SIGNIFICANT LEARNING IN PHYSICS TOPICS RELATED TO ASTRONOMY: A TEACHING SEQUENCE

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Abstract: Physics topics have contents related to astronomy, among them: the study of introductory astronomy concepts, study of the birth, life and death of stars, the Olbers Paradox and the cosmological principles studied in high school. In this article, the case study was applied using a teaching sequence developed using the Stellarium software as a resource for student motivation. The Theory of Meaningful Learning was used in this study through the application and analysis of a teaching sequence with a quantitative and qualitative approach. The results of the questionnaires and the activities carried out gave evidence that there was an expansion of the students' cognitive structure, so that they could anchor new information, concepts, arguments and explanations regarding Astronomy.

Keywords: Meaningful Learning; Physics Teaching. Astronomy; Teaching Sequence. Information and Communication Technologies.

APRENDIZAGEM SIGNIFICATIVA EM TÓPICOS DE FÍSICA RELACIONADOS A ASTRONOMIA: UMA SEQUENCIA DE ENSINO.

Resumo: Os tópicos de Física possuem conteúdos relacionados a astronomia, entre eles: o estudo dos conceitos introdutórios sobre astronomia, estudo do nascimento, vida e morte das estrelas, o Paradoxo de Olbers e os princípios cosmológicos estudados no ensino médio. Neste artigo foi aplicado um estudo de caso utilizando uma sequência de ensino desenvolvida com o uso do software Stellarium como recurso para motivação dos discentes. Foi utilizado neste estudo a Teoria da Aprendizagem Significativa através da aplicação e análise de uma sequência de ensino com uma abordagem quantitativa e qualitativa. Os resultados dos questionários e das atividades realizadas deram indícios de que houve a ampliação da estrutura cognitiva dos alunos, de modo que eles puderam ancorar novas informações, conceitos, argumentos e explicações referentes à Astronomia

Palavras-chave: Aprendizagem Significativa. Ensino de Física; Astronomia. Sequência de Ensino; Tecnologias da Informação e da Comunicação.

1. INTRODUCTION

Astronomy is one of the oldest sciences whose purpose is to study the celestial bodies and the phenomena associated with them. As an interdisciplinary science, it is related to several areas of human knowledge, especially Physics. Nowadays, the astronomical study is composed of several branches of activity, especially Cosmology, Astrophysics, Astrometry, and Celestial Mechanics [1]. Configuring itself as a science structured in several unknown aspects astronomy awakens in man the restlessness, curiosity and aspiration for answers and discoveries, which demarcates its relevance in being part of the school curriculum from elementary to high school level [2]. According to Langhi and Nardi [3], the role of astronomy, in general, is to expand the inner space of the human being creating a "hunger" for this space to be populated by more literature, cinema, music.

From this perspective, this work is based on theoretical references in the context of Meaningful Learning and Information and Communication Technologies (ICTs), for the development and application of a Teaching Sequence with high school students whose goal is the development of a potentially significant material through the generation of a teaching instrument as an educational product composed of: workbook, book, teaching sequence, podcast, and stellarium software.

Thus, it was used in the application of the Teaching Sequence the use of simulators, which are software used for the reproduction and simulation of a real event, as well as presentation of videos, slides and the Google classroom platform, in which the student has access to all educational material, including the quiz. In the Teaching Sequence, we also used the software *Stellarium,* which has been used by some teachers in astronomy education [4]. This program simulates astronomical phenomena, whose observation would require the use of advanced telescopes and would make this visit to the cosmos unfeasible due to the lack of active observatories in the State of Bahia.

Besides this technological resource, in the application of the Teaching Sequence, videos and expository lessons using *power point slides* were used to work on the following subjects: the birth, life, and death of stars; the study of the black hole; Olbers' paradox and cosmological principles. There are several ways to enhance the spread of learning in schools, one of them is the use of technological resources (computer, multimedia resources, educational software), which help both the teacher and the student during the learning process, providing conditions, to the teacher, to teach classes in a more creative way, following the transformations and changes that occur when the student starts to exercise his independence in searching and selecting information and solving problems, thus becoming the main actor in the construction of his knowledge [5].

The case study consisted of 7 classes, whose methodological approach relied on the use of videos, texts, slide presentation, script of activities using the Stellarium software, in addition to the Google classroom platform and the Quiz with questions and answers. It was based on the Meaningful Learning theory developed by the cognitivist theorist David Ausubel and also on the studies related to significant learning conducted by. Professor and Physicist Marco Antônio Moreira.

This article is divided into four chapters where the second chapter will present the methodology, the third chapter will describe the results and discussions and finally the conclusions will be presented.

1.1. The Meaningful Learning Theory

The concept of cognitive structure from Ausubel [6], highlights that it is about contents and ideas organized by an individual. It effectively refers to the organization and storage of knowledge and ideas in the brain of individuals. In light of what Faria [6] highlights, the cognitive structure of individuals is understood as well-organized and hierarchical. The idea of hierarchy can be interpreted as the result of connections that are established between initial knowledge and other more complex knowledge, recognizing the connections that are established between these levels of knowledge.

The organized structure, according to Meaningful Learning Theory, enables learning. Learning, in Ausubelian theory, represents the expansion of knowledge and ideas in the cognitive structure, depending on how such connections between old and new knowledge are established. Meaningful Learning arises from the non-arbitrary and non-literal interaction of new knowledge with prior knowledge (subsunkers) specifically relevant. Through successive interactions a given subsurface gradually acquires new meanings, becomes richer, more refined, more differentiated, and more able to serve as an anchor for new meaningful learning [7].

2. METHODOLOGY

The research was qualitative aided by information such as graphs in Microsoft excel and quantitative, conducted through a case study, initially a questionnaire of initial conceptions was applied with the intention of verifying some subsumptions present in the students. After this questionnaire application, the classes were taught using various teaching resources, among them the use of Stellarium software so that students could have the opportunity to visualize what the physical telescopes provide to their observers. After these classes a final conceptions questionnaire was applied to develop the data and results analysis.

The activities performed during the application of the Teaching Sequence were as follows: application of the Initial Conceptions Questionnaire; use of texts and slides, videos and quiz, discussion of the themes; and application of the Final Conceptions Questionnaire, also contemplating the evaluation of the product by the students. The following schedule presents the details of these classes.

Table 1. *Organization of activities developed during the application of the sequence*

to classes	Resources used	Duration (minutes)
1st class	Application of the conceptions questionnaire initials .	50

2nd class	Video : ABC of Astronomy (https://www.youtube.com/watch?v=0JfksHOJX5U) Lecture on Ancient Astronomy. Guidelines for solving the quiz through google forms and dialogue about the class.	50
3rd class	Video on Astronomy: Birth, Life and Death of Stars (https://www.youtube.com/watch?v=ZMKjm41mwJk); Lecture and debate on The Birth of Stars.; Guidelines for solving the quiz through google forms and dialogue about the class.	50
4th class	Lecture and debate on: The Life and Death of the Stars; Guidelines for solving the quiz through google forms and dialogue about the class.	50
5th class	Video exhibition about The Black Hole: https://www.youtube.com/ watch?v =OUuMVmtTHi4 ; Lecture and debate on introduction to the study of the black hole; Guidelines for solving the quiz through google forms and dialogue about the class.	50
6th class	Olbers paradox video exhibition : https://www.youtube.com/ watch?v =t9XWQxS0a9A; Lecture and debate on introduction to Cosmology, the cosmological principle and the Olbers paradox ; Guidelines for solving the quiz through google forms and dialogue about the class.	50
7th class	Practical class using the Stellarium software to observe some stars, stars and other astronomical elements; Application of the Final Concepts Questionnaire	50

3. RESULTS AND DISCUSSION

The results that will be exposed refer to the material developed and applied with 13 students from a public school of the State of Bahia in the city of Salvador, who participated in all stages of this research. The process of applying the sequence occurred over seven classes of fifty minutes each, in the shift and in the classroom where the students study.

With the purpose of systematization and analysis, the results will be presented according to the schedule developed in the didactic sequence, through three blocks:

1) Application and analysis of the Questionnaire of Initial Conceptions; 2) Development of classroom activities and Quiz; 3) Application and analysis of the Questionnaire of Final Conceptions. The data produced were synthesized in charts and graphs in order to allow a quantitative and qualitative analysis of the results obtained.

3.1. Application and Analysis of the Initial Conceptions Questionnaire

The application of the Initial Conceptions Questionnaire aimed at surveying the students' profile regarding the use of Information and Communication Technologies, in particular Internet tools. It sought, above all, to identify prior knowledge about topics in Physics related to Astronomy. The first part of the questionnaire consisted of objective questions about the access and relationship of students with the internet and its tools, where it was verified that all students have access to the internet, and that they use it predominantly at home, and that most students use cell phones to access social networks. This information was extremely important since this teaching sequence used Information and Communication Technologies. It is worth mentioning that this reality, beyond the specific context of these young people, is a phenomenon of contemporaneity, so that globalization has changed the forms of communication, as well as the production and access to information [8].

The Initial Questionnaire was a necessary activity, since it provided the teacher-researcher with relevant information about the access and use of the Internet and its tools; the contents studied and previous knowledge about astronomy, as well as identifying possible interests on the theme proposed by the teaching sequence.

3.2. Teaching Sequence lessons and Quiz results

The purpose of the Quiz lessons and activities was to develop themes related to Physics topics related to Astronomy, in order to expand the meaningful learning through the appropriation of new sub-substrates. This stage included a set of seven 50-minute lessons, in addition to the extra-class activities (solving the Quiz).

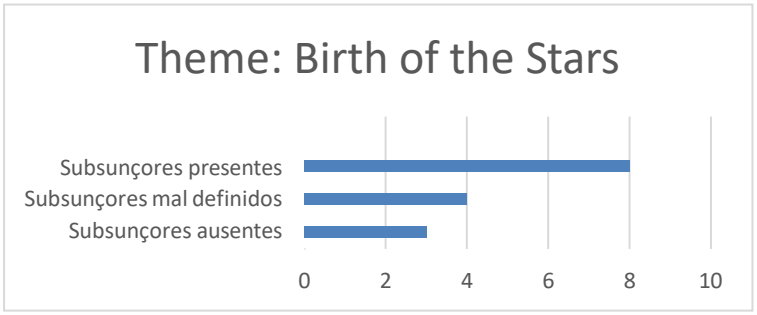
Therefore, through this sequence of classes and activities, we sought to make the teaching and learning of Physics more meaningful, considering some aspects that were considered relevant: 1) active attitude of the student towards the Physics content; 2) willingness to learn and involvement in the proposed activities; 3) valuing previous knowledge for the appropriation of new concepts; 4) working with potentially significant pedagogical material; 5) learning by reception and also by discovery [9].

3.3. Application and Results of the Final Questionnaire

Seeking to organize and systematize the results on the application of the didactic sequence, it was tabulated the data from the answers of the Final Questionnaire. This instrument is a possibility to a) investigate the learning process of the contents studied, identifying subsumers absent, present or poorly defined; b)

identify the perception of students about the use of Information and Communication Technology for learning topics of physics related to astronomy. Next, we present, through graphics, the results of the analytical and expository questions that deal with the appropriation of the topics studied.

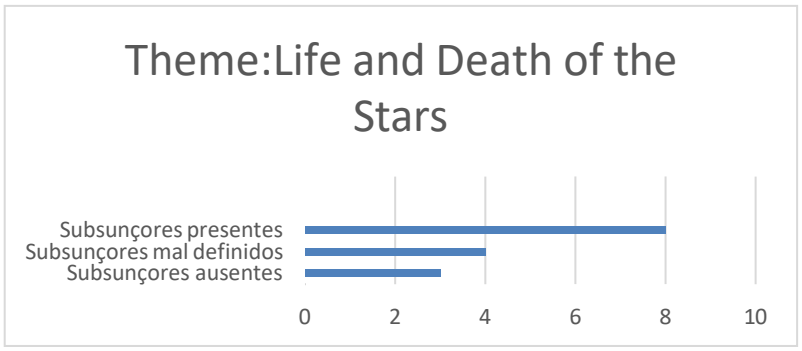
Figure 1: Birth of the stars



Source: Elaborated by the authors (2022).

The data presented in this graph shows that more than half of the students increased their knowledge regarding the topic Star Birth. It is noted, through the answers, a growth in the understanding of the phenomenon, through the subsumers present.

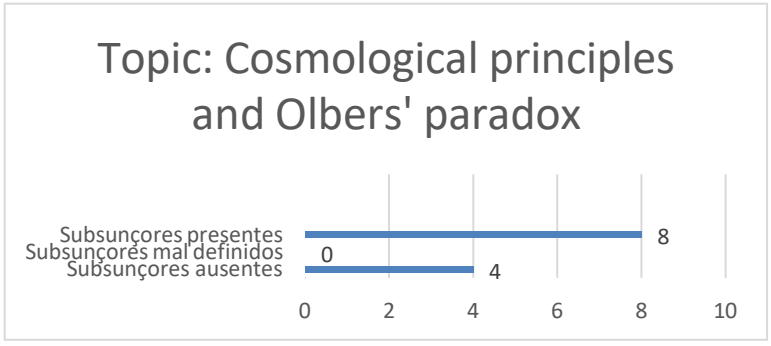
Figure 2: Life and death of the stars



Source: Elaborated by the authors (2022).

Similarly to the previous one, the data presented in this graph shows that more than half of the students increased their knowledge regarding the topic Life and death of stars. It is noted, through the answers, a growth in the understanding of the phenomenon, as students explain and argue, showing subsumptions present.

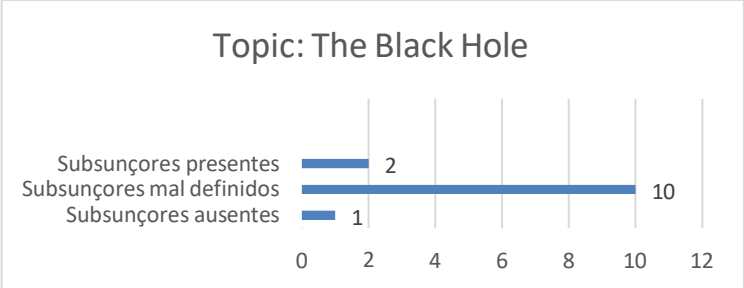
Figure 3: The cosmological principles and Olbers' paradox



Source: Elaborated by the authors (2022).

Also in this graph, the data presented shows that more than half of the students, more than 70%, have extended their knowledge regarding the topic of cosmological principles and Olbers' paradox.

Figure 4: The black hole



Source: Elaborated by the authors (2022).

The data presented shows that almost 85% of the students extended their knowledge regarding the topic of the black hole.

4. CONCLUSION

The elaboration and application of this educational product, whose goal was to develop a potentially significant material on topics of Physics related to Astronomy, traced a pedagogical path from the perspective of the theory of Meaningful Learning [10]. Thus, three didactic movements were contemplated: 1) the identification and exploration of students' previous knowledge; 2) the realization of classes and activities supported by the tools of Information and Communication Technologies, seeking the expansion and reorganization of astronomical physics knowledge; 3) and the verification of new knowledge that was anchored by students from the studies performed.

The work developed aimed, in the three didactic stages mentioned above, to awaken the students' curiosity and enhance learning in the field of astronomy, inserting a theme that is still little present in the high school Physics curriculum. In the current situation of the study of Physics topics related to Astronomy in High School, it is noted the little importance given to the application of the contents that were explored in the teaching sequence. Besides these factors, the introduction of computer *software* in the teaching of Physics topics that involve Astronomy is not observed. What makes this work, in addition to others, a differential.

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