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Astronomy as a Tool for Learning the laws of Physics: Theory of Conceptual fields by Vergnaud

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***Abstract*—** This *work aims to present the results of the analysis of astronomy as a tool for learning the laws of physics in high school in Brazil, in the light of the Theory of Conceptual Fields (TCC)", by Gérard Vergnaud (1990), as an instrument for the planning together with the methodology of the Investigative Teaching Sequence (SEI). The present work is characterized as qualitative research and presents a new perspective on studies in this area, by enabling the configuration of new pedagogical practices, capable of bringing scientific knowledge closer to students. In the work, celestial maps were made from the location of the city of São Luís – Ma, Brazil. It was found that the use of Carta Celeste as a pedagogical tool improved the students' relationship with Exact Sciences, from the moment in which the theoretical knowledge obtained in the classroom was contextualized with field observations.*

I. INTRODUCTION

Learning the discipline of Physics in High School has become a challenge for many students who appropriate this scientific knowledge in order to understand the natural phenomena present in everyday life. Generally, this discipline is seen as loaded with many calculations, and difficult to understand, motivated, many times, by the absence of a contextualized study, and, in some cases, with Astronomy content as a motivating factor for the teaching of Physics in Education. Basic.

The study of Astronomy is extremely important for the cognitive development of students in other areas of scientific knowledge, as it leads the teacher to rethink the didactics of his discipline from the moment he develops in the student new perspectives on a certain astronomical phenomenon, when use your discipline to explain it. The objective of inserting the discipline of Astronomy back into the High School curriculum, in addition to its motivational character, is to allow the student to establish a link between celestial phenomena and their applications through the study of Physics, at the same time as allow this student to observe some of these phenomena, with the naked eye and using equipment such as a telescope, telescopes or a sky chart, overcoming the barriers of the classroom and transforming a simple transmission of content into the development of skills and abilities that will really give meaning of what is learned within the school.

Currently, the way Physics is taught in Brazil to students has become a didactic challenge for high school teachers. This is a consequence of a culture based on traditional pedagogical practices, and of the questions made by students about the absence of topics related to Astronomy that would help in the teaching-learning process, and would make the teaching of Physics more investigative and dynamic, since the study of Astronomy arouses enormous interest in students, from the moment they make physical phenomena understandable with the help of mathematical language and make it possible to understand the world through interdisciplinarity for the organization of knowledge.

In this context, this article presents a qualitative research methodology, consisting of bibliographic research and field research, where an Investigative Teaching Sequence (SEI) based on the Theory of Conceptual Fields (TCC) by Gérard Vergnaud (VERGNAUD) was applied.), as a methodological proposal for the teaching of Physics using different investigative activities, such as: open laboratory, investigative demonstration, historical texts, the Celestial Chart, problems and questions raised with the use of technological resources, such as the Stellarium astronomical simulation programme.

As a research instrument, semi-structured interviews were applied to students from the 1st and 2nd years of High School at Escola Militar 2 de Julho, from the public network of the city of São Luís, in the State of Maranhão, Brazil, involved, in two moments: at the beginning – for a diagnostic evaluation; and at the end – during the assessment of the level of concepts presented by the students after the situations experienced according to the SEI. After the diagnostic evaluation, Astronomy classes began, totaling 10 classes lasting 50 min each class, where the importance of Astronomy was worked on in the classroom and outside it, through celestial observations, in order to make these formative moments stimulating and meaningful for the student. The celestial charts were made from the coordinates where the city of São Luís - MA, Brazil is located, an unprecedented work carried out and applied as an instrument for locating the stars and constellations.

II. THE THEORY OF CONCEPTUAL FIELDS OF GÉRARD VERGNAUD IN PHYSICS TEACHING THROUGH FROM THE STUDY OF ASTRONOMY

The theoretical framework used for the development of this research and data analysis is the CBT, by Gérard Vergnaud. This theory began its development in the 1980s, with the aim of improving mathematics didactics, explaining how the process of progressive conceptualization of additive structures, algebraic relations, multiplicative structures and number-space relations occurs.

Gérard Vergnaud, born in 1933, is a French mathematician, philosopher and psychologist whose doctoral thesis was supervised by Jean Piaget at the end of the 1960s. by Vergnaud, especially with regard to the concept of “scheme” and “operating invariant”. The author seeks to redirect the Piagetian focus from the epistemic subject to the subject-in-situation.

Vergnaud's theory points out, about the role of cognitive structures, that there are competing conceptual points between Piaget's and Vygotsky's theories, since, in Piaget, knowledge can only be assimilated if mental structures are already formed, and in Vygotskian, knowledge can only be assimilated if mental structures are already formed. the structures are being built according to the degree of assimilation of the individual. The fact that Gérard Vergnaud was a student of Piaget ends up making him inherit a part of the concepts used in his theory. He recognizes the importance of Jean Piaget's theories, highlighting the ideas of adaptation, imbalance and rebalancing for research in Science and Mathematics didactics. However, he believes that the fundamental idea in Piaget's theory was the concept of schema, and that it ended up being used also in Vergnaud's theory (MOREIRA, 2002)).

On the other hand, Vergnaud recognizes Vygotsky's contribution when considering that Piaget did not work in the classroom teaching Mathematics and Science, and Genetic Epistemology becomes incomplete in dealing with school learning problems, as he argues (MOREIRA, 2002), on p. 22.

Gérard Vergnaud's CBT is a cognitivist theory that seeks to provide a coherent scenario, and some basic principles for the study of the development and learning of complex competences (information and skills), mainly those related to science and techniques, and whose main objective is to allow the acquisition of new knowledge and ruptures between preexisting concepts in children and adolescents.

Despite its origins linked to Mathematics, CBT has been used in other areas of exact sciences. Most Basic Education students have different degrees of difficulty in learning Mathematics and Physics, due to the complexity in understanding both subjects and in the practical application of their concepts.

For Vergnaud, the interrelationship between Mathematics and Physics serves as a teaching tool that presents a wealth of concepts, and which also serves as an aid for the study of Astronomy, since knowledge is organized into conceptual fields, whose domain by part of

the student happens over a long period, through experience, maturity, and learning, through different situations lived by him. Vergnaud defines Conceptual Fields as “An informal and heterogeneous set of problems, situations, concepts, relationships, structures, contents and operations of thought, connected to each other and, probably, intertwined during the acquisition process” (BAUER, CASSETTARI, & OLIVEIRA, 2017).

The CBT has its structure based on some key concepts, such as the concept of conceptual fields, schemas, situation, operational invariant (theorem-in-action or concept-in-action), in addition to the very concept of It assumes that the core of cognitive development is conceptualization, and that it is the fundamental basis of cognition. Therefore, all attention must be focused on the conceptual aspects of the schemas and the conceptual analysis of the situations, for which it is developed the scheme of each student in or out of school (MOREIRA, 2002), page 9.

Therefore, as has been said before, mastery of a CF does not happen in a few months or years. ities should be studied over several years, so that students can effectively take ownership of them. The difficulties inherent to these problems should not be circumvented, however, students must try to overcome them as they are encountered and faced, gradually (MOREIRA, 2002).

In short, Gérard Vergnaud's CBT represents a neo-Piagetian cognitivist theory that aims to provide a coherent scenario and some basic principles for the study of the development and learning of complex competences, especially those related to science and techniques, considering the contents of knowledge themselves. and the conceptual analysis of its domain.

Although Vergnaud is a researcher in the didactics of mathematics and is mainly interested in additive structures and multiplicative structures, his theory of conceptual fields is not specific to mathematics. In Astronomy, there are several conceptual fields that cannot be seen as isolated concepts, but interrelated with other fields of scientific knowledge, such as Kepler's laws of motion, Newton's gravitation, the nature of light and others.

In the studies presented by Vergnaud, the idea of concept is presented as a complex system, formed by other concepts, as it can have different meanings, according to the context in which it is inserted. These concepts are being developed as the subject begins to represent them in different situations, as he makes the connection between the parts and the whole. The need to diversify situations establishes an important role in conceptualization, as it provides a basis for students to experiment with their models, in order to make them explanatory in different contexts, improving or reformulating them, when necessary, as indicated by Vosniadou (1994) (VERGNAUD apud CARVALHO et al, 2007).

The ideas raised by Vergnaud on the concept of Conceptual Fields (CF) led him to argue that:

> "*1) a concept is not formed within a single type of situation; 2) a situation cannot be analyzed with a single concept; 3) the construction and appropriation of all the properties of a concept or all the aspects of a situation is a very long process that extends over the years, sometimes a dozen years, with analogies and misunderstandings between situations, between conceptions, between procedures, between signifiers (BAUER, CASSETTARI, & OLIVEIRA, 2017) page 68.*"

The study of Astronomy as a didactic and motivating axis, carried out in an interdisciplinary way for the learning of Physics contents in the classroom, converges with the idea conceived by Vergnaud of speaking in conceptual fields instead of studying the use of isolated concepts. Its definition for a Conceptual Fields (CF) encompasses the complexity of the subject in face of the situations experienced. So, in order for there to be a really meaningful learning, the student cannot observe Physics from the perspective of a discipline without practical meanings and disconnected from their daily lives, but schematize situations in connection with the teacher through formal or non-formal classes of the discipline of Physics, integrated with some conceptual fields that are studied in the context of Astronomy, such as: gravitation, optics, wave and electromagnetism, in order to make sense of the situations experienced by the student.

To study the development and use of a concept during the learning process or its use, it is necessary to consider the concept as a triplet of parts of a set formed by: Situations (S), Operative Invariants (I) and Symbolic Representations (R). This set formed as the foundation of a concept is based on a set of situations (S) that make the concept significant, linked by a set of operational invariants (I), which establish the concept and structure the forms of thought organization associated with a set of symbolic representations (R), which can be used in order to represent situations and ways of working with this concept.

The first set that represents the situations is the one referring to the concept; the second represented by the operative invariants is the signifier of the concept, while the third called “symbolic representations” is the signifier. A concept is, therefore, “[...] the act of facing situations, provoking the invariants and representing the situations and

concepts involved in it, thus configuring the idea of mobility towards a foundation" (CEDRAN, 2019), p. 67).

Most students who study Physics in High School are unable to establish links between what is taught by some teachers in the classroom, due to the difficulty they have in motivating and making that knowledge addressed meaningful to students, and also because they do not manage to build effective schemes that can explain a certain class of situations generated by some concepts implicit in the study of Science in Elementary School, and that will continue to generate comprehension difficulties in the discipline of Physics in High School.

With this, the teacher, when intermediating the study of Astronomy as CF to develop some concepts of Physics, generates in the student the possibility of building their own concepts and theorems explicit, and scientifically accepted, from an implicit knowledge. However, explicit concepts and theorems are a part of conceptualization; without the implicit part formed by the operative invariants, the explicit part would have no meaning. They are, as Vergnaud suggests, just the "visible tip of the iceberg" of conceptualization, highlighting that:

> "*There is not necessarily a hierarchy of competences. We understand, therefore, that in several situations that give meaning to a certain concept of a simpler or more concrete order, it can be applied more effectively in the solution of a certain problem than a more complex and abstract concept, depending on the type of situation encountered. This requires, on the part of the individual, not only the joint possession of competences, but the ability to use them properly. Since they depend on teaching-learning [...] between these two processes that is the action and understanding of solutions are didactic (LIMA & MOREIRA, 2005)*"

In the field of scientific learning, the integration between different conceptual fields of science, using different forms of language, develops in the student a capacity for contextualization between the sciences. When studying themes about the Universe, the teacher can make use of a connection between numerous concepts from different areas of knowledge, to make it meaningful to students through situations generated inside and outside the classroom. This opportunity created for the students, generating the students' contact with the situations, expands their cognitive development, passing it from the domain of simple situations to more complex situations, since a situation cannot be analyzed through a single concept, the which implies a more generalized view of knowledge. This kind of vision can contribute most significantly to their learning.

Situations are an integral part of the concepts since they function as a stage where the action is performed. So, situations are responsible for the meaning attributed to concepts. For Vergnaud, the teacher's task is to provoke situations that can make students organize the produced schemas and begin to master this set of lived and schematized situations, effectively giving meaning to the concepts and procedures they learn. But, on the other hand, it is the operative invariants that mediate between theory and practice, since it is the concepts contained in the schemas, concept-in-action and theorem-in-action, that allow the perception and obtaining of information from the student. In this way, these two expressions – concept-in-action (propositions held to be true about the real), and theorem-in-action (objects, predicates, categories of thought, pertinent and relevant to the situation) – are the operative invariants that make up the schemas.

Students learn in CBT that situations are like tasks that they have to complete at a given time. The meaning that situations acquire in this theory is completely different from didactic or learning situations. Its meaning implies that the student has to be challenged in his quest to acquire knowledge, so it is important to assign tasks in the classroom that improve the process of acquiring answers. These tasks show two fundamental ideas, which, according to Vergnaud (1996), are equivalent to the meaning commonly attributed by psychologists: the subject's cognitive processes and responses are a function of the situations experienced by him/her (LIMA & MOREIRA, 2005).

For Moreira (2002), a concept becomes significant if there are many situations in which it can be understood. Giving meaning to a concept means that it becomes a relationship between the subject and situations and signifiers. Especially, when a subject recognizes the meaning of a certain task (situation) or representation (signifier), there are indications that he has elaborated schemes, that is, he has organized his behavior in the face of the situation (MOREIRA, 2002).

A schema is a universal and efficient model in any class of situations, and can generate different sequences of action, collection and control of information, depending on the individual characteristics of each situation. These invariant forms of behavior organization can be expressed by the students and recognized by the teacher through the operative invariants (concepts-in-action and theorems-in-action), which constitute the conceptual part of the schemes, that is, adequate knowledge to select information and process it.

The main function of operational invariants is to collect and select relevant information, and infer useful consequences for action, control, and subsequent information capture. It is then a function of conceptualization and inference (CEDRAN, 2019) p. 73).

In CBT, cognitive development depends directly on the specific situation and conceptualization. The situation is a task, theoretical or empirical, that must be performed by the subject.

In his work, Gérard Vergnaud, unlike Piaget, sought to relate the subject to tasks and their possible solutions, rather than building a general theory for development. For him, cognition is directly linked to the situations involved, and its core is the construction of concepts, that is, conceptualization. Conceptualization is a process that takes time and requires a set of different situations (VERGNAUD apud CARVALHO et al, 2007).

To conceptualize and solve a class of situations, the subject organizes them into representations so that they serve as a link between the schemas, that is, the actions and their organization, generated by them and their conduct. The notion of schema is, according to Vergnaud, Piaget's most important contribution, and is defined as "[...] the invariant organization of behavior for a certain class of situations" (MOREIRA, 2002), p. 12. The concept of schema was introduced by Piaget, in order to supply the forms of organization, and therefore present a fundamental position within the CBT, as they act in the complementation of the idea of situation, being essential for the understanding of the relationship between situations and intellectual development (MOREIRA, 2002), p. 12.

The knowledge contained in the schemes (concepts-in-action and theorems-in-action) can be manifested according to the situation, implicitly or explicitly. The theorem in action is a proposition considered to be true, about the real; while the concept-in-action is a category of thought considered relevant, that is, it may or may not be adequate for a given class of situations. The concept-in-action is a category of thought considered true or not, so it has the status of object and others of predicates. However, a concept-in-action, defined as an object or predicate, does not allow inference, as Vergnaud points out, because it leaves no room for questioning. In this way, relationships are possible through theorems-in-action.

Cedran and Kiouranis (2019) state that one can have concepts-in-action, such as pressure, volume and temperature, which are deemed relevant or not, however, "[...] when the volume of a container is reduced, with constant temperature, it depends on a theorem, or even, considering a situation, a theorem-in-action" (CEDRAN, 2019), p. 74. Similarly, these concepts remain, for the most part, implicit in the actions of the subject, and can become explicit through the mediation of a teacher whose function is to make them scientific concepts.

According to Vergnaud, the relationship between theorem-in-action and concept-in-action is dialectical and inseparable:

> "*The relationship between theorems and concepts is obviously dialectical, insofar as there are no theorems without concepts and no concept without theorems. Metaphorically, we can say that concepts-in-action are the building blocks out of which theorems-in-action are made and that the only reason for the existence of concepts-in-action is precisely to allow the formation of theorems-in-action. (true propositions), from which the organization of the activity and the inferences are possible. Conversely, theorems are constitutive of concepts, because without true propositions, concepts would be empty of content (VERGNAUD apud CARVALHO et al, 2007), p. 8.*"

The construction of knowledge by the student is not based on easy and identifiable processes of acquisition. On the contrary, it is slow, and presents continuities and ruptures in some cases. Prior knowledge is crucial for the progress of acquisition of some conceptual fields, but it can also be an impediment. Therefore, to rely on some previous knowledge, the student needs to identify it in advance, so that there is a rupture or not, on the part of this student, during the process of interaction with them.

This work proposes the characterization of Astronomy as Conceptual Fields (CF), and a didactic sequence was developed with the objective of analyzing how the use of the Celeste Chart[1] and computer programs, such as the Stellarium Software[2], can contribute to advances in the schemes of students in, using the elaborated didactic planning as a reference, whose activities are correlated with other CF, such as the discipline of Geography, Mathematics, Chemistry and especially Physics. The teacher must consider the scientific ideas that are being formed over a long period of cognitive development by the student, through these situations to which he experiences and

[1] A Celestial Chart (CF) is a map of the sky, which can depict the entire extent of the 88 existing constellations or a part of the sky, showing how it is seen from a certain region.

[2] Stellarium Software is a free open-source planetarium for your computer. It shows a realistic sky in three dimensions, as you would see it with the naked eye, with binoculars or with a telescope.

evidence in his knowledge until then implicit, and that are within the Zone of Proximal Development. (ZDP) of the student.

The teaching of Astronomy must make this transformation of implicit knowledge into explicit, progressively, and without underestimating or devaluing that knowledge already formalized by the student. Students cannot be expected to master a CF such as Astronomy, much less learn another CF such as Physics from studying one or two chapters of Astronomy in a few months, but that they will develop their own schemes through each situation experienced inside and outside the classroom, and with the mediation of the teacher so that they can promote fruitful learning situations, stimulating this subject-situation interaction, and that provide and add diversification to their action schemes, that is, to their cognitive development. Therefore, the foundations of this theory for teaching Physics through the study of Astronomy aimed at High School are crucial for the proposition and evolution of new knowledge relevant to students, and for a more complete, interdisciplinary didactics focused on their reality.

Thus, teachers can also use mental models that are nothing more than representative models made of theorems-in-action to help their students in the process of assimilating new situations. As the student appropriates more scientific knowledge, their mental models will necessarily approach scientific models. However, remembering that there will be a discard as these mental models reach their desired functionality, which will not occur in the case of schemas that, as explained above, represent the invariant organization in face of a certain class of situations.

In this sense, the potential of CBT in Astronomy for teaching and learning in Physics was glimpsed, especially in the applications of significant situations, and in the understanding of the conceptual development process, through the analysis of operative invariants. Although CBT in Astronomy reveals a vast literature, especially for mathematical and physical concepts, its approach is still little used in the classroom to understand the development of cognitive processes in other areas of science.

III. THE STUDY OF ASTRONOMY AND THE INTERDISCIPLINARY CHARACTER IN THE TEACHING OF CONCEPTUAL FIELDS OF PHYSICS

In the various teaching methods that are adopted in schools, some Physics teachers transmit verbally and in writing to students the CF of each curricular series, following a still traditionalist model and plastered that does not allow the student to be the protagonist of their own learning. By becoming a protagonist, the student breaks with old pedagogical practices from the moment that the teacher also leaves this mechanistic model of scientific knowledge transmission in the past.

Langhi justifies in his book "Education in Astronomy", about the importance of including in the Basic Education curriculum the teaching of Astronomy as a CC with motivating potential, both for students and teachers, due to its interdisciplinary character capable of generating a minimally acceptable training. in the participants of this educational scenario. The study of Astronomy is capable of deepening knowledge in several areas of knowledge, especially by diversifying Physics classes in different classroom environments (LANGHI & NARDI, 2012), p. 108.

Teaching Astronomy in an interdisciplinary way with the other sciences have motivating characteristics, as they allow the student a great aesthetic pleasure linked to science, as well as providing the pleasure of understanding a little of the Universe, with explanations through conceptual fields linked to disciplines, which, in the student's conception, did not have any link with each other. But that, like the other sciences, it must be understood as a process of knowledge production and a human, historical activity, associated with aspects of a social, economic, political, and cultural order, and not as the school presents it, namely, a set of timeless and neutral knowledge, without political and cultural ties (LANGHI & NARDI, 2012) p. 141.

With the objective in order to provide practical learning of content related to Astronomy, the PCN emphasize the need for practical activities, and prepared visits to observatories, planetariums, associations of amateur astronomers, astronomy and astronautics museums. This way of experiencing Astronomy provides a differential during your learning. The teaching of this science can be based on the great potential existing in establishments located throughout the national territory, making it different from the contents taught in school subjects, which leads to the possibility of strengthening relationships between communities: professional astronomy, amateur astronomy and school (LANGHI & NARDI, 2012). However, although the PCN recommends that Astronomy be taught in Elementary School, there is no record of any public school in Maranhão that performs this integration with other Basic Education subjects and, in particular, with Physics.

Astronomy as a science switch from the possibilities of interaction between sciences, in addition to the interdisciplinary character, the contents of Astronomy can still provide students with a less fragmented view and with an integrative function of knowledge (DIAS, 2008). In addition, it allows the student to have a real and

observational experience of concepts explained only through brushes and boards inside the classroom, which makes challenging questions and exchanges of knowledge about CC of Astronomy, which are explained through the use of formulas and concepts of Physics, Chemistry, Geography, Biology, Mathematics, among others.

As a sample of this interdisciplinarity, there is the technological evolution that the study of Astronomy provides in several areas of scientific knowledge. For example, the development of antennas, mirrors and new telescopes such as the James Webb, which replaced the Hubble telescope, has made it possible to monitor space and the Earth itself, facilitating research in the areas of space sciences, telecommunications and geosciences, in addition to assisting in some areas of medicine, such as ophthalmology (DIAS, 2008).

The thematic axis "Earth and Universe", which covers subjects related to Astronomy, is linked to the area of Natural Sciences and its Technologies, where the objectives are related to the student's degree of maturity. In Elementary School, third cycle students already have mastery over written and spoken language, as well as the ability to create hypotheses about the natural phenomena they observe. In High School, the student is able to assimilate knowledge through the abstract, advancing in the process of acquiring new scientific knowledge, which allows the student to develop activities such as explaining the functioning of the world, solving problems, planning, evaluating human-nature interactions. and develop explanatory models for technological systems (DIAS, 2008).

The contents proposed in the National Curricular Parameters (PCN) (PCN, 1997), referring to the third and fourth cycles, which correspond to higher elementary education, address astronomy topics to which they need competences within the teaching-learning process, they are:

- History of Astronomy of ancient peoples, such as China, Babylon, and Egypt.
- More recent histories from the Greeks to Newtonian astronomy, with an emphasis on the opposition of the heliocentric and geocentric models.
- Sun-Earth System: movements of the star, eclipses, phases of the Moon, seasons of the year, tidal phenomenon, among others.
- Solar System: study of the star that compose it, evaluation of the size and distance of the planets in relation to the Sun.
- Shadow theory: study of the apparent movement of the Sun, construction of a sundial.
- Notion of Galaxies: positioning of the Sun in the Milky Way.
- Introduction to Cosmology: Big Bang Theory, the origin, expansion, and size of the observable Universe.
- In High School PCN+, it is necessary to learn Natural Sciences in the area of Physics, the structuring theme "Universe, Earth and Life", which is composed of the following thematic units:
- Earth and solar system:
- Knowing the relationships between Earth movements, of the Moon and the Sun for the description of astronomical phenomena (duration of day and night, seasons, phases of the Moon, eclipses, etc).
- Understand gravitational interactions, identifying forces and conservation relationships, to explain aspects of planetary system motion, comets, spacecraft, and satellites.
- Universe and its origin:
- Know the theories and models proposed for the origin, evolution, and constitution of the Universe, in addition to the current forms for its investigation and the limits of its results in the sense of expanding its vision of the world.
- Recognize orders of magnitude of astronomical measures to locate life (and human life), temporally and spatially in the Universe and discuss the hypotheses of life outside Earth.
- Human understanding of the Universe.
- Know aspects of explanatory models of the origin and constitution of the Universe, according to different cultures, looking for similarities and differences in their formulations.
- Understand aspects of the evolution of science models to explain the constitution of the Universe (matter, radiation and interactions) through time, identifying specificities of the current model.
- Identify different ways in which explanatory models of the Universe have influenced culture and human life throughout of human history and vice versa.

According to the reform of the new High School, which is being applied as of this year in all schools, the student must be the protagonist in the process of building knowledge, having his teacher as a mediator in the process of promoting conceptualization, that is, the student must have a mastery of the concepts involved in a broader and

closer way to the scientifically accepted concepts. The current school model is based on the BNCC, which has the specific competence of the natural sciences and their technologies: to analyze and use interpretations on the dynamics of Life, Earth and the Cosmos to elaborate arguments, make predictions about the functioning and evolution of living beings and the Universe, and to support and defend ethical and responsible decisions.

In this specific competence, conceptual knowledge related to: the origin of Life; to biological evolution; to the fossil record; to exobiology; to biodiversity; the origin and extinction of species; environmental policies; to biomolecules; to cellular organization; to organs and systems; to organisms; to populations; to ecosystems; to food webs; to cellular respiration; to photosynthesis; to neuroscience; to reproduction and heredity; to Mendelian genetics; to epidemiological processes; to the electromagnetic spectrum; atomic, subatomic and cosmological models; to Astronomy; to stellar evolution; to gravitation; to Newtonian mechanics; the weather forecast; to the history and philosophy of science, among others.

This competence has as one of its skills to elaborate explanations, predictions and calculations regarding the movements of objects on Earth, in the Solar System and in the Universe based on the analysis of gravitational interactions, with or without the use of digital devices and applications. In addition to analyzing stellar evolution, associating it with the models of origin and distribution of chemical elements in the Universe, understanding their relationships with the conditions necessary for the emergence of solar and planetary systems, their structures and compositions and the possibilities for the existence of life, using representations and simulations, with or without the use of digital devices and applications (such as simulation and virtual reality software, among others) (BRAZIL, 2018)

This work becomes potentially significant by making use of Physics concepts through immersed CC in the study of astronomy. That is, the teacher encourages students to create their own concepts from new methodologies applied in the context of classes held in open environments, so that they can make astronomical observations using the Celestial Charts, and associating with CC of Physics, such as: gravity, distances, forces, and speeds. These Charts are considered celestial maps that serve to identify and locate astronomical objects in this immense laboratory called “sky”, in addition to being considered an important didactic resource to make Physics classes more meaningful.

The methodology presented in this work is of a qualitative nature. For Minayo (MINAYO, 2009), the important thing about qualitative research is objectification, because during scientific investigation it is necessary to recognize the complexity of the object of study, critically review theories on the subject, establish relevant concepts and theories, use collection techniques of adequate data and, finally, to analyze all the material in a specific and contextualized way.

Objectification helps to ward off the excessive incursion of value judgments in research: it is the appropriate methods and techniques that allow the production of acceptable and recognized knowledge (MINAYO, 2009).

In order to obtain the data, the following collection instruments were used: semi-structured interview with closed questions, assessment carried out by the students on the elective given, construction of Celestial Charts with the students and socialization through observations using these Letters.

Therefore, this work uses the observational method, which according to Gil (2008) (GIL, 2008) the observational study only analyzes something that happens or has already happened. In this way, this research is characterized with the observational method, as it developed observations of the celestial constellations.

From the point of view of the nature of the problem, qualitative research was chosen precisely because of this critical nature, using techniques to collect the data necessary for students to start building their own Charts, and understand how to use them according to their needs. the day and time they had to adopt during the elective called “Discovering the Universe”.

The Astronomy course, the construction of the Celeste Chart and its use in formal and non-formal classes were carried out through the elective courses that at IEMA constitute the “Diversified Part” of the curriculum and have a fundamental importance in order to assist and complement CC that are part of the BNCC and cannot fail to be taught during High School. However, these electives are exposed to students at a time called “Feirão das Eletivas”, where the subjects can be chosen by each student, according to their affinity and the number of places available. Thus, only nine students enrolled in this elective course offered.

In the construction of this Celestial Chart, which was carried out in a period prior to the Astronomy course taught during the execution of that elective, the stars that make up the zodiac range were selected: Pisces, Aries, Taurus, Gemini, Cancer, Leo, Virgo, Libra, Scorpius, Sagittarius, Capricornus and Aquarius. In addition to these, others constellations were chosen – to compose this work –: Orion, Fornax, Perseus, Lepus, Canis Major, Vela, Centarus, Serpens, Bootes, Octans, Hydra, Crux, and ending in a separate Celestial Charts, referring to the constellation of

the Tupinambás Indians of Maranhão, known as the "Old Man Constellation".

It is worth mentioning that the calculation for any star is equivalent, so only the star "Beta Crux" (Mimosa) was selected, constituting the constellation known as "Southern Crux", to perform the calculation from the latitude of São Luís. Maranhão, since for the other stars the calculations follow the same pattern, changing only the right ascension (α) and declination (δ), which are constant during some periods for each star.

Data collection, analysis and interpretation of the results of this research were carried out at the Instituto Pleno Professor Doutor João Bacelar Portela, therefore, setting up field research.

With the right ascension in hand and following the studies by (JUSTINIANO & BOTELHO, 2016), it was possible - through these equatorial coordinates - to calculate the hour angle by summing the declination with the calculated local sidereal time of each star. One of the composite stars in this Chart and concluding with the calculation of the altazimuth coordinates (azimuth and altitude).

From the result found for the horizontal coordinates for the calculated star, in this case Beta Crux, a comparison was made with the Stellarium program. where it can be observed that the values of Az and h, determined in this research, are compatible with those of the software, but with a difference of less than one degree, both for the azimuth and for the altitude. This confirms the argument that, as this simplified method does not take into account the periodic corrections of the coordinates, it is possible to build the Celestial Chart.

The values of Az e h for the Beta Crux star, found in this research, are 155.691148235°/15.9440372936°, and when compared with the values obtained in the Stellarium Software literature, there is 155.4527777778°/15.3083333333°, resulting in a difference of less than 1° (one) for both horizontal coordinates.

For this purpose, SEI was developed with the 1st year of high school in the form of remote and face-to-face classes, leaving the possibility of participation for students from other high school grades. This decision was thought based on the contextualizing character of Astronomy, as a CC for teaching Physics.

Both the students of Colégio Militar 2 de Julho and the students of Colégio Pro. Dr. João Bacelar Portela participated in the OBA and ONC. The OBA is held and organized annually by SAB in partnership with the Brazilian Space Agency (AEB), being an event open to the voluntary participation of students from any school network. While the ONC is an event held by the Ministry of Science, Technology and Innovation (MCTI) of the Federal Government and is open to the participation of any student from the school network. In both events, demand from students was still small, and the results, consequently, are not expressive in Maranhão.

The application of this sequence aimed to improve student participation inside and outside the classroom when studying concepts and theories in Astronomy, which requires knowledge of Physics as a tool for the clarification of some celestial phenomena. The central idea was to bring the study of the Universe to the classroom universe, and its learning possibilities through schemes developed by the students, as well as the different situations that might or might not make sense at the moment, but that over time become scientifically constructed concepts and theorems.

In this context, what was proposed in this work is an improvement of Physics classes, making them more dynamic through the contextualization with the study of Astronomy and the pedagogical moments that are contained in SEI, such as: classes, celestial observation activities with the use of the Stellarium program, geographic orientations and use of the Celeste Chart to observe and locate stars and constellations in the sky, in addition to encouraging participation in scientific knowledge Olympics.

During the application of the SEI, methodological interventions were made in concepts such as: gravity, movements, astronomical coordinates, stellar projections in the plane, stars and constellations. The role of the teacher in this phase was fundamental to intermediate this teaching-learning process, offering situations that generate new concepts, in order to cause ruptures between knowledge based on common sense and scientific knowledge from the relationships that were obtained between different concepts. formulated during this process.

This work considered only the calculation of the stars, not taking into account the planets of the solar system, because, unlike the stars that have constant equatorial coordinates due to their relatively large distance, the stars that make up the solar system - such as the Sun, Moon and the Planets – are relatively close and, therefore, have variable equatorial coordinates over time. For the planets of the solar system, at each moment of observation these coordinates need to be recalculated through a procedure that was not described in this research.

The research is characterized as observational, as it deals with the construction and observation with a Celestial Chart in order to make Physics classes really meaningful, through the study of Astronomy. For this, active methodologies were used, which, according to Morán (2015) (MORÁN, 2015), are ways to advance further in

deep knowledge, socio-emotional skills and new practices, such as hybrid learning.

This research contributed by providing the student with a methodology that, according to Morán (2015), combined face-to-face learning during the Astronomy course, associating it with remote classes when it was not possible to be present at school, allowing students freedom to learn online. online or in the classroom with colleagues, and with the teacher as a mediator of this teaching-learning relationship.

Thus, during the development of the "Discovering the Universe" elective, we sought to encourage students to establish a dialogue about the proposed observation activities using the Celestial Charts, and on how to carry them out, since the use of technology made it possible to observe the sky even during the day, showing the need for students to have ample access to technologies, regardless of their economic situation. In other words, Morán (2015) shows that a student who is not connected, and without the digital domain, misses important opportunities to inform themselves, to access rich materials available, to communicate, to become visible to others, to publish their ideas. and to increase their possibilities through professional training in the future. We put in the appendix the unpublished figures of the letter from approx. (-2.5632, -44.3140).

3.1 APPLICATION OF THE DIDACTIC SEQUENCE

The application of the didactic sequence took place at Escola Dr. João Bacelar Portela, belonging to IEMA, located at **Rua** Jorge Damus, s/nº, in the Ivar Saldanha neighborhood, **São Luís, Maranhão, with the proper authorization to carry out the work provided by the general manager as shown in Appendix**B. This school has five classes of 1st, 2nd and 3rd scientific year with capacity for 40 students, working in the morning and afternoon shifts, in the full-time school model, and has as Pedagogical Manager Prof. Me. José Jorge de Carvalho Marvão, and General Manager Prof. Dr. Manuel dos Santos Costa.

The class chosen at this school, to participate in the Astronomy classes and use of the Celeste Chart, was formed according to the students' registration in the elective entitled "Discovering the Universe", where only 1st year students chose to participate. of this elective. It is worth mentioning that, as Astronomy has an interdisciplinary character, any student from the three grades of High School could participate in the course. However, the adhesion at the beginning was very good, however, in addition to not entering Google Meet to attend classes, for several reasons, when returning to the face-to-face model, the course had only nine students enrolled, but the teacher left it open for anyone who wanted to participate in classes, which at first yielded a reasonable audience of students.

Image 1 – Full-Time School Dr. João Bacelar Portela (IEMA)

The choice to carry out the research with these students was motivated by being at the school as a Physics teacher of the 1st year, and by knowing that exactly this public that is starting high school has not had any contact with astronomy in elementary school.

Before starting the Astronomy course, on November 6, 2021, a semi-structured survey was carried out, still in the midst of the Covid-19 pandemic, in order to assess students' prior knowledge on topics related to Astronomy, exploring the question of movements, the number of constellations, number of planets that make up the Solar System, as well as the name of the closest star to Earth after the Sun, and if they knew how to locate themselves geographically according to the region; however, only nine responses were returned.

The collected data were analyzed through graphs and tables, showing the existing relationships in the proposed inquiries. The semi-structured interview consisted of 10 multiple-choice questions, where only one was the correct answer, and was applied remotely.

This initial assessment was essential to know the ideas that the students had on the subject, and so that the teacher could outline a direction to be followed in the next classes, because, as Zabala (2008) (ZABALA, 1988) asserts, the knowledge that each student knows, knows how to do it and how it is, it is the starting point that should allow – in relation to the objectives and learning contents foreseen –, to establish the type of activities and tasks that have to favor the learning of each student.

At the first meeting, after the basic knowledge test held on September 15, 2021, the course was presented in the form of an elective that would be taught, and its importance as a basis for learning in dialogicity, and more interdisciplinary for students. Thus, the theme “Solar System and its components” was worked on. At that moment, their formation made up of eight planets was explained, as seen in Figure 2, dozens of natural satellites, thousands of asteroids, meteors, meteorites and comets that

orbit around a star, and what keeps them trapped in these orbits. and its implications here on Earth, as well as the idea of what light-years mean as a measure of distance and what an astronomical unit means. In addition, the theory of geocentrism was very defended for years, and heliocentrism ending with the apparent movement of the stars.

On October 1, 2021, the second class was taught online, on the solstices and equinoxes, where it was explained that these two astronomical phenomena mark the beginning of the seasons, showing that they are directly related to the incidence of solar rays and the inclination of the Earth, and that due to its position in relation to the Sun, it receives these solar rays on its hemispheres differently. Therefore, the idea that students have about rotation and translation movements was evaluated, followed by a video that was transmitted to them so that they could discuss and determine the difference between them. After watching the video, they were questioned by the teacher about why the Moon always has the same face every night, regardless of the location of observation. The students did not know how to answer, denoting a total lack of knowledge about one of the most basic topics in Astronomy. Showing that the time it takes the moon to complete a revolution around the Earth is equivalent to the time it takes to complete a revolution around itself and, thus, the same face of this star will always be seen.

There was a brief conversation about how many motions the Earth has, and many responded that there are only two types of motion. The professor explained that, in fact, the Earth has 1 single type of movement that can be decomposed, according to some criteria, into more than 110 components currently observed, however, the best known are rotation, revolution and precession, explaining how long it takes every move.

Thus, the teacher can explain to the students that each night is slightly different from the night before, and only after a year will the night be exactly the same again, with the same stars in the sky rising and setting at the same time. Therefore, as the Earth performs its translation movement in 365 days and six hours, only after four years will the night be exactly the same, always considering the same observation time. Associated with each explanation, the students were asked to download the Stellarium program, which was presented to the students, where some initial features were exemplified, such as the simulation of the Earth's rotation, as seen in image 3, below.

In the third class held on October 15, 2021, still online, Kepler's Laws and their implications were worked on, such as the importance they have for alignment of planets and their influence such as the effect of tides, or even the alignment between planets that only occur over very long periods. It was finalized with Newton's Law of Universal Gravitation, and its difference to gravity established by Albert Einstein. Added to this class was a video broadcast for better understanding of students. It was explained to the students, briefly, that in the process of building the Celestial Chart, both Kepler's Laws and Newton's Gravitation, as seen in Image 4 below, would not be important in this construction process; however, in the course of the night, over time and months, it was noticed the change of position of some constellations, and this is due to the rotation and translation of the Earth. It was explained to the students that there is a CC that is not explained in High School, and is not treated in Physics textbooks, but that has fundamental importance in the construction of the Charts that are the astronomical coordinates.

This is a failure carried throughout High School, as the teacher teaches concepts such as force, velocity, acceleration, references, but does not teach the student to understand what a celestial sphere is, astronomical coordinate systems, spherical trigonometry, and so on Student fails to understand the concepts that are worked on in the OBA, ONC and OBF, as they are unaware of these conceptual fields of scientific knowledge.

In the fourth class, held on November 3, 2021, in the ace-to-face model, it was about Solar and Lunar Eclipses, where we had the opportunity to show students the idea about the phenomenon of the cone of shadow, self-shadow, projected shadow and penumbra, explaining why the moon is reddish during a total eclipse, and demonstrating the phases of the moon, and why you can't see its other side, as seen in Image 2, below, and why it was precisely an Eclipse that was important to prove Einstein's theory of relativity.

The students questioned a lot about the Lunar Eclipse phenomenon, where the teacher had the opportunity to explain to them that this Eclipse always happens at the full moon, as it is at this stage that the Earth is positioned between the Sun and the Moon *(Image 5)*. However, emphasizing that this phenomenon does not occur throughout every month, because the Moon's orbit around the Earth is not in the same plane as the Earth's orbit around the Sun.

The phenomenon of the "Blood Moon", much admired by all, was explained to the students that this phenomenon used to disturb the indigenous peoples a lot, since in the tribe of the Tupinambás Indians there was a belief among men that they would die, and this was reason for much joy, because, in their conception, they were going to meet their ancestors, while women and children cried in fear of death. And that "Blood Moon" is just the name given to this phenomenon due to the appearance of the moon that turns reddish, when the Sun, Earth and Moon are in perfect

alignment, with the Earth at its center. The Solar Eclipse only happens when the Moon is in the new phase, because it is in this phase that the Moon is arranged between the Earth and the Sun.

Image 2 – Class on Solar and Lunar Eclipses

On December 1, 2021, the fifth class regarding the Astronomy course was taught, and the class where the teacher taught how to work with the Stellarium program was continued, as seen in Image 6, to make observations of stars, constellations, how to adopt different references for the visualization of a certain astronomical phenomenon, how to insert latitudes and longitudes of their region for an observation regarding the sky of the student's city. It is worth mentioning here that there were difficulties on the part of the students, given that, in some cases, their cell phone did not have enough space, in other cases the student did not have a cell phone and, the vast majority, did not have a computer that could work at that time. This ended up disturbing the progress of the Stellarium course a little, however, it was not a reason to stop activities.

The teacher shared with his students why some constellations are visible, and others are not in the celestial sphere, and the appearance that each of them has, in addition to the apparent movement they make in the celestial sphere throughout the night, and where they will be during the night. day using the Stellarium program. This made it easier for students to visualize some constellations, without having to wait for dusk to visualize the constellations again. It was discussed with the students that the area of the sky that corresponds to that located between the tropics of Cancer and Capricorn corresponds to the band of the zodiac, and is where, apparently, the Sun, Moon and planets move throughout the year. This apparent view of the movement of the Sun was discussed with the students, since it is the rotation of the Earth that influences the position of the Sun throughout the day, until its setting on the West side.

Students were shown how this program simulates a planetarium that is usually quite expensive for a school to purchase, and the issue of some concepts such as celestial sphere, azimuth, ecliptic, and geographic coordinates. In teaching about precession, it was shown that the ecliptic crosses the equator, forming an angle of approximately 23.5º, and that the crossing point is known as the "Aries point", however, due to precession, this point changes over approximately 26,000 years.

Image 3 – Class on the use of the Stellarium Program

In the sixth meeting, which started on December 15, 2021, there was talk about the constellations and how to locate them in the celestial sphere. In order to find a particular constellation, the teacher had to teach the student, first of all, to find himself geographically, and soon afterward relations of proximity were established with others already known, from Southern Crux. By obtaining this observational knowledge, the student was able to understand how ancient scholars observed the sky, establishing relationships with observations made today with the use of optical instruments or even Celestial Charts. The apparent movement of the stars in the celestial sphere was discussed.

Firstly, it was explained that, for the purpose of studies on the stars, a perfect sphere was adopted, where the Earth would be immersed within this sphere, and in which it is called the "celestial sphere", which is the place of the projections of the stars, and where one has the impression that they are all at equivalent distances from the horizontal plane.

Then, the class continued talking exactly about the impossibility of seeing stars during the day, and that this is a consequence of the strong light coming from the Sun, in addition, the dispersion of solar rays in the atmosphere, which make it impossible to see any star during the day, except for the Sun itself. Students were taught to determine the cardinal points simply by observing a few constellations, asking them to do this at home, and then looking for a constellation that always appears on the southern horizon. This class ended by showing how many planets make up the Solar System, some of their properties and their respective natural satellites – if they have one –, as seen in Image 7, below.

Image 4 – Class on the constitution of the planets of the Solar System

In the seventh meeting, held on December 16, 2021, the class started talking about the constellations, which actually represent 89 areas in the celestial sphere, and they are not just those stars that form images in the sky. There was talk about their names and their respective abbreviations, and about the body that defined, in 1930, this division of the sky into constellations, with 52 constellations in the northern sky, of which 12 are zodiacal and 36 constellations in the southern sky.

Thus, we began to teach how to find the equatorial coordinates in the Stellarium program, and the calculation for the chosen star, which in this case was Beta Crux, began. Previously, JD, S, TSS, sidereal time at Greenwich and TCL were calculated. At that moment, so that it would not be too tiring, this meeting was divided into two moments, that is, the calculations of the Charter were continued in the eighth meeting. But, before the end of the class, the Origin program was presented to the students, and it was commented that this type of graph that would be created was of the polar type, and that it needed other types of coordinates so that it could be built. It was shown how to assemble the data of a single constellation, and that it would be necessary to visualize the connection points of each star to form the image that was needed, according to the image formed by Stellarium together with the information of the constellation by the image platform of the Google.

Immediately after this action, and combining the output and arrival coordinates, each pair of coordinates to be linked in the program was always set in lines, as seen in Image 5 below, so that after forming the image of a single constellation, merged them all into a single graph. The professor explained that the Charter's function was celestial observation to understand the movement of constellations throughout the night. As this activity was not performed at night, but during the day, the students used Stellarium to advance the time and simulate the night of that specific day, or even over the months.

Image 5 – Calculation of the Celestial Chart

The calculation of the Celeste Chart in the eighth meeting was carried out on December 18, 2021. This day was a school Saturday for the students, in which the work could continue. In this part, collective work was prioritized, gathering students into groups where they could share knowledge with those who presented a little more difficulty.

The students continued the Celestial Chart calculations based on the teacher's teachings, and they find it very difficult because they are not used to working with equatorial, hourly and horizontal coordinates. In addition, many astronomical terms such as ecliptic, TSS, sidereal time, azimuth were still a barrier, which was only overcome from the Astronomy elective.

The objective of this eighth meeting was, after learning the Stellarium program, to put into practice the observations of the stars and constellations together with the use of the Celestial Chart, in order to become familiar with the 88 existing constellations, and also to make observations of the alignment of some planets. , as is the case of Jupiter and Saturn, in addition to identifying the different types of objects visible in the night sky, seeking to encourage the student to bring to their universe a little of the dynamics that is appreciated when looking at the sky at night, and compare with the Celeste Letter that they helped to build in partnership with the teacher. It is logical that the time was not enough to complete the construction of the Celestial Chart in the classroom, however, the calculations of the azimuth and altitude for the star Beta Crux were completed.

The students were taught to use the Origin Software, and to enter the data in the program, however, it was not very successful at this point due to the difficulty of all having notebooks, as seen in Images 8, 9 and 10.

During the conversations, there was talk of the behavior of some stars that have variable equatorial coordinates, as is the case of the planets, however, that the Sun, unlike the other stars, also does not have, and varies from day to day. Each day the Sun moves one degree in relation to the stars. And that if it were possible to see the Sun during the day, and in this case you can through the Stellarium, you can see the Sun apparently walking through the constellations. And

that after a year, the Sun returns to the same position, in relation to the stars of the celestial sphere.

Image 6 – Construction of the Celestial Chart

Image 7 – Construction of the Celestial Chart

Image 8 – Construction of the Celestial Chart

In the ninth meeting, held on December 20, 2021, a brief review of the implications of studying the celestial sphere was carried out. The students were invited to the schoolyard and observed that for this study it is necessary to determine all the movements of the Earth previously taught, as seen in Image 9, below. It is possible to determine the coordinates of each place and, therefore, make a survey of terrestrial maps, today with the aid of GPS. Another implication would be to determine the measure of time that is needed to determine the passage of the constellations in that time interval. And it could be shown that, with the help of Stellarium, it is possible to calculate the distance of the closest stars or any other, simulating the appropriate moment that one would like to calculate.

It was shown, with the help of Stellarium, the apparent path that the Sun makes called "ecliptic through the celestial sphere and the point", where it and the equator meet called "equinoctial points" or "equinoxes". At one point it was shown that the point at which the Sun passes from the Southern Hemisphere to the North is known as the "spring equinox" or "γ point" (gamma), and that the other, diametrically opposite, is known as the "autumn equinox", or "Ω point" (omega). The students had the notion that the first is the starting point for counting angles when it is necessary to determine the positions of planets or stars in the sky, and that the points of the ecliptic that are furthest from the equator are known as solstices (summer and winter). Therefore, they are the points where the Sun is more to the South or to the North.

At the tenth meeting, held on December 21, 2021, it was a matter of putting into practice, outside the classroom, everything that was studied in the classroom, and which generated moments of intense debate, especially on the movement of the celestial constellations. These apparent movements were still unknown to the students, as they had always heard of Earth movement. They ended up alluding to the motion of the stars as equivalents. However, despite knowing that the stars have movement, like everything else in the Universe, these movements are neglected due to the distance they are from Earth.

Image 9 – Non-formal meeting for observation using the Charts and Stellarium

It was explained to the students that this apparent diurnal movement of the constellations is due to the rotation of the Earth, that is, rising in the East, moving until it disappears in the West, and that every two hours a constellation is born in the place where the first one was born. Just as it is due to the translation that when observing with the Celestial Charts for the same region of the Earth (North, South, East or West), one has the vision of different constellations throughout the months of the year if observed at the same time. , and that because of the Earth's translation, the Sun, with respect to the stars, seems to move from West to East, and that because of the Moon's translation around the Earth, the Moon, with respect to the stars, appears to move from West to East, because the Earth's motion rotates towards the right hand, while the celestial sphere rotates towards the left hand.

In addition to all this study on the stars, observations were made concomitant with the use of Celestial Charts, observations of indigenous constellations (especially that of the Old Man), and the use of the Stellarium software, in

order to familiarize them with this important product. educational, which served as a motivator for discussions and learning about Astronomy using Physics, and for explanations of some celestial phenomena, as seen in Images 12 and 13.

Image 10 – Discussions and learning about Astronomy using Physics to explain some phenomena

itled "Discovering the Universe", the last semi-structured research was carried out, to evaluate what the students were able to assimilate and learn, in a way that serves the educational development of each of them, and that they can apply this learning throughout their school years and during the scientific olympiads.

IV. PRESENTATION AND ANALYSIS OF RESULTS

This section aims to present the results obtained during the Astronomy course through the elective entitled "Discovering the Universe". This didactic sequence was designed for 12 classes, where the first and the last are semi-structured research, with the purpose of evaluating previous knowledge and those acquired by the Astronomy course. The initial semi-structured research evaluated the students' previous knowledge about the CC addressed in each question, while the final questionnaire evaluated the students' evolution when using these astronomy concepts to structure their scientific knowledge and reformulate in an interdisciplinary way with the Physics discipline.

4.1 Results of the Semi-Structured Diagnostic Survey

The semi-structured survey included a diagnostic assessment consisting of 10 basic questions as shown in Appendix C, and a final assessment at a slightly more elaborate level also consisting of 10 Astronomy questions as shown in Appendix D The answers will be presented in the form of a bar graph, where the green bar represents the correct alternative. In both surveys, only eight students participated, which made the research universe a little more restricted, however, it shows the need for urgent changes in the training curriculum of Elementary and High School, as shown in the graphs below.

1 Which science is responsible for studying the universe, stars and celestial bodies, in order to explain their origin and movement?

a) Physics

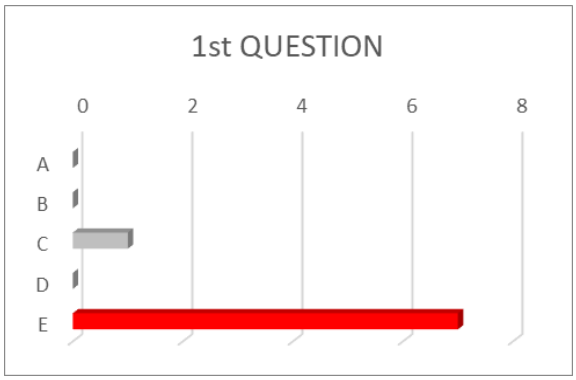
b) Chemistry

c) Astrology

d) Philosophy

e) Astronomy

Graph 1 – Answers to the 1st question



In this first question it can be seen that even today some students confuse Astronomy with Astrology. Currently, modern science does not define Astrology as a science, although it has been widely used in the past by the kings of the time to justify some astronomical phenomena. This kind of conceptual misconception would be easily eradicated if high school teachers had some continuing education in Astronomy.

2 What is the equivalent of what the Earth describes around the Sun, that is, its orbit?

a) Rotation

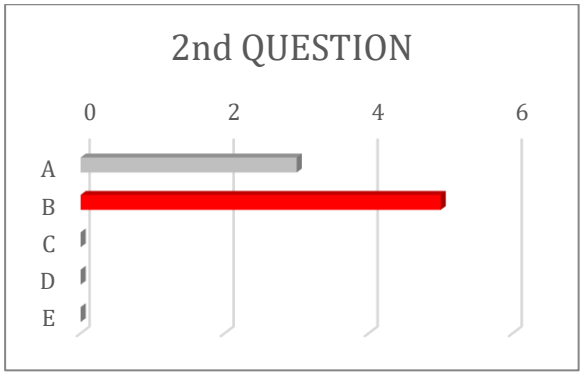
b) Revolution

c) Precession

d) Revolution

e) Nutation

Graph 2 – Answers to the 2nd question



It can be seen, in this second question, that many students still confuse translation (which is the movement of the Earth around the Sun) and rotation (which is the movement of the Earth around the Sun of its own axis). This implies a serious conceptual error, because if they cannot discern about these two concepts, they will consequently have difficulties in understanding the movement of stars and constellations, or even could not understand why different constellations appear in the place where the Sun sets along of months.

3 *Astronomical phenomenon that occurs whenever the Earth is between the Sun and the Moon, exactly on the line of intersection of its orbit with that of the Moon, the so-called "line of nodes", and whenever the Moon is in the full phase, it is known as?*

a) Solar Eclipse

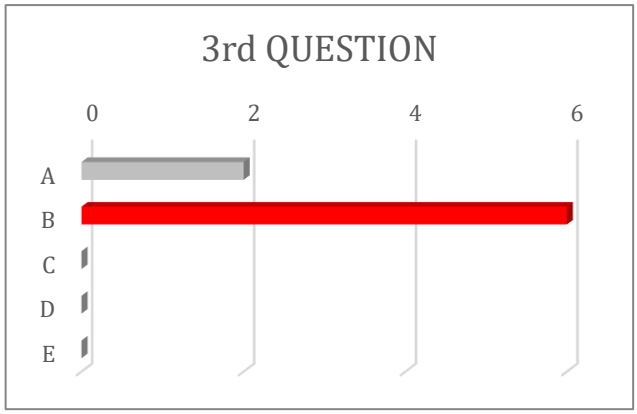
b) Lunar Eclipse

c) Southern Eclipse

d) Eclipse Space

e) Eclipse Stellar

Graphic 3 – Answers to the 3rd question



In this third question, the graphical analysis shows that there is a methodological deficit in the teaching of Physics, because even today students cannot understand the Lunar Eclipse phenomenon, and that through computer programs, such as Solar System Scope or even Stellarium, students will be able to more easily understand the Physics behind the phenomenon, such as the astronomical event shown here by Figure 39.

Figure 39 – Lunar Eclipse of the 15th of December May 2022

Source: Solar System Scope Program (2022)

4 *Why does the moon have a different phase (appearance) each night?*

a) Because the Earth revolves around the Moon

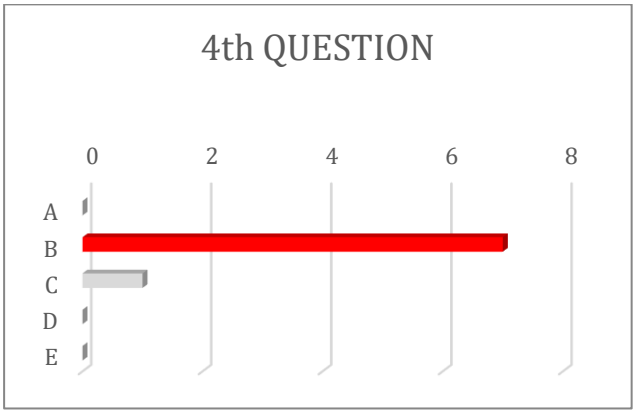
b) Because the Moon revolves around the Earth

c) Because the Moon passes in the Earth's shadow

d) Because the Sun revolves around the Moon

e) None of the previous answers

Graph 4 – Answers to the 4th question



This fourth question demonstrates that even with most having got the answer right, it is necessary to reinforce contextualized classes with astronomy themes, so that the few students who got it wrong can understand that the Moon maintains a translational movement around the Earth, and the Earth around the Sun, and during these movements there will be a moment when the Earth will be placed between the Sun and the Moon, which will consequently cause the Lunar Eclipse, which is nothing more than the shadow of the Earth projected on the Moon.

5 *Planets in the Solar System can be classified according to their composition. Based on this classification, it can be said that we have:*

a) 5 rocky (Mercury, Pluto, Mars, Ceres, Neptune) and 3 gas (Uranus, Saturn and Earth)

b) 3 rocky (Pluto, Ceres and Earth) and 4 gas (Mars, Uranus, Neptune and Mercury)

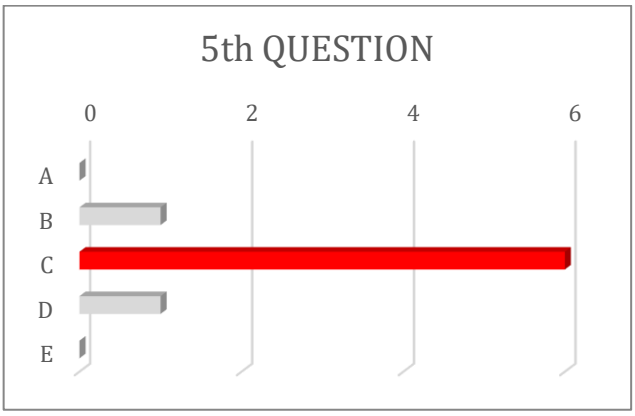
c) 4 rocky (Mercury, Venus, Earth and Mars) and 4 gas (Jupiter, Saturn, Uranus and Neptune)

d) 6 rocky (Pluto, Mars, Ceres, Neptune, Venus and Moon) and 2 gas (Mercury) and Saturn)

e) None of the previous answers

In this fifth question, the intention was to analyze the students' knowledge about the quantity and constitution of the planets currently known, which orbit the Sun. It can be seen that there are still students who do not know the correct number and tend to confuse some of them with stars when observed with the naked eye, because they know absolutely nothing about the Solar System, and even less about the stars outside it.

Graph 5 – Answers to the 5th question



6 How many constellations geometrically divide the celestial vault, apparently being a sphere?

a) 87 constellations

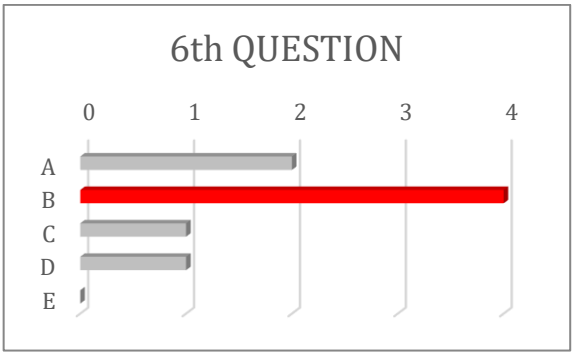
b) 88 constellations

c) 86 constellations

d) 85 constellations

e) 84 constellations

Graph 6 – Answers to the 6th question



In the sixth question, the subject highlighted was the number of known constellations, and if the students knew the exact number. And it became clear that half of them did not know how many constellations there are currently, which requires more studies on stars and constellations, and why images are formed with the joining of some of them.

7 A sky map, which can depict the full extent of existing constellations or a part of the sky, showing how it is seen from a certain region, is known as?

a) Geographic map

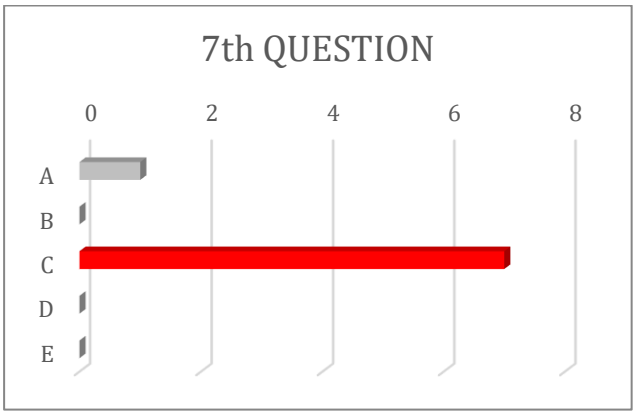
b) Educational

c) Celestial Chart

d) Chart Western Map

e) Solar

Graph 7 – Answers to the 7th question



About the main theme of this work, in the seventh question the question is whether the students knew a Celestial Chart, and their answer was evidenced showing that, currently, they still there are high school students who don't know what a map of the sky is, let alone what these maps are for. This demonstrates the importance of taking Astronomy courses.

8 Why do we always observe the same face of the Moon?

a) Because the time it takes for the Moon to rotate around its own axis is equal to the time it takes for it to rotate around the Earth

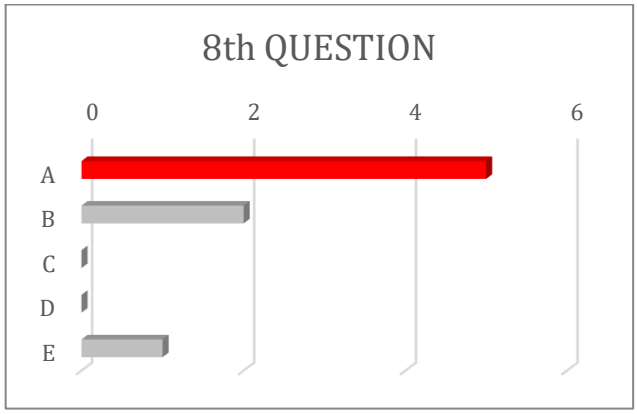
b) Because the time it takes for the Moon to rotate around its own axis is different from the time it takes for it to rotate around the Earth

c) Because the time it takes for the Moon to rotate around its own axis is different from the time it takes for it to rotate around the Sun

d) Because the time for the Moon to rotate around its own axis is equal to the time it takes it takes to revolve around the Sun

e) Because the time it takes for the Sun to rotate around its own axis is equal to the time it takes to revolve around the Earth

Graph 8 – Answers to the 8th question



When analyzing the answers to this eighth question, which deals exactly with the process of observing a star, it is clear that there are still gaps unfilled in the process of assimilation of knowledge by the students, or the teacher deprived of continuing education that allows him to establish a link between the phenomenon and the acquisition of knowledge about this phenomenon on the part of the student, in a scientific way.

9 How many planets make up the Solar System, and what are they?

a) 7 – Mercury, Earth, Mars, Saturn, Pluto, Jupiter and Aldebaran

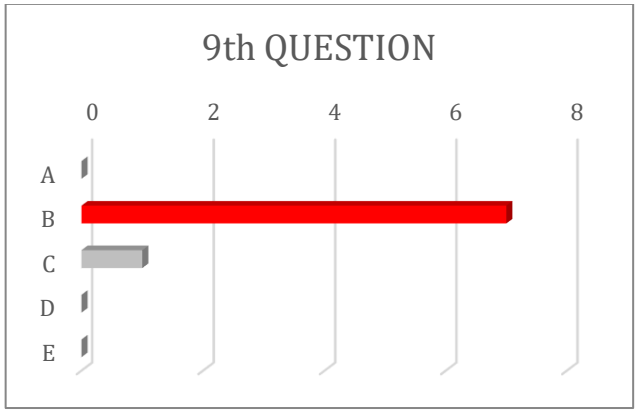
b) 8 – Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus and Neptune

c) 9 – Saturn, Uranus, Jupiter, Mars, Earth, Pluto, Andromeda, Neptune and Io

d) 10 – Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, Pluto and Io

e) 11 – Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, Pluto, Io and Callisto

Graph 9 – Responses to 9th question



This ninth question is similar to the fifth, however, it still shows a lack of knowledge of some students about the number of planets in the Solar System, and that through computer applications, Physics classes could be improved in teaching methodological processes. learning.

10 What is the name of the closest star to Earth after the Sun?

a) Andromeda

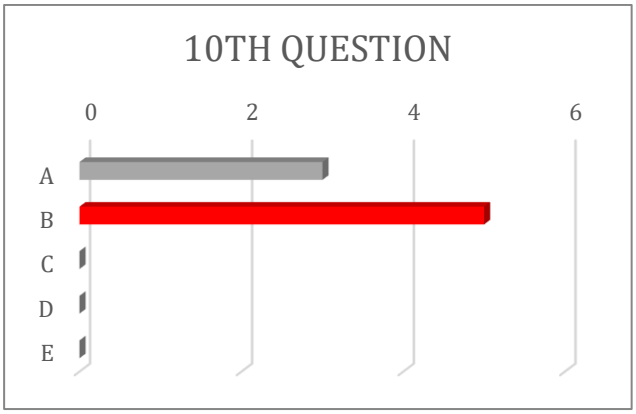
b) Proxima Centauri

c) Mintaka

d) Alnilam

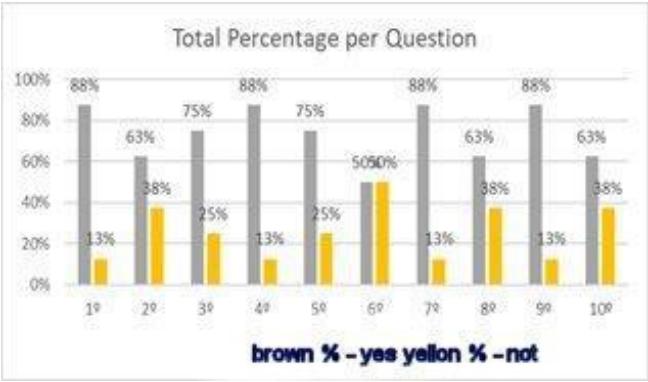
e) Betelgeuse

Graph 10 – Answers to the 10th question



In the tenth question, it can be seen that when it comes to stars outside the Solar System, the ignorance of the students is more evident, for not having the habit of reading about the Universe and their constitutions. Here, about 50% were not aware of this star, and do not know any of the others that made up the answer table for this question. Below is an overview of the diagnostic evaluation.

Graph 11 - Total percentage due to diagnostic evaluation



- *SEMI-STRUCTURED RESEARCH AFTER THE ASTRONOMY COURSE*

At this moment, the students were evaluated after the elective course entitled "Discovering the Universe", and after the classes inside and outside the classroom, they were observed what were the schemes they created, in order to understand the concepts studied and apply their theorems and concepts in action at more elaborate levels, going on to confirm some concepts as really significant, or to refute those that were theoretically outside the scientifically proven concepts. Some questions in this survey were purposely repeated to see if students still remembered and other questions were modified to a higher level.

1 In space, what is a group of stars relatively close to each other called?

a) Solar System

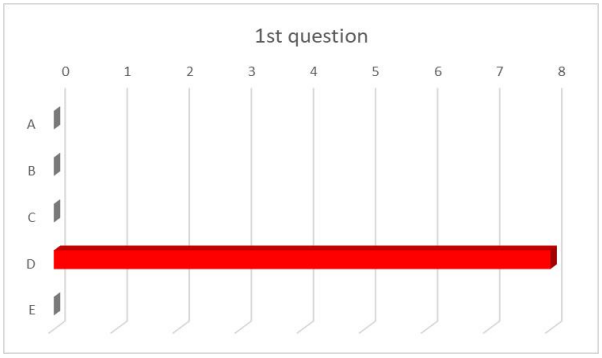
b) Black Hole

c) Planetoid

d) Constellation

e) Comet

Graph 12 – Answers to the 1st question



In this first question of the final research, it is noticed that everyone has knowledge about constellations, however, in a wrong way, because it is learned in textbooks that a constellation is a set of stars linked together. This is a didactic mistake, because, in reality, they are not associated star systems. In general, they are very distant from each other, within the Galaxy.

2 Which planets are visible to the naked eye from Earth?

a) Eta Carinae

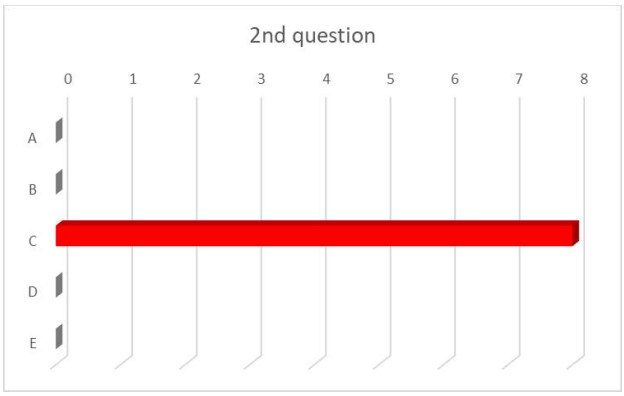
b) Jupiter and Pluto

c) Mars, Jupiter, Venus and Mercury

d) Uranus and Venus

e) Ceres

Graph 13 – Answers to the 2nd question



In this second question, the students proved to be knowledgeable about the planets that are visible throughout the night, however, it was unknown to them that these planets occupy the band of the zodiac, which is nothing more than an imaginary band, centered on the ecliptic, through the celestial sphere, and about 16º in width, where the Sun, the Moon and the planets Mercury, Venus, Jupiter and Saturn are always located. That was interesting, because it represented a certain amazement, as if they were discovering something really new.

3 The Moon completes one revolution around the celestial sphere every 27.321662 days. This period, measured relative to the fixed stars, is known as?

a) Month Austral

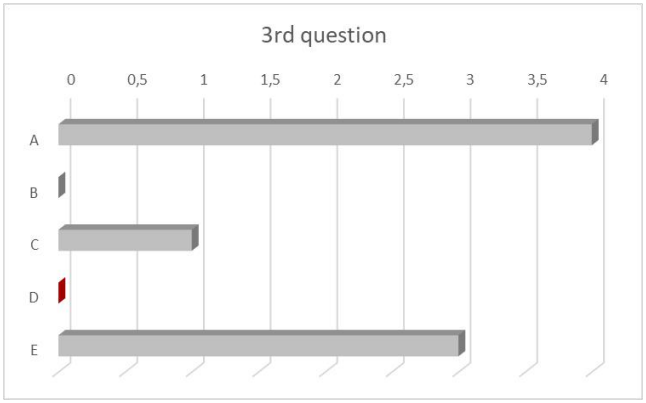
b) Lunar Day

c) Sidereal Time

d) Sidereal Month

e) Lunar Year

Graph 14 – Answers to the 3rd question



In this third question, it can be seen that although it was shown in the classroom, the students did not assimilate it properly, so that none of them managed to answer satisfactorily. In the classroom it was explained to them that

the sidereal month is the period of translation of the Moon in relation to a fixed reference. Its difference from the synodic month[3] is explained by the fact that it depends on a composition of the movements of the Earth and the Moon. As the sidereal month is exactly the same as the Lunar day, the same face of the Moon is always seen.

4 *Band of the celestial sphere along the ecliptic, about 18º wide, through which the Sun, Moon and planets transit is known as?*

a) *Zodiac*

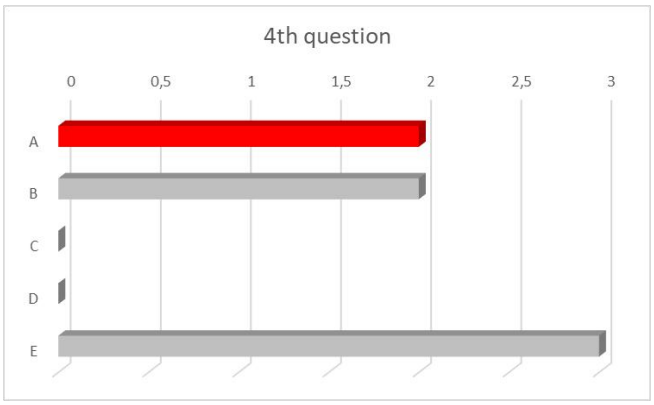
b) *Range*

c) *Ecliptic*

d) *Transition Space*

e) *Revolution Zone*

Graph 15 – Answers to the 4th question



As already discussed in previous questions, we return to talking about the zodiac that represents a band. The constellations that form the Zodiac (circle of animals, or path, from Sanskrit Sodi), a band of 18º around the ecliptic, were defined around 500 BC by the Babylonians, dividing the ecliptic into 12 equal subdivisions of 30º each. They can be related by the mnemonic *ArtaGeCa LeViLiSco SaCAquaPi*, as they are: *Aries*, *Taurus*, *Gemini*, *Cancer*, *Leo*, *Virgo*, *Libra*, *Scorpius*, *Sagittarius*, *Capricornus*, *Aquarius* and *Pisces*.

5 *The projection on the celestial sphere of the apparent trajectory of the Sun, observed from the Earth, is called:*

a) *Plane Solar*

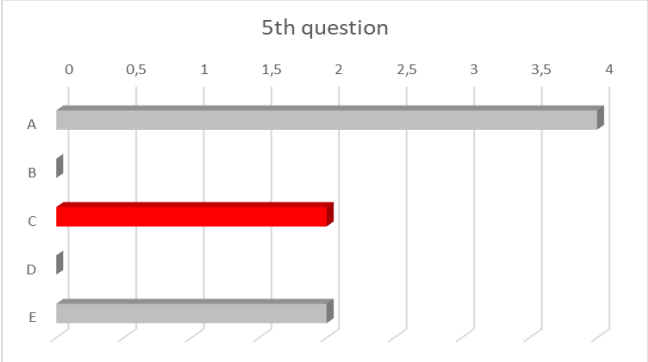
b) *Plane Spatial*

c) *Ecliptic*

d) *Celestial Sphere*

e) *Celestial Pole*

Graph 16 – Answers to the 5th question



In this fifth question, it was exactly the meaning of the ecliptic in Astronomy, and it was explained to students that it represents the plane of the Earth's orbit around the Sun. From the perspective of an observer on Earth, the movement of the Sun around the celestial sphere over the course of a year traces a path along the ecliptic against the background of the stars. This path, which joins all the daily positions of the Sun on the celestial sphere throughout the year, is called the ecliptic. According to the heliocentric referential (view from outside the Earth), the ecliptic is the plane of the Earth's orbit around the Sun (LANGHI, 2016).

6 *How many constellations geometrically divide the celestial vault, apparently being a sphere?*

a) *87 constellations*

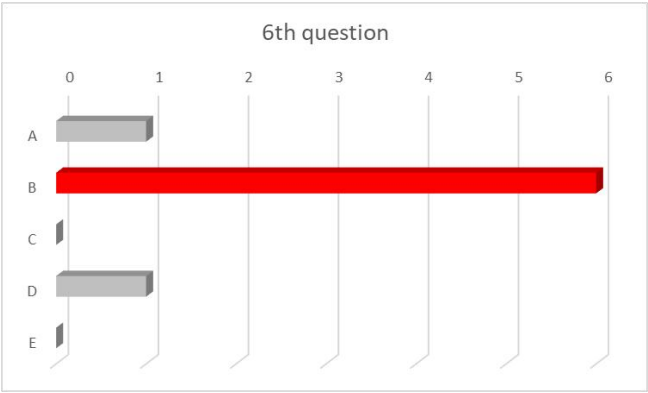
b) *88 constellations*

c) *86 constellations*

d) *85 constellations*

e) *84 constellations*

Graph 17 – Answers to the 6th question



This sixth question repeated the previous research to see if there was any improvement in learning, and the

[3] The synodic month or lunation is the average time interval between two consecutive equal moon phases.

question shows exactly the expected result. In the previous survey, 50% of the students got it right, while in this survey 75% of the students got the question right. Knowing how to define the number of constellations, which are the zodiacal ones and their respective abbreviations is important for students who want to follow this line of research in Position Astronomy, or just learn to calculate a Celestial Chart.

7 A sky map, which can depict the full extent of existing constellations or a part of the sky, showing how it is seen from a certain region, is known as?

a) Geographical Map

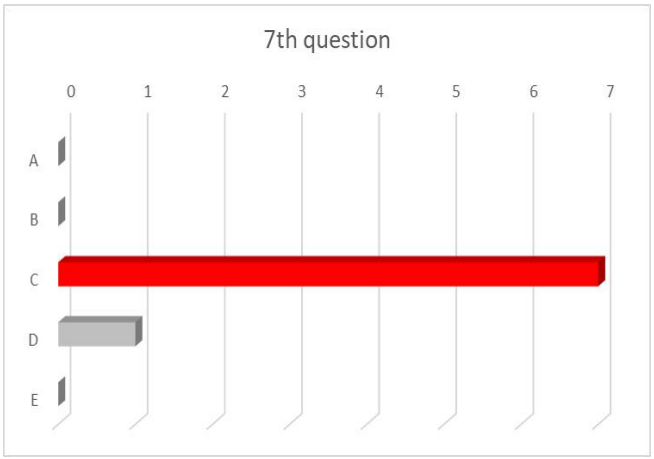
b) Educational

c) Celestial Chart

d) Chart Western

e) Solar Map

Graph 18 – Answers to the 7th question



On this seventh question, there were no changes, as there was still a student who showed a lack of knowledge about the object used to map the sky, and which also makes it possible to understand about the movement of constellations throughout the nights and months of the year. This celestial map also makes it possible to understand, in the case of the Sun, the change in constellations that can be observed when looking in different directions of the sky due to the translation of the Earth around the Sun. This celestial phenomenon was duly worked with students outside the classroom with the Celestial Letters produced in this scientific research.

8 Can we identify a Total Eclipse of the Moon when it completely passes through the region called the?

a) Penumbra

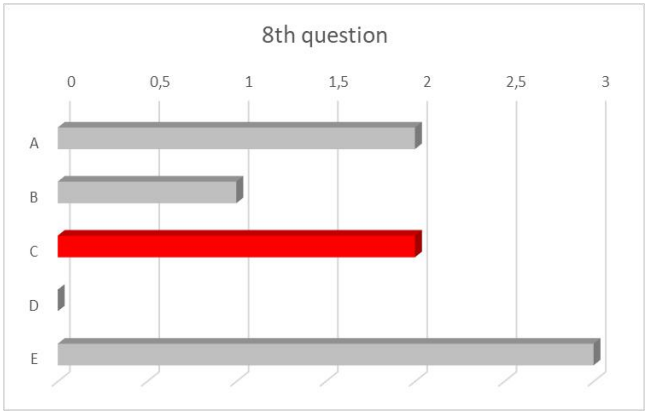
b) Shadow

c) Umbra

d) Darkened Region Eclipse

e) Zone

Graph 19 – Answers to the 8th question



In this eighth question, it is noted how important Astronomy classes are in Elementary and High School, given that this subject is addressed in the 2nd year at the Optical CC Geometric, and it can be seen, through Graph 19, that only two students or 25% of the class got this question right, while the other students do not have the schema formed in their ideas of how the Lunar Eclipse phenomenon happens. Understanding the movement of the stars is also important so that we can understand some phenomena here on Earth, such as, for example, the syzygy tide.

9 Is the altitude of any star at the zenith in degrees a?

a) 360º

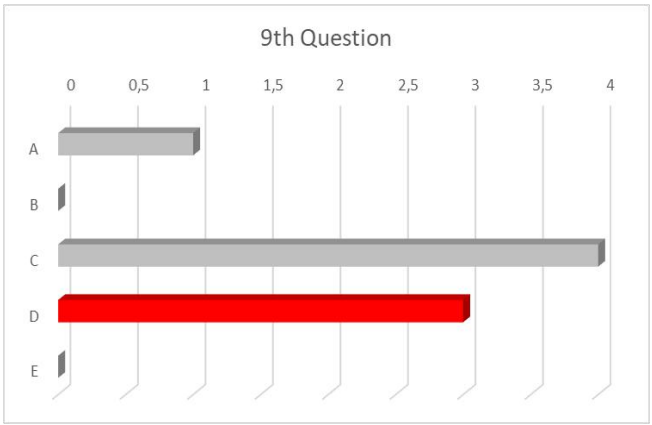
b) 270º

c) 180º

d) 90º

e) 45º

Graph 20 – Answers to the 9th question



In the ninth question, only 37.5% of the students got it right, which demonstrates a lack of knowledge or even a lack of a discipline like Astronomy that approaches the CC of science in an interdisciplinary way. This result reflects the low rates of approved and medalists in the OBA and

ONC at the Bacelar Portela school, and through this result it can be extended as a reflection to other schools in Maranhão, especially the private ones, whose focus is only on the entrance exam.

10 What is the name of the closest star to Earth after the Sun?

a) Andromeda

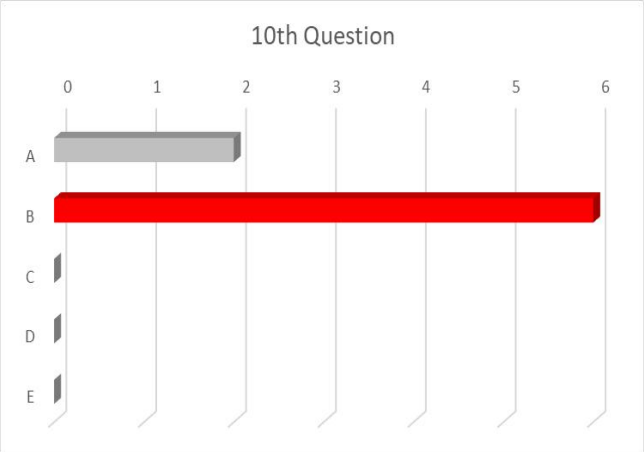
b) Proxima Centauri

c) Mintaka

d) Alnilam

e) Betelgeuse

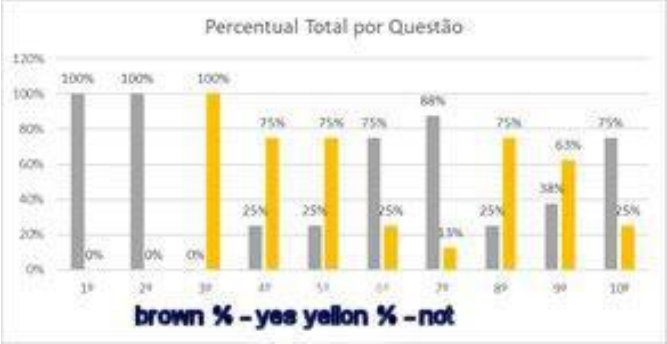
Graph 21 – Answers to the 10th question



In this tenth question, which was also purposely repeated, it was noticed that after the course, there was an evolution of the participating students, as now there were 75% of correct answers, and how the evolution was small, it is believed that only through an extensive course in Astronomy, focusing on observations, practices inside and outside the classroom, will a more effective result be obtained, calling for more girls to engage in science, research and innovation. Students' knowledge about the best-known stars is still very small in public schools in Maranhão. Perhaps, with more courses being held in the form of electives at IEMA, more candidates will emerge for researchers who can help develop the scientific and technological hub, helping to improve the Human Development Index (HDI) through education aimed at community development in the region. from maranhão.

In summary, we have, in general, the analysis of this second moment of the classes, in which there were advances in CC of Astronomy.

Graph 22 – Total Number of Students who responded to the final survey



- *FORMATIVE ASSESSMENT (QUALITATIVE ASPECTS)*

The other part of the survey corresponded to listening to the students, knowing how they received the course and what they thought of this new experience, how this elective would influence the life of these students, in order to bring improvements in their learning. What did you think of the experience of learning to build and use a Celeste Letter in open school environments, and using the Stellarium program as a helper, given that the timetable was daytime? How was the experience of understanding the movement of constellations using coordinate systems still unknown to these students? Next, the students summarized all their criticisms, whether constructive or not. The teacher asked them to be extremely sincere, so that teaching practices could be further improved.

The speeches of the students referring to the Astronomy course, and the practices of observation and discussion of the topics covered, it was even proposed a more lasting course in another opportunity, given the great interest of this team that was during this elective at the school. João Bacelar Portela. Working with Astronomy, using the conceptual tools of Physics, developed in them a more critical and argumentative posture when carrying out observations using Celestial Charts and Stellarium as a guide in celestial observations.

V. CONCLUSION

The choice of the object of study and the investigation technique used in this research was carried out during the Master's activities, given that there are few bibliographic references that would allow the professor to develop the work, and due to the lack of continuing education in Astronomy that would allow the even to do more solid and scientifically correct work. This absence of continuing education for the training of teachers and disciplines - which can show students that it is possible to work in an interdisciplinary CC of Astronomy with the other sciences -

still represents a very strong obstacle in Maranhão, in addition to the rates of approved students. and science Olympiad medalists are extremely low in public and private schools. And it was exactly after the realization of these facts, and so that the students could acquire greater interest in Astronomy, that the student decided to develop the first Celeste Chart of São Luís do Maranhão.

In this research, students' cognitive difficulties regarding the assimilation of questions related to basic Astronomy were found, which can be explained through the teaching of Physics. However, there is a need for innovative pedagogical methodologies that give a new meaning to the studied conceptual fields and allow the student to establish relationships between celestial and terrestrial events.

The elaboration of Celestial Charts required a knowledge of Astronomy that was well above those imagined at the beginning. Some of this knowledge was not possessed, not even by the teacher, due to the lack of disciplines focused on Astronomy in Higher Education, or even of continuing education in Astronomy for the development and improvement of teaching practices.

Developing in the student the ability to generate conceptual schemes, so that they could understand what a celestial sphere is, consists of enabling them to achieve the following knowledge: associating the movement of the celestial sphere as a result of the Earth's rotation around its axis of rotation in the range of a sidereal day, not a solar day; notions of astronomical and geographic latitude; notions of altazimuth coordinates, in order to represent the sky visible at a location, at a specific date and time; familiarization with hourly and equatorial coordinate systems; notions of time scales, since there was a need to transform universal hours into time zones and true solar hours, in order to obtain true sidereal time, data that are essential to relate equatorial and time systems; knowledge of spherical trigonometry to relate hour systems with altazimuths; knowledge of computer applications that allowed the efficient calculation of the necessary mathematical transformations; knowledge of computer applications that generate graphics from numerical data in a spreadsheet; in addition to the knowledge of the movement of the celestial sphere, in order to extrapolate 12 punctual Celestial Cards so that they could be used throughout the year. These learning phases have become a methodological challenge in the midst of a completely adverse scenario.

Another difficulty presented during the course is that not all students had notebooks to carry out the work, so only the Letters were used together with the cell phone, for the elaboration of the activities of observation of the sky.

As the topic has always aroused everyone's curiosity, the observations with the Celestial Letters and the use of the Stellarium in outdoor environments allowed debates on Astronomy and Physics, promoting an educational and motivating role, both for students and for teachers, as triggered numerous questions on the part of everyone involved about the movement of stars, position of stars in space, coordinate systems involved, in addition to the idea of time involved in celestial phenomena.

As a result of the semi-structured surveys, the students ended up having an improvement in some questions, however, they did not perform well after the course in most of the questions presented. This is due to several factors, such as: excessive time without school activity due to the pandemic, lack of continuing education in Astronomy for Basic Education teachers, lack of Astronomy discipline that can work the contents required by the BNCC (BRASIL, 2018), in addition to technological equipment that can help the teacher in the development of these classes, inside and outside the classroom, such as notebooks, tablets and data show.

Even so, it was found that the use of this pedagogical tool (celestial letter) improved the students' relationship with the Exact Sciences, from the moment it contextualized the theoretical knowledge obtained in the classroom with field observations.

It was proposed, in this research, a specific discipline of Astronomy that can work contextualized with the other sciences, with the use of Celestial Charts in formative moments outside the classroom, so that the students can become familiar with other types of coordinates not seen. in Basic Education, in addition to more visits to planetariums or lectures in schools by teachers who work on topics related to the study of Astronomy and the dissemination of science in Brazil and, in particular, in Maranhão.

Finally, it is proposed, in future studies, a greater development of studies on the Celestial Letters from São Luís do Maranhão, mainly taking into account the brightness of the stars, in the development of the Letters, which is of fundamental importance for the study of Position Astronomy. This theme was not highlighted in this research, due to the impossibility of working in schools, due to the pandemic for a certain period, and the lack of time after the release of school activities. However, it serves as an important CC to be developed in future works, where, from this research, new works for the Maranhão region may emerge.

ACKNOWLEDGEMENTS

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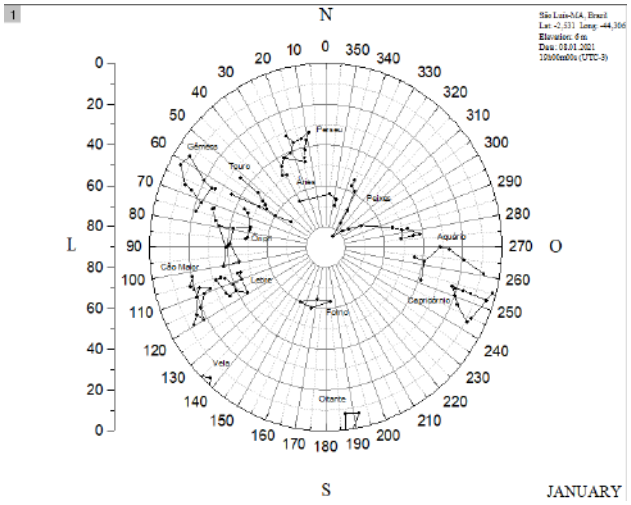
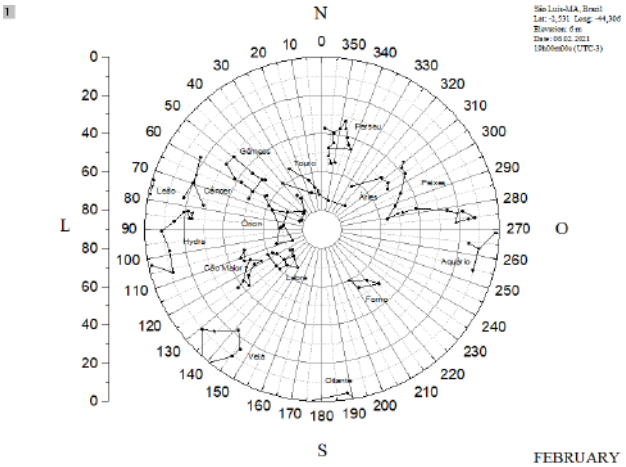
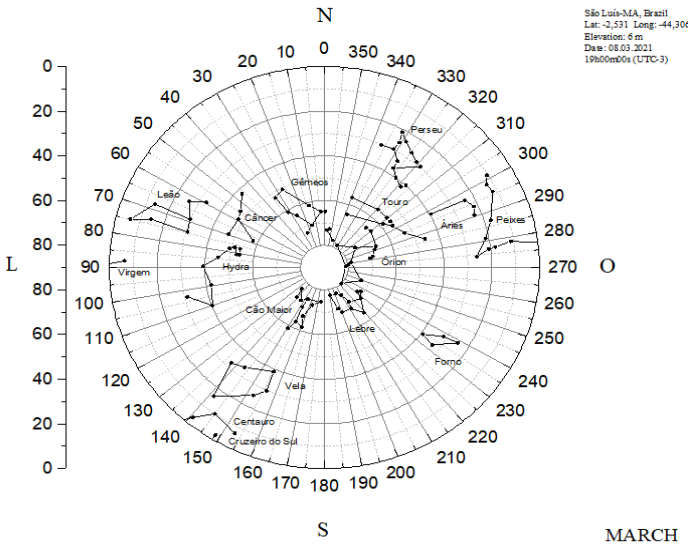
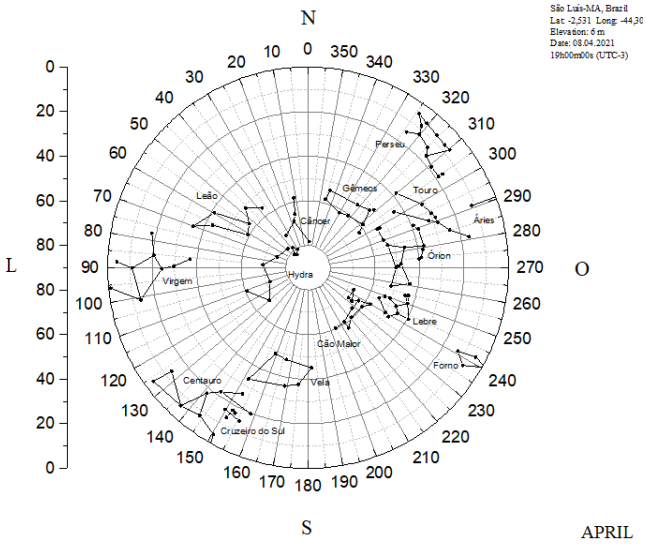
APPENDIX

CELESTE LETTERS YEAR 2022 FROM THE CITY OF SÃO LUÍS – MA – BRAZIL.

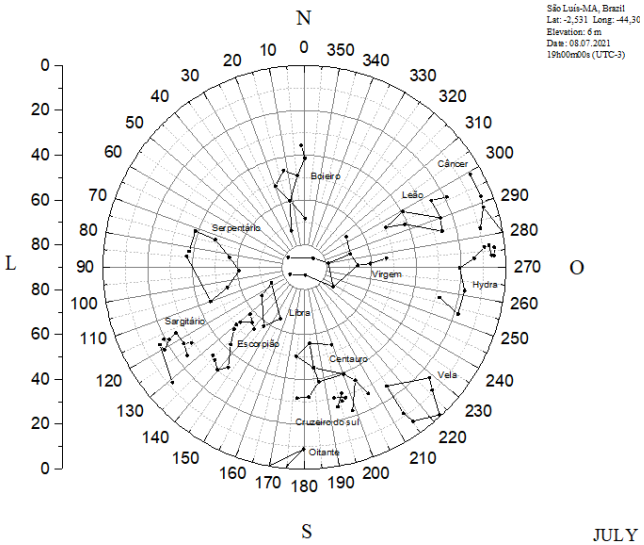




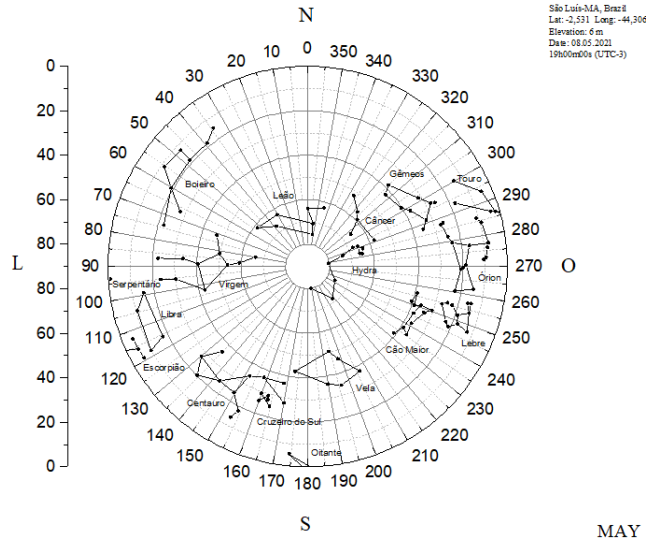




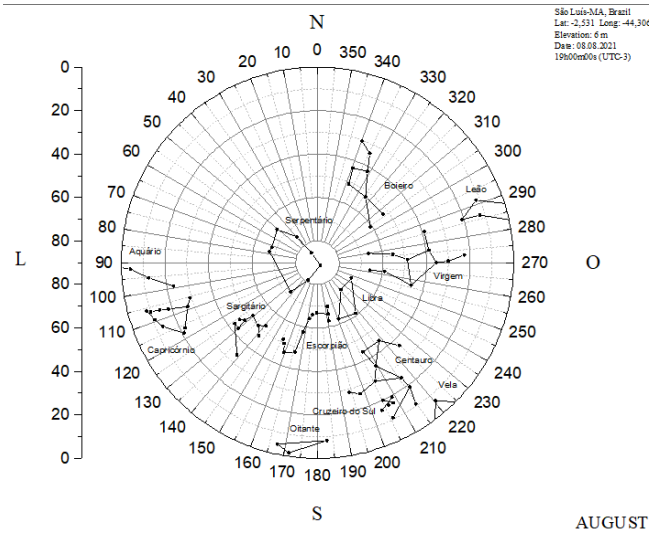
APRIL



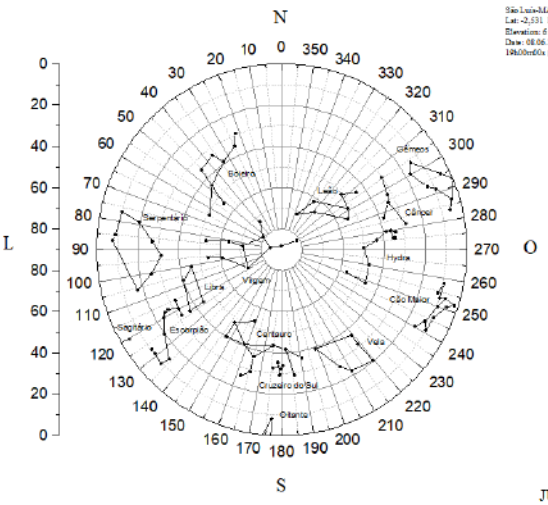
JULY



MAY



AUGUST



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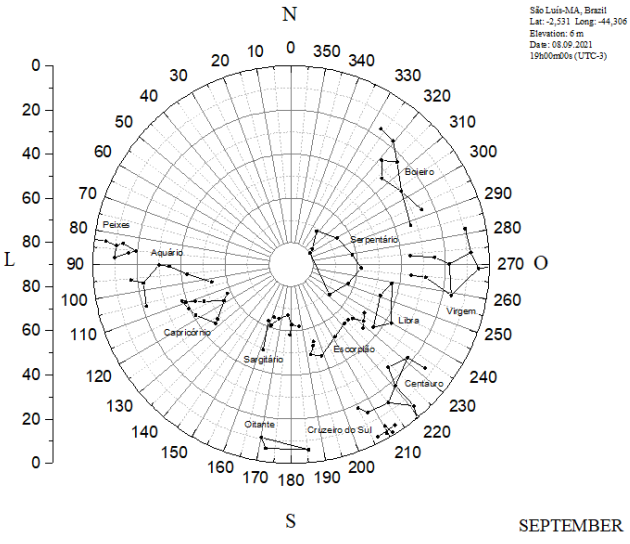
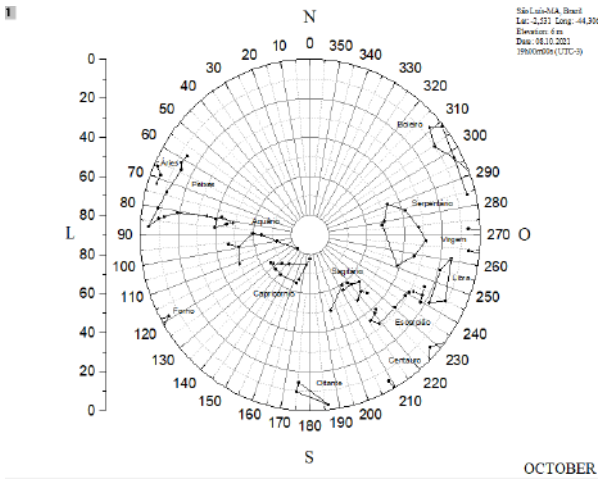
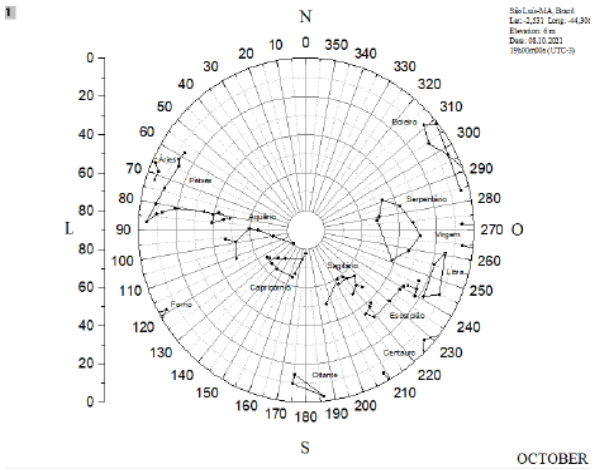
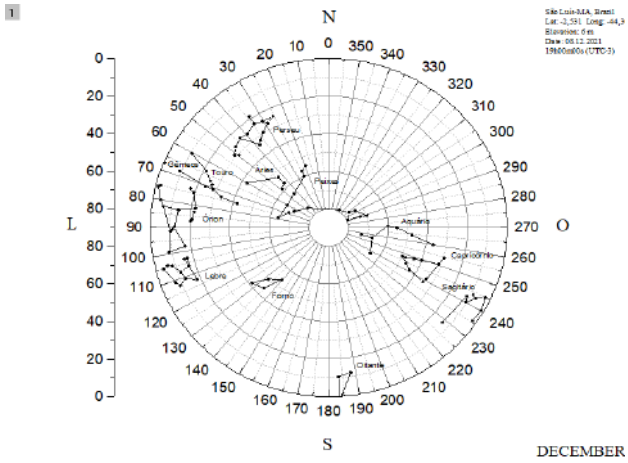


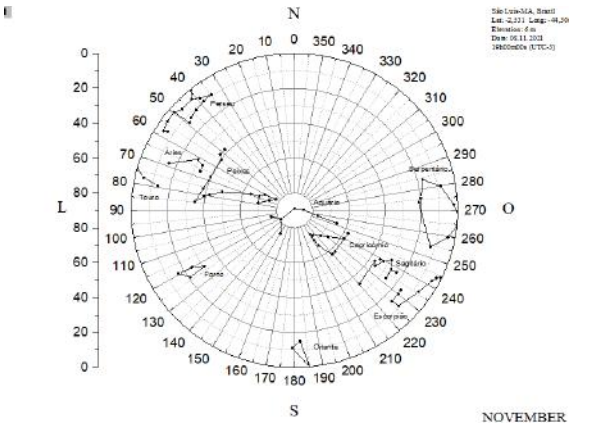
SEPTEMBER

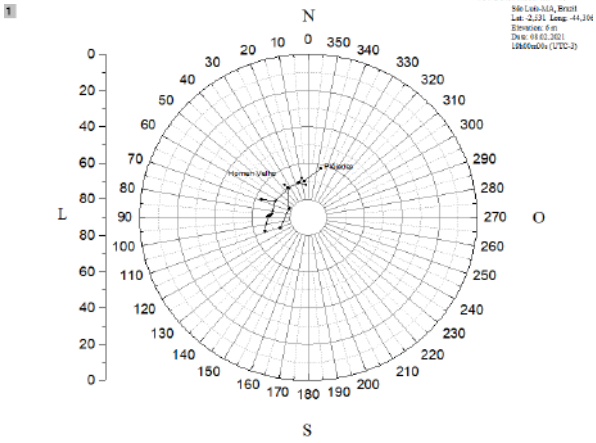






CELESTE INDIGENOUS CHARTS YEAR 2022 FROM THE CITY OF SÃO LUÍS – MA – BRAZIL. - OLD MAN COSTELLATION





The Celestial Chart was prepared containing the "Old Man Constellation", of the Indians Tupinambás of Maranhão. Only this constellation was built in this work due to the difficult construction of the other constellations because it is the union of different constellations, which makes its construction difficult. Therefore, it would be necessary to look for the right ascension (α) and declination (δ) of each star that made up this constellation, assemble the original constellation and, finally, visualize the connection that the corresponding stars made, to then build with the coordinates correct for each in the Origin.