phase, data were gathered by questionnaires immediately after the visit, interviews with students a few days after the visit, and field observations of students' discussions during the visit.

Two types of questionnaires were used: The first was directed to students, and the second was directed to teachers who accompanied them. The first questionnaire was applied in order to assess students' perceptions concerning the visit, their knowledge about the topics explored during the visit, and their motivation to visit the Observatory again with their families. The definitive version of the questionnaire for students was applied to another 137 students. Before that, a pilot version was applied to 197 visitors. The main change was to decrease the number of written questions and to include more true-or-false questions. The time available for answering the questionnaire was about 10–15 min for a group of 20 students. The questionnaire for teachers was used in order to investigate if they had been at the Observatory before the visit and about their background in astronomy since it certainly must influence their teaching. The goal was not to check specific content but to know if teachers had studied astronomy before either in preservice or in-service courses.

Due to difficulties in investigating learning using only a written questionnaire, semistructured interviews were performed with students at their schools a few days after the visits. The interviews aimed at accessing the visit impact regarding cognitive (learning astronomy concepts) and emotional (motivation toward science learning) gains. Students were stimulated to remember and discuss with the interviewer and colleagues what they had seen and learnt during the visit.

4. FINDINGS

The analysis of students' answers to the written questionnaires pointed that most of them (60.6%) have never visited the Observatory before. On the other hand, after their visit, 95.6% claimed that they desired to return with their family members, friends, and colleagues. It shows that the guided visits are interesting enough to motivate students toward keeping in contact with astronomy concepts.

Many students presented major difficulties in understanding astronomy contents: 86.7% stated that the Sun is a star, but only 18.3% answered that the Sun is the only star in the Solar System. Our results and other researches in the field (Aroca 2009; Leite 2002) demonstrate that it is not trivial to understand that the Sun is a star similar to stars visible in the night sky.

Another result of the present research refers to the order of the planets in the Solar System that is highlighted during the visit. Usually, students know the names of the planets but are unable to place them in the correct position in the Solar System; only 13.1% of the investigated students placed them correctly.

Research in astronomy education points out that students' knowledge about astronomical phenomena is limited (Sharp and Kuerbis 2006). Osborne *et al.* (1994) investigated elementary English students from different schools, finding that the percentage of students that remembered all planets varied from 6% to 62%. Another difficulty mentioned by these authors was the difference between stars and planets since many students placed stars inside the Solar System, corroborating results of a study conducted by Trumper (2001) with seventh- and eighth-grade Israeli students, who placed Pluto behind the stars; 13% stated that the stars are the closest objects to Earth. Students that participated in the *Daytime School Guided Visit*s to the Observatory performed better in recognizing the planets names than those investigated by Osborne *et al.* (1994); however, it may be that they know the planets' names by heart without a deeper understanding because the majority of the investigated students failed in ordering them according to their distance to the Sun, as discussed below.

Some results obtained by applying written questionnaires immediately after the visits are shown below. It is important to highlight that data obtained from questionnaire application were essential for conducting the research in classroom with the semistructured interviews and also for discussing some aspects of the *Daytime School Guided Visits* to the Observatory (Figure 2).

Question 1: Is the Earth the largest planet in the Solar System?	True	31%
	False	69%
Question 2: Is Jupiter a gaseous planet?	True	67%
	False	33%

Question 3: Are asteroids and comets part of the Solar System?	True	75%
	False	25%
Question 4: Are you part of the Solar System?	True	45%
	False	55%
Question 5: Does the Sun move around the Earth?	True	41%
	False	59%

The foregoing table contains data concerning the application of the definitive written questionnaires to 137 students of ages between 10 and 11 years.

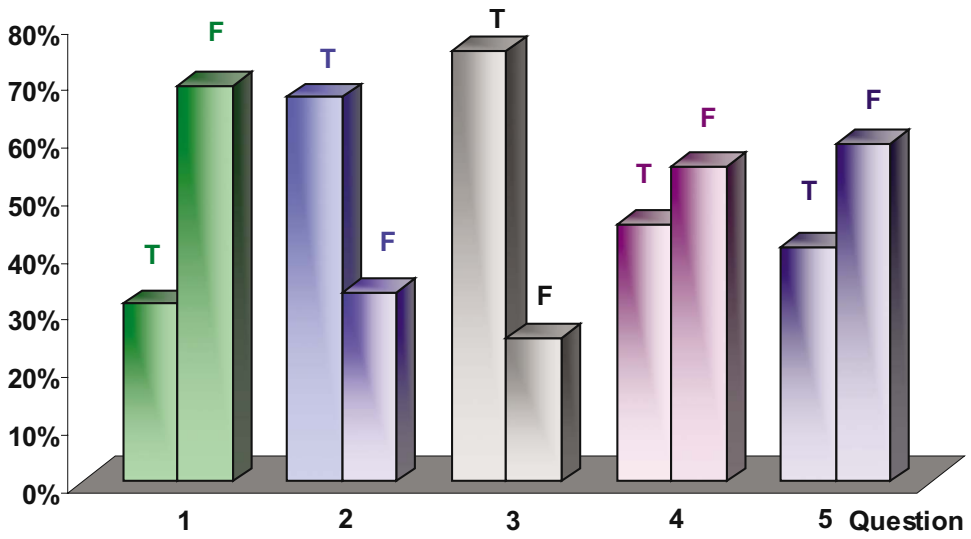

Figure 2. Student responses

Questions 1–3 show that students learned information about sizes and constitution of Solar System bodies such as planets, asteroids, and comets; however, they were not able to build a mental representation of the whole Solar System, including the Earth and themselves as Earth inhabitants, as part of the Solar System, as shown in Question 4. Almost half of the students conceived the Sun orbiting Earth, as shown in Question 5; this result agrees with the perceived daily Sun movement and with the fact that younger children more often rely mostly in their senses.

The interviews performed at schools aimed at, among other things, verifying if students understood the basic questions discussed during the Solar System lecture. When asked about the order of the planets in the Solar System, almost all interviewed students answered correctly, which can be interpreted as evidence that the subject was explored by teachers after the visit. (During the visit, only 13.1% had answered correctly to the written questionnaire.) Many students made independent observations when questioned about, for example, the classification of Pluto and Charon as dwarf planets, as seen below in two students' responses.

> Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune […] Pluto is not a planet any more because of its size (A. P.—10 years old).
>
> Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune […] Pluto was demoted dwarf planet, and Charon is also a dwarf planet (V.—10 years old).

When questioned about the Sun, most students answered correctly that it is a star but added that it is not the only star in the Solar System, persisting an error identified in the questionnaires.

> **Interviewer** – Is the Sun a star?
>
> **Student** – Yes.
>
> **Interviewer** – Is it the only star in the Solar System?
>
> **Student** – No.
>
> **Interviewer** – So how many stars are there in the Solar System?
>
> **Student** – We can't count them, there are so many here and many outside (K.—10 years old)

On the other hand, some students presented a degree of knowledge far beyond the expected, as seen below.

Interviewer – Let's say, for example, the Sun "was turned off" suddenly, what would happen? What would happen here on Earth, what would we see in the sky at night?
Student 1 – At night we would see stars, but not the Moon (C. e A.—10 years old).
Student 2 – The day would be dark […] it would be very cold (L.—11 years old)
Student 3 – It would be very dark; we would not be able to see the moon only stars (F. e G.—10 years old).
Student 4 – We wouldn't see anything (R.—11 years old).

The responses above show that most students understood the relation of the Sun to the Moon and Earth since few students answered incorrectly to those questions. Nevertheless, a contradiction persists among students since they continue answering that the Sun is not the only star in the Solar System.

Our results with students can be correlated with other research findings performed with Brazilian in-service teachers. Bisch (1998) showed that teachers know that the Sun is a star; however, they seldom are able to generalize and understand that the Sun is a celestial body of the same nature as other stars seen in the night sky. We interpret these teachers' misconceptions as related to their difficulties in comprehending distance scales and spatial distribution of heavenly bodies. Teachers' misconceptions influence students understanding about stellar nature. Both teachers and students' misconceptions are reinforced by textbook representations of the Solar System with stars in the background, without explaining to the reader that the stars are really far beyond the Solar System. This can be illustrated by a fifth grade student representation of the Solar System shown in Figure 3 (Aroca 2009) (see Note 1).

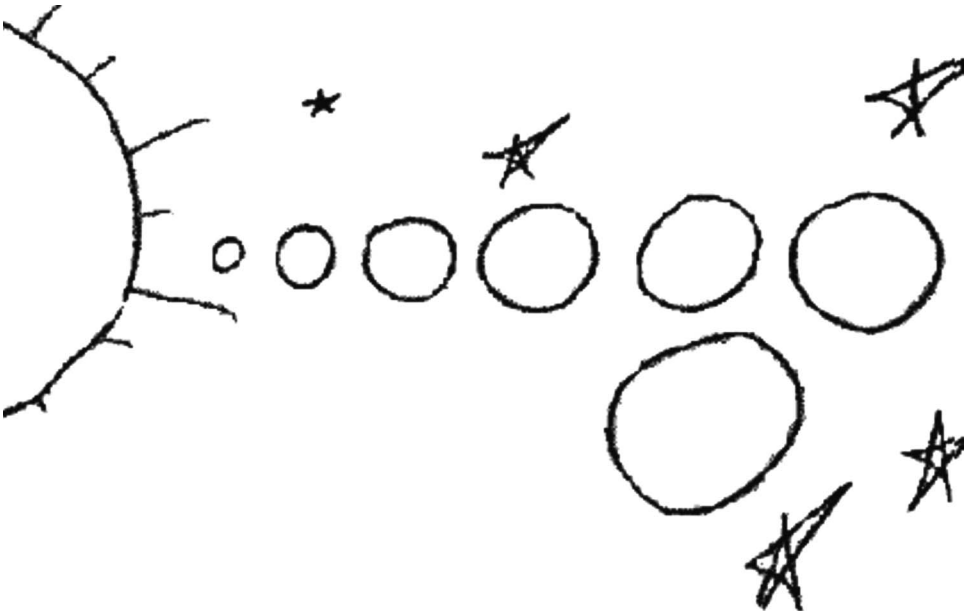

Figure 3. Solar System representation of a fifth grade student

The comparison of results obtained with interviews performed at schools after the visits with Questions 1–5 shows that there was cognitive gain and a better understanding of some astronomical concepts by most visitors. This probably happened because teachers continued teaching about the Solar System after the visit. This sustains the idea that the visit to the Observatory has a motivating character since concepts addressed during the visit are discussed in more detail by teachers at schools and children return with family members to the Observatory.

70% of teachers involved in this research and who teach astronomy in fourth and fifth years have never attended a preservice or in-service course on the subject. This fact is a serious obstacle for astronomy education because teachers do not feel confident enough to talk about this topic (Langhi 2004). Furthermore, when they do, it is not rare that they propagate their own misconceptions to the students.

5. FINAL REMARKS

Even though astronomy is part of the Brazilian school curriculum, our findings at the Observatory confirm that usually teachers who teach astronomy rarely have studied it in their preservice courses. Brazilian teachers of primary and low secondary schools usually have a background in biology or pedagogy but not in science in general. In addition, until less than ten years ago, it was common to find serious mistakes in Brazilian science textbooks related to astronomy topics, like misrepresentations of the Solar System and incorrect explanation of seasons (Leite and Hosoume 2005). Currently, these problems have been mitigated because textbooks are evaluated by expert referees, and now it is atypical to find content mistakes. Furthermore, there are several actions being done in order to overcome this problem and improve the teaching of astronomy; among them, the Observatory offers courses for public school teachers on basic and advanced astronomy (http://www.cdcc.sc.usp.br/cda/professor-2010/index.html).

The partnership between schools and science museums is also an important element in improving the teaching of astronomy mainly in public schools that suffer from a lack of infrastructure and well qualified teachers. Guides and teachers play key roles for a successful visit to a science museum. Thus, their partnership should be strengthened because guides know astronomy concepts but usually lack pedagogical training, while teachers have pedagogical knowledge but have a superficial scientific background, particularly in astronomy. The findings in this article make it clear that a successful guided visit to a science museum with the objective of learning basic concepts relies on three moments (before, during, and after the visit). Before the visit, it is important that science museum guides learn about research results on students' conceptions and cognitive achievements according to their ages and about scientific content. Teachers should briefly discuss with students the main topics they will explore in the science museum and ask them to write questions about things they would like to learn. During the visit guides and teachers should motivate students to participate in inquiring discussions about topics being taught in order to promote interactivity between them (Griffin 2004). Teachers have the main role of relating the content seen during the visit with topics learnt at school by elucidating unresolved questions and curiosities. Thus, a solid cooperation between schools and science museums is essential in order to improve scientific education.

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NOTES

Note 1: Figure 3 is a picture done by a fifth grade student who was not part of research in the guided daytime school visits presented in this article. He attended a course on solar physics taught by one of the authors at the same observatory (Aroca, Schiel, and Silva 2008).

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