Boletim da Sociedade Astronômica Brasileira, **30**, no. 1, 16-17

Sundials as a teaching tool to understand time, calendar, seasons and Earth orbit

M. P. Ferreira & G. R. Hickel

[1] Federal University of Itajubá e-mail: mauriciopereiraferreira@hotmail.com, gabrielhickel@unifei.edu.br

Abstract. The sundial was constructed in the classroom and used in a flat location with a good solar incidence during the whole daytime period, where the students use the following knowledge: mathematics; art; ecology, geography, history and physics (astronomical), that is, in this project interdisciplinarity was necessary for a good development. For this work, it was decided to make the horizontal sundial. The work obtained a satisfactory result, with a better understanding of the seasons of the year and of the movements of rotation and translation of the Earth. Interdisciplinarity contributed to the development of this work and the classes taught. Another important factor was the realization of a class outside the classroom, providing a break in the traditional classroom routine.

Resumo. O relógio de Sol foi construído em sala de aula e utilizado em um local plano com uma boa incidência solar durante todo o período diurno, onde os educandos utilizam os seguintes saberes: matemática; artes; ecologia, geografia, história e física (astronômicos), ou seja, nesse projeto a interdisciplinaridade foi necessária para um bom desenvolvimento. Para esse trabalho, escolheu-se confeccionar o relógio de Sol horizontal. O trabalho obteve um resultado satisfatório, com uma melhor compreens´ ao das estações do ano e dos movimentos de rotaç ao e translaç ao da Terra. A interdisciplinaridade contribuiu para o desenvolvimento desse trabalho e das aulas ministradas. Outro fator importante foi a realizaç ao de uma aula fora da sala de aula, proporcionando uma quebra na rotina da aula tradicional.

Keywords. History and philosophy of astronomy – Time – *(Sun:)* solar-terrestrial relations

1. Introduction

One of the first marking mechanisms of the passage of time to be constructed was the sundial. By determining the bright part of the day, the Sun was already used as a qualitative marker of time, even by the nomadic tribes. But it is with the first set civilizations (and the advent of numerical symbology) that the first sundial were built. From the systematic observation of these clocks, the early civilizations also perceived that the shade of these artifacts varied significantly with the seasons of the year, allowing also a marker of the tropic year (time interval between two consecutive springs). Even with the hassle of not working on cloudy days, the sundial was a key element in the organization of early societies.

The sundial is a useful tool to determine not only the time during the day, but also the seasons and even the geographic position. Today, the sundial has a historical value (in pieces built centuries and even millennia) and is still made as a decorative piece (in reduced sizes) and also as an architectural element, in great monuments.

Its use as a teaching tool has been rescued over the past 50 years, especially in Europe and the USA. In Brazil, with the greatest diffusion of astronomical knowledge, especially in the last 20 years (with good participation of the schools in the Brazilian Astronomy Olympics - OBA) where the students came to have greater contact with the subject, there was a certain rescue of the importance in the construction and use of sundial for the understanding of issues relating to the movements of the Earth (Oba.org.br 2016).

2. Procedures

The sundial should be constructed in the classroom and later used in a flat location with a good solar incidence during the whole daytime period, where students should use the following knowledge: mathematics; art; ecology, geography, history and physics (astronomical). With the use of the sundial, it will be possible the interdisciplinarity, where it consists in the interaction of the contents of several disciplines, thus providing a new knowledge (Azevedo 2012). Already as a teaching tool, it can be used to explain the following topics: day movement, apparent movement of the Sun, time, gnomon, latitude and longitude, cardinal points, solstices and equinoxes, seasons of the year.

2.1. Materials

For this work, it was decided to make the horizontal sundial, which can be easily transported and used anywhere within the 21’ latitude, which is the latitude of the city of Alfenas - MG, Brazil. For the preparation of the horizontal sundial, the following materials were used:

- pencil;
- protractor;
- ballpoint pen;
- stylet;
- drawing of the horizontal sun clock printed on A4 paper using *Shadows 4.0* software;
- compass;
- hand level;
- plywood of 15 mm and 10 mm thickness.

The *Motion of the Sun Simulator* software was also used to simulate the apparent motion of the Sun, and it is possible to visualize the projection of a person’s shadow throughout the year in any latitude that is. The figure below shows the main screens of such software, the drawing of the horizontal sundial printed on four A4 paper and the sundial finished.

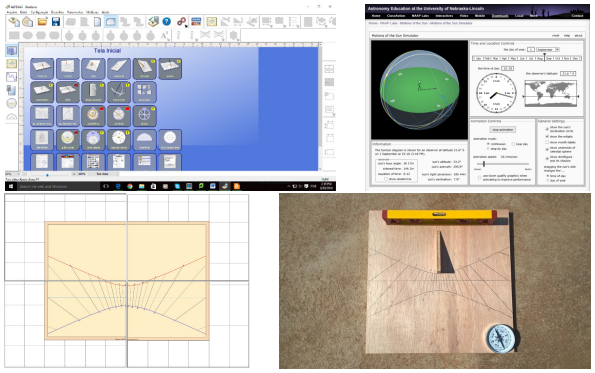

Figure 1. *Shadows 4.0* software (top left); *Motion of Sun Simulator* software (top right); drawing of the horizontal sun clock printed on A4 (botton left); sundial finished (botton right)

3. Results and discussion

The classes were developed at the State School Padre José Grimminck, in the city Alfenas – MG, in class 1 of the 1st year of High School. The students initially showed a lack of interest in the sundial, but in the course of the classes developed, especially in the first class, where with the use of the earth globe, we tried to explain the seasons and the projection of the shadows on the surface of the planet, thus recovering , which they had previously learned about solstices and equinoxes, they began to be curious about the subject, asking questions about what they were witnessing in that lesson. Already, when the *Motions of the Sun Simulator* software was introduced, students easily understood the projection of the surplus generated by it, but not with the same enthusiasm as using the globe. At the end of the study, the following questionnaire was distributed to analyze the fixation of what had been learned during the classes:

1. What is solstice? What do you mean by summer and winter solstice?
2. What is an equinox? What do you mean by spring and autumn equinox?
3. What are the seasons?
4. Why do we have 4 seasons of the year?
5. How and why did you start counting time?
6. What is the sundial for?

The results of the questionnaires are presented in the following graphs, considering the correct answers, incorrect answers and no answer:

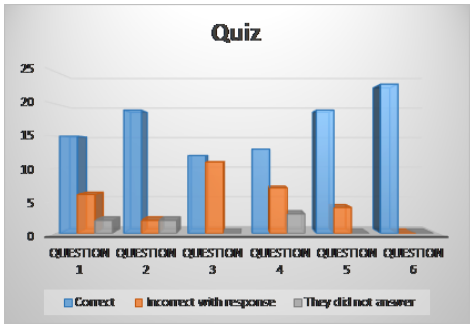

Figure 2. Graph of the quiz applied at the end of classes.

It is possible to note on the graph that everyone understood what the sundial is for, followed, but not 100% of the students, by equinoxes and how and why they started counting time. Question 3, *what are the seasons*, was the one that had almost 50% of error and correctness. Even with the classes developed with the use of the terrestrial globe and the use of the sundial and simulators softweres, 50% of the students still can not understand, what are the seasons of the year.

4. Conclusion

The work obtained a satisfactory result, because with the use of the sundial it made possible a more palpable lesson, and a better understanding of the seasons of the year and of the movements of rotation and translation of the Earth. Interdisciplinarity contributed to the development of this work and the classes taught. Another important factor was the holding of a class outside the classroom, providing a break in the traditional classroom routine.

References

Azevedo, S. S. M. 2012. Relógio de Sol Analêmico: Método Pedagógico Interdisciplinar. (Campos dos Goytacazes: Universidade Estadual do norte Fluminense Darcy Ribeiro), 1: 50 p.

Astro.unl.edu. Motions of the Sun Simulator. Program of simulation of apparent movement of the Sun. Available in:`http://astro.unl.edu/naap/motion3/animations/sunmotions.html`. Acess in August 03, 2016.

Oba.org.br. Atividades Práticas da X Olimpíada Brasileira de Astronomia e Astronáutica. Avaliable in: `http://www.oba.org.br/downloads/atividade_pratica_xoba.pdf`. Acess in May 20, 2016.

Shadows 4.0. Program for the design of Sundial and Astrolabe. Available in: `http://www.shadowspro.com/en/index.html`. Acess in August 30, 2016.