

Exploring universes in education:

Astronomy teaching for teachers

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Abstract. In this work, we present a panorama with the justifications and conclusions for the three-month long course “Oficinas de Astronomia: A Evolução das Medidas e do Conhecimento Astronômico”. This course took place in Abrahão de Moraes Observatory (IAG/USP, Valinhos, São Paulo), and was aimed to teachers from basic education and disseminators of Astronomy. The main objective was to reinforce and clarify aspects from some of the most fundamental concepts of Astronomy, such as the definitions of time and space, that may not be as trivial as some of us thought them to be. However, they are essential ideas from this field of Science that must be transmitted in the most scientifically accurate manner possible, avoiding, for instance, the dissemination of ambiguity or misconceptions.

Resumo. Neste trabalho, apresentamos um panorama com as justificativas e conclusões para o curso de três meses de duração “Oficinas de Astronomia: A Evolução das Medidas e do Conhecimento Astronômico”. Este curso aconteceu no Observatório Abrahão de Moraes (IAG/USP, Valinhos, São Paulo), e foi voltado para professores da educação básica e divulgadores de Astronomia. Seu principal objetivo foi reforçar e esclarecer alguns dos conceitos mais fundamentais para a Astronomia, como as definições de tempo e espaço, que podem não ser tão triviais quanto alguns de nós podem imaginar. Entretanto são ideias essenciais deste campo da Ciência que devem ser transmitidas da maneira mais cientificamente precisa possível, evitando, por exemplo, a disseminação da ambiguidade e de mal-entendidos.

Keywords. Teaching of Astronomy

1. Introduction

Throughout the months of April, May and June (and, by the time these proceedings are published, also the months of September, October and November), we conducted a three-month long course “Oficinas de Astronomia: A Evolução das Medidas e do Conhecimento Astronômico” (Astronomy Workshops: The Evolution of Astronomical Measurements and Knowledge), as part of the proposal for the “Aprender na Comunidade” program¹, funded by the University of São Paulo as an initiative to bring the university’s students to interact with the community.

These meetings focused on discussing basic themes and astronomical concepts, that are, from our judgment, not disseminated as accurately as they should, which can be noticed from a quick look over some educational workbooks that still fails to convey fundamental ideas of Astronomy (and other sciences as well) without taking ambiguous or misleading approaches.

2. Justification

Besides the previous mention of the insufficiency of workbooks on the explanation of basic astronomical concepts, it is highly considerable the Brazilian position on international examinations (according to the latest PISA data, Brazil placed both 63rd and 65th for the Exact and Earth sciences’ test respectively among the 70 participating countries²) as an indicator of the

country’s secondary view on science education and outreach in basic education schools. As a result, many students and even teachers lack knowledge on the scientific method, which leads to misinformation and even the rise of pseudo-sciences’ teaching inside schools³.

Our main goal was to provide an environment where teachers could discuss and collectively conclude over such concepts. The strategy was to follow the steps taken by scientists, and being able to reproduce such setting inside their classrooms, emphasizing the collective nature of Science and how these concepts are developed and accepted.

3. Methodology

The meetings were organized following the scale of human comprehension of the dimensions of space and time, present and detailed on the Master’s degree work “O conceito de espaço e a evolução das distâncias astronômicas: Construção de uma material didático” (Rodrigues, 2017). In one of our gatherings, for instance, we discussed questions such as the continuous space, first inquired by Zeno’s paradox of the tortoise and Achille, that provided a fruitful debate on the nature of space and how this concept can really be discussed inside a classroom environment. The concepts of absolute and dynamic space as well as gravity were also debated.

¹ Programa Aprender na Comunidade: 2019 edition, the Aprender na Comunidade program is an initiative of the Pro-Rector of Graduation (PRG) from the University of São Paulo that aims supporting outreach and educational activities developed by students from USP as an exercise of their professional experience.

² Source: Saldaña, P. Alunos brasileiros não chegam ao fim de prova em avaliação mundial. Available at: <http://folha.uol.com.br/educacao/2018/07/alunos-brasileiros-nao-chegam-ao-fim-de-prova-em-avaliacao-mundial.shtml>. July 19th, 2018.

³ Source: Fonseca, A. Experiência com palavras de amor e ódio muda forma de arroz em escola do Paraná. Available at: <http://g1.globo.com/pr/parana/noticia/palavras-de-amor-e-odio-fazem-parte-de-experiencia-e-mudam-forma-de-arroz-em-escola-do-parana.ghtml>. May 31st, 2017.



FIGURE 1. Making-off of the acrylic celestial sphere workshop, where teachers learned about the Sun's daily apparent movement.

Following discussions were related to the observation of the daily movement of celestial bodies and, in particular, the annual movement of the Sun. The goal in this case was to stress the importance of such activity to understand the time measurements, the concepts of day, week, year, seasons of the year, phases of the Moon and also the history of calendar building, all so intimately connected to our daily routines. These observations were responsible for the changes in the way we see the Universe, for instance, on Copernicus' heliocentric model that was one of the first great ideas to ignite the 16th, 17th and 18th centuries scientific revolution.

A brief summary of each workshop done throughout the three meetings (in chronological order) is presented ahead:

- **Planetário de Pobre (lit. Planetarium of the Poor, O Céu, Caniato, 1993):** This workshop is based on the utilisation of a round bottom flask (commonly used in laboratories) as an illustration of the celestial sphere, with the objective of defining some of its elements and discuss the daily apparent movement of celestial bodies.
- **Acrylic Celestial Sphere:** This time, we used a transparent acrylic semi-sphere to, through the Sun's reflection on its surface, define its daily trajectory, with which we can determine the local latitude, longitude, the Sun's declination on that day and the time of its meridian crossing.
- **Determining interstellar distances:** At this workshop, we determined the distance of some known stars through the measurement of the major axes of their parallax ellipse.
- **Duration of day, night and Earth's movements:** This time, using the Stellarium software, we could illustrate the transposition from a geocentric to a heliocentric model including elliptical trajectories, through the observations of two consecutive transits of the Sun and of a randomly chosen star, concretely verifying the differences in the time intervals between both cases, the annual variation of the Sun's movement and discuss possible explanations.
- **Building the HR diagram:** After a detailed introduction on stellar evolution and how the HR diagram was built to better visualize the evolution of such astronomical bodies, the teachers received the information of some stars, such as its surface temperature and the ratio of its luminosity compared to the Sun's, so that they could collectively build, using balls

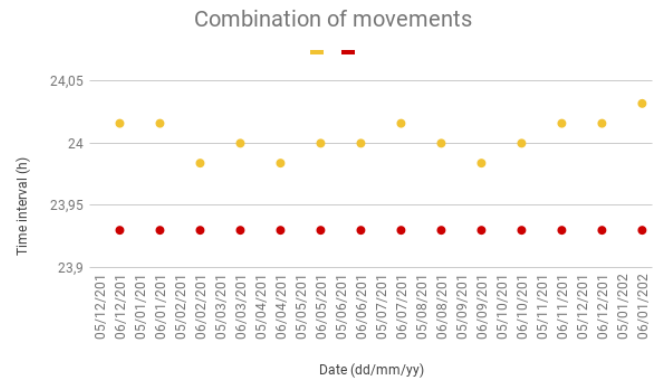


FIGURE 2. Graph resulted from the Stellarium's workshop, where teachers could notice the differences between the Sun and background stars' movements and also the variation of the solar day throughout the year.

that attached on a board, a large-scale version of the diagram and discuss about the various types of stars that exist.

4. Discussion

Throughout the gatherings, there were no formal evaluations such as tests or exams capable of measuring quantitatively how such concepts were absorbed by the teachers or even their students (if such topics were to be brought up in class). However, we agree that education is a field of knowledge and outreach that may have long-term results. The fact that this course was elaborated by professors and undergraduate students from the University of São Paulo may show a shift in the university's relationship and approach with its community that can have a great impact on how basic education is currently conducted in states like São Paulo.

It is important that such concepts are presented to students in the most similar way possible to those accepted by the scientific community (with the help of various recreational methods), with definitions that avoid ambiguity or incorrect conclusions on astronomical phenomena. Defining the day, for instance, is fundamental so that a student can comprehend the differences between the apparent movement of the Sun and the background stars, which can be concluded simply given continuous sky observation. Often, small questions that we forget to ask ourselves accumulate in a series of misconceptions that implicate a poor development of our students' learning processes. More than describing the events that happened at the meetings, we attempt here to identify the importance of discussing such concepts so apparently trivial for Astronomy in the process of formation of teachers from the basic education.

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