The Diary of the Sky as a methodological strategy to teach Astronomy in Elementary School

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Abstract

The aim of this paper is to describe some activities undertaken at different phases of a broader research project named "The Northern and Southern Skies: Teaching astronomy in schools". This project is a collaborative agreement between São Paulo State University (Bauru Campus, São Paulo, Brazil) and La Sapienza Università (Rome, Italy). The project aimed to bridge the gap between the academic production in the field of astronomy education and the classroom experiences of elementary school teachers and their students. The project finds justification in the fact that elementary school teachers, in general, face significant challenges when teaching astronomy elements to their students. In this article, we describe some steps of this project and the teaching resource named Diary of the Sky and its implementation, starting with the translation of the original *Il Diario del Cielo*, in its Italian version, to Brazilian Portuguese (*O Diário do Céu*). The aforementioned Brazilian university offered in-service specialization courses to several elementary school teachers in the last few years (2018–2023), enabling them to interact with the dairy and understand key aspects of its methodology. Before using them, the Brazilian version was adapted to suit geographic local coordinates in the southern hemisphere—an opportunity for teachers in training to incorporate astronomical concepts into their planning. Throughout the academic year, students filled out their diaries on a daily basis. The *Science Education Graduation Program* at UNESP, along with teachers and researchers, acknowledged the value of this strategy and shared the data collected to be used in teaching courses at the masters and doctoral levels. Current studies on this methodology have now showed that the Diary of the Sky is a powerful and efficient tool for working introductory astronomy concepts with elementary students and training their respective teachers.

Introduction

This paper describes part of a larger research project named *The Northern and Southern Skies: Teaching astronomy in schools*. This project is a collaborative agreement between the *Postgraduate Program in Science Education* (PPGEdC 2023) at the School of Sciences of the São Paulo State University (Bauru Campus, São Paulo, Brazil) and the Research Group on the Pedagogy of the Sky at the *La Sapienza Universitá* (Rome, Italy) from the Movement for Educational Cooperation (MCE 2018).

The project is coordinated in Brazil by the Research Group in Science Education (GPEC 1994), from UNESP. GPEC's research has shown the gap between academic production in the area of Science and Astronomy Education and the knowledge and practices of undergraduate students and teachers working in elementary school. The lack of knowledge in science and astronomy, as well as in teaching methodologies, causes feelings of incapacity and insecurity when teachers work with these subjects, especially astronomy, along with their students at school (Langhi & Nardi, 2012).

Thus, this project aimed to bridge the gap between academic production in the field of astronomy education and the classroom experiences of elementary school teachers and their students. To accomplish this, we will discuss a few specifics about the project and how it was carried out, such as how the Diary of the Sky came to be used by students, researchers, and teachers in training alike. This includes how it was translated from Italian (*Il Diario del Cielo*) to Portuguese as *O Diário do Céu*, and then adjusted for the Brazilian version to reflect the local coordinates in the southern hemisphere (Bauru, São Paulo).

In the last years (2018–2023), UNESP provided in-service specialization courses to numerous elementary school teachers to familiarize them with the astronomy contained in the diary and to master important aspects behind its methodology. Afterwards the diaries were filled out by the elementary school teachers' students during every day of the scholar year. All these steps were recorded and data turned into findings about the implementation of this methodological strategy, becoming part of Masters and PhD theses at the Science Education Graduation Program at UNESP (Fernandes, 2018; Prado, 2019; Cavalcanti, 2019; Silva, 2021; Garcia 2022). These studies have showed that the *Diary of Sky* is a powerful and efficient tool for teaching introductory astronomy concepts to elementary students and training their respective teachers.

Lanciano (2019b) suggested that direct and systematic observation of celestial phenomena in the sky serves as the primary resource for students to explore them. However, in general, elementary school teachers and students do not conduct these observations, limiting their exploration of astronomical concepts.

In this sense, this project sought to provide a theoretical and practical background on relevant topics of astronomy teaching to in-service teachers. It involved the active participation of undergraduate and post-graduate students enrolled in the PPGEdC program in 2023. Here are some topics that were covered to help teachers and researchers better understand and use the diary: day and night cycles, seasons and phases of the moon, angular measurements, ephemeris of the sun and the moon, shadows, and reference systems. The goal was to promote the sharing and creation of knowledge that is socially relevant, as well as to enhance understanding for educators and scholars, highlighting the essential connection between teaching, research, and outreach as the fundamental approach to academic instruction (Fernandes 2018).

Therefore, the detailed process of planning and developing teaching activities based on research is the focus of this project. The main objective is to improve participant interactions and explore the teaching practices in astronomy instruction. It is worth noting that this topic has been overlooked or given less importance in the initial training of elementary education teachers (Fernandes 2018).

The Diary of the Sky as a methodological strategy for teaching Astronomy

Elementary school teachers in the Bauru region face challenges in teaching astronomy to their students, which is a pattern that we hypothesize to be a global educational issue. Previous studies conducted by our research group (Langhi & Nardi 2012) revealed that teachers had naïve or alternative conceptions about astronomy conceptions and ephemerides, some of which were similar to those of their students. We realized that using the Diary of Sky could provide a new, very specific, and challenging meaning to the approaches and practices of astronomy education for elementary school students. Additionally, it contributes to make this essential science more present in students' daily lives (Lanciano, Nardi, Langhi, & Fernandes, 2019).

This decision made us to take the first step of the project: the translation of the *Il Diario del Cielo* into Portuguese as *O Diário do Céu*. Also, it was when the local coordinates used in the book were first changed. This part of the project became the focus of Fernandes' PhD study in 2018, which awarded the researcher a grant to spend one scholar year at the Università di Roma, working with the *Gruppo di Ricerca sulla Pedagogia del Cielo*.

Thus, the first Brazilian version of the Diary of Sky, *O Diario do Céu* (Lanciano, Nardi, Langhi, & Fernandes 2016), and the successive versions (2018, 2019) were the product of translating and adapting the Italian-origin teaching resource *Il Diario del Cielo* (Lanciano 2013), to be used along the southern tropical belt within the geographical coordinates of the region of Bauru, São Paulo State, Brazil. The original book is the result of Professor Nicoletta Lanciano's teaching expertise in Higher Education at the *Università la Sapienza di Roma*, organised from the outcomes of research and instruction of astronomy as part of the *Gruppo di Ricerca sulla Pedagogia del Cielo* (MCE 2018).

The Diary of Sky is designed to be a valuable teaching resource for elementary school students, taking inspiration from an astronomy diary. The original purpose of this project was to study celestial phenomena in the Northern Hemisphere, with a specific focus on Rome, Italy. Designed with the principles of observational astronomy in mind, this learning sequence encourages students and teachers to keep a daily journal of their observations of astronomical phenomena throughout the school year. Figure 1 shows covers of *Il Diario del Cielo* and the 2018 edition of the Brazilian version, *O Diário do Céu*.

Figure 1: The original instructional material in Italian (*Il Diario del Cielo*, Lanciano 2013), and the translated and adapted version in Portuguese (*O Diário do Céu*, Lanciano et al. 2018).

In Figure 2, we show some examples of the daily journal data filled in by students in elementary schools of the region. The daily journal is filled with students' observation of the sky and its surroundings. These tasks are supervised by their teachers, after taking the specialization courses at the university. The discussions make it possible for students to compare their data with each other and with their teachers. During these moments, teachers assist in formulating hypotheses, inferences, remarks, new observations and reflections, inquires, and recommendations. The university professor, other teachers, and graduate students discuss all the questions teachers bring to the table. These documents served as data for an investigation into the use of the Diary of Sky and the ways in which teachers alter their approaches to teaching astronomy to elementary school students. The point being that they have enhanced their understanding of astronomy through innovative approaches, the creation of basic tools, and the integration of astronomy into their school's curriculum.

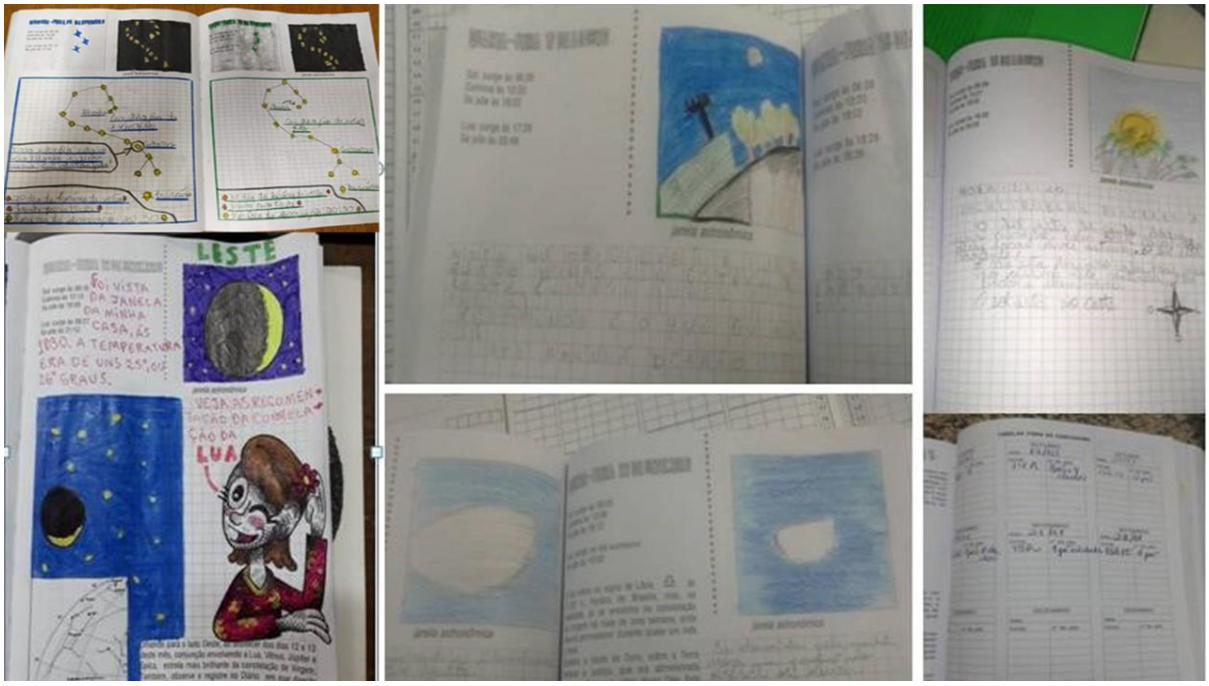

Figure 2 – Examples of daily journal data in *O Diário do Céu* after elementary school students' observations of astronomical phenomena in the sky and its surroundings in Bauru, São Paulo, Brazil, between 2016 and 2019.

We intended each new edition of *O Diário do Céu* to build upon the previous ones, incorporating changes and additions based on feedback from masters' and doctoral researchers, teachers, and students involved with the PPGEdC at UNESP in the city of Bauru, as well as from a group of school teachers working in the region, and on relevant authors in the fields of science, mathematics and astronomy teaching.

The book aims to broaden the discussion and cooperation among readers, particularly educators who teach contents of mathematics, physics, geography, and other related curricula. By providing an abundance of enriching options to deal with the processes involved in teaching and learning astronomy, its goal is to shorten the gap between academic study and practical classroom application.

The project's essence is to encourage teachers to create astronomy-related supplementary materials as early as the elementary school years, with an emphasis on explaining instructional models. As Fernandes (2018) points out, this is done with the hope of achieving certain objectives laid out in the official Brazilian Curriculum documents, such as the National Curricular Parameters (PCN) and the National Common Curricular Base (BNCC) (MEC 1998, 2018).

Based on these guidelines, the primary objective in astronomy is to search for and organize information related to direct sky observation. Additional objectives include knowledge about the movement of the stars, the length of the day at different times of the year, and the times of rise and set of the sun, moon, and stars over time. Furthermore, students should be able to establish a relationship between the different illuminated periods of the day and the seasons of

the year. Through direct local observation, the idea is to recognize the cyclical nature of these events and associate them with the cycles of living beings and the calendar. Finally, these lessons should also emphasize the value of historically accumulated knowledge, taking into account the role of new technologies and the clash of ideas in the major events in the history of astronomy to date (MEC 2018).

Activities involving the difficulties of teaching astronomy were encouraged, debated, and expanded to find effective and different methods of instruction that make use of a variety of linguistic and representational forms and modes in the classroom. Teachers and students are placed in research scenarios involving astronomical phenomena that can be explored, with consideration given to the growing difficulty levels and intricacy of the tasks at hand, while respecting students' varying educational backgrounds. It also emphasises the importance of funding initiatives that promote critical and independent teacher preparation, which is where the findings of educational research coalesce (Lanciano 2014).

Research Methodology

The PPGEdC (2023) at UNESP has offered courses called "Specialisation in Science Education for the Continuous Training of Teachers in Astronomy" to better equip teachers in science, mathematics, physics, geography, and other related fields of elementary education from the public school system of the city of Bauru and region. Between 2016 and 2020, as well as in 2022, a dedicated professor and a team of highly qualified PhD students from the PPGEdC consistently provided these courses on an annual basis. The courses' goals are to equip teachers with the knowledge and skills that they need to succeed in a variety of contexts, including but not limited to: direct and continuous observation of the sky and surroundings; activities with explanatory didactic models; work in natural environments and outdoors; and the creative use of simple, inexpensive materials (Fernandes 2018).

All the activities are based on the Diary of Sky (*Diário do Céu*) and all of them were recorded to give feedback to teachers and professors involved. Also, teachers completed questionnaires following each activity and/or discussion throughout the year. That happened in all the courses from 2016 to 2022.

The project and the courses had approval of the Ethics Committee on Research (CEP-CONEP 2023), through a Certificate of Presentation for Ethical Assessment (CAAE # 32207919.6.0000.5398). So, all participants were assured that the recordings and questionnaires would be used solely to enhance future courses and conduct research on astronomy education, especially about using the *Diario do Céu* as a methodological tool for teaching astronomy at the elementary school level. Figure 3 shows one of the outside activities carried out during one of the courses.

Figure 3: Photographs of astronomy-related classroom exercises conducted with in-service teachers to train them in using the Diary of the Sky with their elementary school students.

The courses aimed to align with the São Paulo Curriculum (SEDUC-SP 2018) and the official curriculum documents, PCN and BNCC, mentioned earlier. Typically, the course timetables consist of a total workload of 120 hours. This time is divided between face-to-face sessions with teachers and their activities with students throughout the course.

During the meeting sessions, teachers collaborate to design exercises that promote students' ability to make systematic, direct observations of the sky and their immediate surroundings. Teachers also encourage students to record their observations in a journal. Furthermore, students are encouraged to develop and implement methodological strategies that aid them in visualizing and conceptualizing the everyday phenomena they are exploring. There are various tools that students can use to engage in dialogue and explore the interdisciplinary potential of the teaching activities. These tools include virtual astronomical planetariums, collaborative course-of-work planning with students, and the focus group technique. The goal is to expand and enhance the discussion on various astronomy topics, considering conceptualisation, cognition, methods, didactics, as well as historical and cultural objectives.

The remaining hours of the course are devoted to the implementation, supervision, and follow-up of targeted activities based on the *Diary of the Sky* along with students from the project's partner schools (Fernandes 2018). Teachers who successfully completed at least 70% of the classes and practical work, which involved closely monitoring students' progress through their journals, were eligible for certification. This certification played a significant role in advancing their careers. Notably, the course's last two versions, in 2020 and 2022, were offered with lighter responsibilities and in virtual and mixed modes, respectively, to adapt to the complicated socio-economic and educational reality posed by the many breakthroughs stemming from the pandemic situation caused by COVID-19.

Despite these challenges in the classes during the most recent iterations of the course, the research group, teachers, and students involved in this endeavour have kept up the vital lines of communication to keep sketching out the full scope of their knowledge. Additionally, participants discussed what they had learned during the course, how they would explain astronomical phenomena to their students, and which of these phenomena should receive more

attention in the classroom, as well as whether they had incorporated aspects and contents related to astronomy into their daily teaching practice at the school.

Data analysis and discussion

For students to document their insights from everyday life while studying, in this case, the sky, keeping a journal is an enjoyable pastime. In this sense, the Diary of the Sky allows students to observe and record the movements of stars in respect to numerous points of reference, such as the horizon, their own shadow, and the shadows of objects on the ground. It can also can also provide a deeper understanding of concepts such as day and night. All this live recording provides academics and teachers with a large and priceless collection of student comments. Based on all the gathered data on the project—be it from students, research output, meetings, classes, roundtables, and so on—we will thus present the use of the diary as an innovative methodology in astronomy education.

As a teaching resource that incorporates advancements in celestial observation activities and instructional models to enhance creativity and understanding, teachers were interviewed to share their opinions on the matter. Among the results from the application of the diary in specialisation programs in scientific education for the continuous training of teachers in astronomy, we highlight some below. Examples and narratives that support these findings are described in detail in Fernandes, T.C.D; Nardi, R; Lanciano, N (2017), presented at the National Symposium in Physics Teaching promoted by the Brazilian Society of Physics, so that here we sought to convey a concise overview of the evidence and teaching benefits that support the use of the diary:

- increased participation and depth in discussions, dialogic expositions, and reflections on the content, as well as on suggested scientific texts on the field, both linked to the theoretical, methodical, and educational study of ideas of common celestial objects and phenomena, such as: identification of the local horizon and spatial-temporal alignment, the specific periods of rise, completion, and set of the Sun and Moon, the length of the day according to the Sun and Moon, and so on;
- the creation of a connection between the topic of study and the daily events that encircle them, analysing their feelings as a consequence of their actions, and being at ease with their surroundings;
- one of the key advancements in the creation of daytime and night-time guided celestial observation activities is the development of data-driven instructional models. These models help students understand what they witness from different perspectives. For example, workshops such as "The Local Horizon", "Astronomical Window", “Moon and Lunar Cycles”, “Angular Measurements and Shadows”, and “The Parallel Local Globe” provide hands-on experiences that allow students to explore and observe celestial objects. The diary serves as a record of these observations, allowing students to reflect on their experiences and deepen their understanding based on science.
- advancements in master’s and doctoral-level research projects in Astronomy Education; and advancements in the articulation of teaching, research, and extension activities in complementary training, for teachers working in elementary education and for

undergraduate and graduate students, giving them the opportunity to get in touch with a reality in which they will work after their academic training;
- the improvement of circumstances for teaching and learning astronomy principles for both the teachers and students of public schools in the Bauru region.

In general, among the difficulties and limitations expressed by teachers during the development of the teaching sequences that included the activities proposed in *O Diário do Céu*, we emphasise those perpetuated, sometimes, by the ineffectiveness and/or absence of public policies for teacher training in Brazil, which limit the training of professionals, including in the field of Astronomy Teaching, and the improvement of education systems in the country. For example:

- the lack of teacher input into the creation of school curricula, which results in a naïve understanding of astronomy topics among those responsible for teaching it;
- the teachers' workloads are heavy, to the point that it is impossible for them to continue their education and improve as educators in the field of astronomy;
- in astronomy, meaning-making requires situating academic knowledge within a long-term, consistent trajectory that includes and transcends immediate experience;
- the sloppy method and quality of initial training for astronomy teachers, which can leave some of them feeling incapable and insecure, in addition to the absence of contextualization and sufficient sources of information when dealing with the subject in schools;
- the difficulty of teaching astronomy due to the contrast between the times of astrological events (day/night cycles, moon cycles, eclipses, asteroids, among others) and those of the school, in terms of open areas under the sky and classroom confines;
- the challenges in overcoming barriers to information and suitable infrastructure, with material resources resulting from scientific and technological development, which ensure greater speed and quality for educational applications and analysis, and in their use in teaching and learning processes in elementary education.

Given the challenges faced by teachers in staying motivated to pursue professional development, it becomes increasingly difficult to clearly communicate the theoretical principles, educational practices, and technological effectiveness that support the integration of continuous higher education and elementary education. This includes the need for effective and practical teacher training programs, which could also incorporate astronomy training. This is mostly a result of the economic and societal degradation of the teaching profession, which often includes the absence of a career plan, as well as the unstable working conditions in schools, low wages, and the difficulty of juggling the many roles that schools and classrooms have taken on in recent years.

On the other hand, by incorporating a more practical approach, students are able to connect theoretical knowledge with real-world application, resulting in a more profound comprehension of astronomy. In addition, the use of diaries can help address challenges related to accessing information and appropriate infrastructure by offering an inventive, structured framework for educational applications and analysis. Besides, we recognise the interest of teachers and their students in astronomy phenomena, as well as their recorded enthusiasm for learning the methodological strategy around the Diary of Sky. This has led many teachers to

seek knowledge by coming to the university. It is important to also consider how the course's certification can benefit teachers and researchers in advancing their professional career.

Overall, despite the challenges and constraints that educators face when attempting to align educational practice and theoretical concepts of astronomy education, research based on the use of the Diary of the Sky (Prado, 2019; Cavalcanti, 2019; Silva, 2021; Garcia 2022) indicates that this resource is workable and pertinent for enhancing the teaching of celestial events. It provides a hands-on approach that promotes a better understanding of these concepts. Thus, by reflecting on participatory research and presenting their own perspectives, educators can share their expertise with one another and their students in a classroom setting. They can then support or refute these perspectives based on the accuracy (or lack thereof) of their students' descriptions of observed astronomical phenomena.

We also understand that the restructuring of teaching activities outlined in the *Diary of the Sky* aims to bridge the gap between teachers' continuous professional development and the actual implementation of these practices in schools that take part on the project. This serves as an example of how collaborative training can enhance teacher autonomy, which is a key contribution of educational research to the field of astronomy teaching. We are now studying the impact of the activities on teachers' practice to further substantiate these results, and interviews are one of the resources that we are using for this purpose.

Collaborating with the Italian Research Group on the Paedagogy of the Sky (MCE 2018) has provided a valuable opportunity to engage in discussions about teaching activities and scientific outcomes in Brazil. This collaboration has led to the sharing of new explanatory models for astronomical phenomena at UNESP's GPEC (1994) and has highlighted the importance of continuous training for teachers and teacher educators.

In this sense, a curriculum that is guided by *The Diary of the Sky* stands out as an important opportunity for in-service teacher training and scientific research in astronomy education, favouring a diverse group of participants, including graduate students, university professors, and researchers with the goal of producing research at the master's (Cavalcanti 2019; Prado 2019; Silva 2021; Silva 2022; Garcia 2022) and doctoral levels. The project's unique aspects and approaches are then adapted to school students and according to different research interests. The diary is a strategic educational tool that is studied for articulating knowledge, translation, science, society, and practice in teaching astronomy-related concepts to both teachers and students.

Final remarks

Through its different yearly versions, the course *The Diary of the Sky: an introduction to astronomy teaching for primary school teachers* have updated dozens of elementary education teachers affiliated with the Bauru City Department of Education and the São Paulo State Department of Education (Bauru Regional Directorate) in fundamental astronomy concepts.

The *Diary of the Sky* has been recognised as an effective tool for teaching introductory astronomy concepts to elementary school students and providing valuable training for their teachers. We have developed a Brazilian version of the diary, *O Diário do Céu*, by carefully

translating and adapting the original Italian version to cater to the specific geographic coordinates of the southern hemisphere.

By extension, hundreds of elementary school teachers and students used during the scholar years their annual versions of the *Diário do Céu*, making the experience remarkable. By other side, professors and graduate students from the Science Education Graduate Program conducted a project to gather valuable data to make research about the teaching of introductory astronomy, especially about the use of the *Diary of the Sky* in Brazil. The collected data greatly supported research at the master and PhD levels, ultimately resulting in the future publication of a book about the experience. These research findings provide valuable guidance for effectively integrating astronomy into elementary school curricula.

We attribute the project's successful outcome to the fruitful collaboration between research groups in Brazil and Italy, as well as the unwavering dedication and inquisitiveness of the teachers and students involved. However, we believe that similar implementations can be just as effective as a novel methodological strategy in teaching. The program that we shared in this paper has worked a space for teachers to share knowledge and reflect on their practice, promoting greater autonomy and professional growth.

Overall, the *Diary of the Sky* has demonstrated its effectiveness as a teaching tool that successfully captivates students in the study of astronomy. It offers a practical and interactive approach to learning, enabling students to directly observe and document their findings while tackling common issues related to education and teaching as a profession. The project has highlighted the significance of ongoing teacher training and the incorporation of research and teaching methods in enhancing astronomy education in elementary schools. Ultimately, teachers can use the diary to ignite a passion for astronomy and enhance students' comprehension of the universe.

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