Teaching of Astronomy and Teacher Training: disciplinary knowledges

Enseñanza de Astronomia y Formación de Profesores: Conocimientos disciplinares

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Abstract. Astronomy has always been present in humans' life and relates the most diverse topics, from religious practices, existential issues and agriculture, to technological development and creation of models about the functioning of the Universe. Its vast field of knowledge is notorious, and this characteristic makes Astronomy a theme of interest to be studied in Education. Astronomy is present in the documents that guide Brazilian Education, but even so, some studies indicate that the theme is almost not taught in the schools. The objective of this study was to discuss the cause of this problem with a focus on teacher training, based on the application of a questionnaire followed by an analysis of the teachers' knowledges. It was verified a poor knowledge about Astronomy by teachers and the absence of the theme in their training, despite a great interest for learning that they have shown.

Key words: Astronomy, Teaching, Teacher Training.

Resumen. La Astronomia siempre estuvo presente en la vida del ser humano relacionando los más diversos temas, desde práticas religiosas, indagaciones existenciales y agricultura, hasta el desarrollo tecnológico y creaciones de modelos acerca del funcionamento del Universo. Es notorio su vasto campo de conocimiento, y esa característica hace a la Astronomía um tema de interés a ser trabajado en la Educacíon. La Astronomía se muestra presente em los documentos que orientan la educación brasileña, pero aún así, algunos estudios apuntan que el tema es poco trabajado en la escuela. El objetivo de este estudio fue la discusión de la causa de este problema con enfoque en la formación de los professores, a partir de la aplicación de un cuestionario seguido de un análisis de los saberes docentes. Se verificó el poco conocimiento acerca de Astronomía por los professores y la ausencia del tema en su formación a pesar de un gran interés por el aprendizaje del tema apresentado por ellos.

Palabras clave: Astronomía, Enseñanza, Formación de Profesores.

INTRODUCTION:

Throughout humans' history, they have always sought answers to some issues about their existence: "Where did this world came from? [...] What does all this mean? " (Martins, 1994, p.4). For this, the sky that was observed by the ancients became object of questioning, which is evidenced in some cosmogonic myths (Martins, 1994).

The Astronomy has always aroused the human's curiosity to understand the different events observed in the sky. In this perspective, Mourão (1987) defines Astronomy as science of stars, objects and celestial phenomena,

however, these type of knowledge wasn´t always related to Astronomy, when "until the end of the seventeenth century, there wasn't semantic distinction between Astrology and Astronomy" (Mourão, 2003, p.15). Historically, the Astronomy has shown itself as a "the result of na impressive collective construction that has crossed continents and eras" (Longhini, 2010, p.9).

The first evidences of some astronomical knowledge, according to Ridpath (2007), were found in Egyptian pyramids dating from 2500 B.C., and Babylonian tablets dating from 700 B.C., both indicating ancient knowledge about planets and stars. The pyramids, for example, were built as tombs for the kings of the period, oriented with extreme precision to cardinal points (Spence, 2000). Barreto (2001) points, in contrast, that the first historical evidences about Astronomy were identified in rock engravings dating from, approximately, 4400 years ago, which describe the appearance of comets and meteors.

Both evidences mentioned above point out how old is the human fascination about subjects related to the sky, from its contemplative to the practical character, once that some ancient people used the knowledge about the position of some stars in order to identify, for example, seasons of the year to assist in their agricultural practices (Saraiva, 2014).

The knowledge about the stars also contributed to the development of methods of geospatial location that were mainly used in Portuguese navigations, which opened new ways to the scientific thinking (Bicalho, 1999). The practical character of astronomical knowledges was also evidenced by the Babylonians in their measurement of a year duration, which was divided in twelve months, and the sexagesimal conception of time, in which the hour was sixty minutes and the minutes were sixty seconds (Hallo, 1996).

Later in its historical development, the astronomical knowledge helped to formulate new models, laws and theories about, for example, the celestial bodies proposed by Aristotle, Ptolemy, Copernicus, Brahe, Kepler and Galileo (Ridpath, 2007). The improvement of some astronomical theories was largely attributed to the use of measurement instruments and observations that, with the advancement of technology, became increasingly effective, from the observational instruments made of wood used by Brahe, as well as the optical instruments of Galileo (Faria, 1987), to the instruments currently used, such the Hubble Space Telescope.

It is observed that Astronomy has in its development a causal relation with the Technology's development, and it is evidenced according to Ferreira e Voelzke (2012) in:

> "[...] experiments with rockets made at the beginning of the 20th century by the American Robert Hutchings Goodard (1882-1945), and especially during World War II with the German Werner Magnus Maximilian Von Braun (1912-1977), which has culminated in the development of aerospace technology and with the first human on the Moon, the astronaut Neil Alden Armstrong […]" (Ferreira; Voelzke, 2012 p.246)

In that context, as this historical discussion points out, Astronomy is understood as a human construct, and as "[...] an area of investigations that renews itself. Forcibly an interdisciplinary area by nature [...] it represents a new dialogue between ancient human" (Longhini, 2010, p.10). This interdisciplinary characteristic denotes the importance of Astronomy as a subject to be studied and taught, in consonance with what is recommended by the official documents that guide the Brazilian Basic Education.

TEACHING OF ASTRONOMY IN BRAZIL

Even with its importance highlighted by history, the insertion of Astronomy is still hardly noticed in Brazilian schools. To understand this scenario, it is necessary to know, in a succinct way, some pillars of Brazilian Education, in other words, how it was thought and structured.

The Brazilian Basic Education has as guiding documents the National Curricular Parameters (PCN) and the Supplementary Guidelines to National Curricular Parameters (PCN+) which are valid for the whole federal sphere, and serve as a basis for each state's curricular proposals. These documents support a "[...] a curriculum structured by competences, interdisciplinarity and contextualization" (Ricardo; Zylbersztajn, 2008, p.258).

The PCN structures the curriculum around these competencies that must be acquired by the students, and defines them as follows:

> "What competences are we talking about? The capacity of abstraction, the development of a systemic thinking, unlike the partial and fragmented understanding of phenomena, creativity, curiosity, the ability to think about multiple alternatives for solving a problem, i.e. the development of divergent thinking, ability to work as a team, willingness to seek and accept criticism, willingness to risk, development of critical thinking, communicating knowledge, ability to seek knowledge" (Brasil, 2000, p.11).

It is evidenced that the use of the term competence " [...] is a consequence of the need to overcome a teaching that, in the majority of cases, has been reduced to a memorized learning of knowledges [...]" (Zabala; Arnau, 2015, p.10), in other words, there is an opposition to the traditional content-based curriculum, since the skills rely on "[...] a contextualizing teaching, that forms a subject that is conscious of his own reality"(Oliveira; Langhi, 2011, p.2). However, it should be noted that the " competence and knowledge are not antagonistic, since any competent action always represents the use of knowledge interrelated to skills and attitudes" (Zabala; Arnau, 2015, p.11).

Once it is pointed out what are competences and their role, it remains to know how they should be promoted in the teaching-learning process. The PCN+ presents some guidelines on the subject, in its volume about Natural Sciences, Mathematics and its Technologies:

> "[...] the organization of learning would not be conducted by the teacher of each discipline in a solitary way, because the pedagogical choices made in one discipline would not be independent of the treatment that is given to the others, since it is an interdisciplinary action that articulates the work of the disciplines in order to promote competences" (Brasil, 2001, p.13).

In this perspective, it is verified, then, that the interdisciplinary action allows the promotion of competencies through the articulation of disciplines. Otherwise, some authors point out that this isn't the only thing that occurs, since that the " interdisciplinarity and contextualization are the guiding principles of a curriculum based on competences" (Ricardo; Zylbersztajn, 2008, p.271), where the "interdisciplinarity [...] proposes the examination of teaching objects in their real context, which brings it closer to the notion of contextualization [..] : the interdisciplinarity and the competences are born from the context" (Ricardo; Zylbersztajn, 2008, p.272).

Within this discussion, it is evidenced the fundamental role that context and interdisciplinarity play in this teaching-learning dynamic, where the close relation of both would provide a connection between content and competencies. Astronomy shows itself as an interesting subject to be studied, because it " is one of the areas of knowledge that allows not only the contextualization of concepts of Physics, but also the interdisciplinarity" (Oliveira; Langhi, 2011, p.2). In this context, Langhi (2009a), points out:

> " In the curricular structure of primary and secondary schools, Astronomy can be presented in the portuguese language, chemistry, physics, biology, mathematics, history, geography, arts and associated topics such as poetry, psychology, enviroment, archeology, geology, media and sociology" (Langhi, 2009a, p.19).

Due to this wide interface with several areas of knowledge, " [...] the contents can provide to students a less fragmented view of knowledge, thinking further, this discipline could act as an integrator of knowledge" (Dias; Rita, 2008, p.53).

With such contextualizing and interdisciplinary approach, Astronomy is present in the educational official documents as a subject of study in the Basic Education. It is suggested that Astronomy should be taught through two thematic axes: Earth and Universe in the third and fourth cycles, which correspond to the 5th to 8th grade, and the Universe, Earth and Life axis in High School (Dias; Rita, 2008).

It is important to note that besides being present in the notes of the guiding documents, Astronomy is taught in schools "[...] in a reduced way, and often even null" (Langhi, 2009b, p.163), and the "insufficiency of the teachers and students remains very large" (Bretones, 1999, p.5). Besides being an infrequent theme in Basic Education, when it is approached in the classroom, the theme is permeated by 'alternative conceptions' about astronomical concepts that are often based on conceptual errors present in didactic books that persist even with the evaluations carried out by Ministry of Education (Langhi; Nardi, 2005).

These factors make up the current panorama of Astronomy Teaching in Brazil. Some authors point out the need for a careful look at teacher training, since it is believed that such problems come from it (Albrecht, 2012; Albrecht; Voelzke, 2014; Aroca; Silva, 2011; Langhi; Nardi, 2005; Leite; Hosoume, 2007) .

In this context, the present research has sought to carry out the investigation with a group of teachers about the possible causes of the current panorama of the Teaching of Astronomy, also investigating the initial training of these teachers. From this perspective, it will be tried to summarize what such training means, and what is expected to be extracted from it.

TEACHER TRAINING

The principle of a teacher formation, or as it is commonly called, initial formation, can apparently be understood "as just the beginning of a professional career" (Langhi, 2009a, p.16). However, it is not only in his professional trajectory that the teacher acquires elements that influence his classroom performance, but in all his life trajectory (Langhi, 2009b), therefore it is much more than a vocational training, but a training in the social ambit.

It should be borne in mind the influential components of this life trajectory, such as his family, school, initial and post-initial training, which determine their sets of knowledge in all ambits (Langhi, 2009a). Tardif (2014) suggests a possible classification of such knowledge, and separates them into: disciplinary, curricular, professional and experiential knowledge.

The disciplinary knowledges are social defined, and they correspond to the different fields of knowledge, such as History, Mathematics and Geography, such knowledges are selected by university institutions, and they are structured as disciplines (Tardif, 2014). As for the professional knowledges are constituted by the set of knowledge transmitted by teacher-training institutions, which try to incorporate the aforementioned knowledges into the practice of teachers (Tardif, 2014).

In the course of this professional practice, the teacher must also appropriate another set of knowledges, known as curricular knowledges, which are presented in the form os school programs, i.e. objectives, contents and methods that the school institution uses to categorize and to present previously defined social knowledge as models (Tardif, 2014).

At last, in addition to the aforementioned knowledges, there are the experiential knowledges, which is acquired by the teacher in the exercise of his practice and in his daily life, these knowledges are composed of individual experiences, i.e., they can vary depending on the teacher (Tardif, 2014).

The present study aimed to analyze the reflex of the teachers' training through their disciplinary knowledge in order to understand how this corroborates with the current panorama of the Teaching of Astronomy, and how such knowledge was constituted.

METHODOLOGY

This study fits in the qualitative research presented by Lüdke and André (1986) which is based on obtaining descriptive data that are acquired in the direct contact of the researcher with his object of study in order to give more emphasis to the process than the product with the concern of portraying the perspective of the participants. The present study is part of a project titled 'Astronomy in the teacher training and in the Basic Education', which has as one of the objects the delineation of the current panorama of the Astronomy Teaching.

For this study, a questionnaire was applied to teachers who were participating in an extension course titled 'Concepts of Astronomy for Teachers of Basic Education'. The course was realized in the Federal University of ABC in the year 2017 and it had teachers from public and private schools as target group, as well as students of the undergraduate courses of the University, totaling 60 participants of different levels of Education.

The questionnaire was applied to 36 teachers present in the course, and it was divided in two parts, the first one referring to the profile, and the second referring to the teacher's knowledge. The participants took about 30 minutes to complete the questionnaire, and it was guaranteed the confidentiality of their identifications.

The 11 questions related to the profile aimed to characterize the participants through the identification of the aspects of their formation, performance and their relation with the theme Astronomy. The questions related to the profile are presented below:

Table I – Profile's Questions

Q1	What discipline do you teach?	**Q7**	Do you consider important work with Astronomy in a Basic Education's class? Describe it briefly.
Q2	What school do you work?	**Q8**	Have you ever studied Astronomy in your Basic Education? Describe it briefly.
Q3	How long have you been teaching?	**Q9**	Have you ever studied Astronomy in your graduation course? Describe it briefly.
Q4	What area did you graduate?	**Q10**	Have you ever worked with Astronomy in your class? If the answer is yes, write the name of the discipline.

Q5	When was your last update course?	**Q11**	Have you ever made any material related to Astronomy?
Q6	Have you already taken any training course in Astronomy? Describe it briefly		

Source: the author

The questions related to Astronomy aimed to investigate the participants' disciplinary knowledge in order to evaluate what they know about some basic topics of the theme.

Table 2 – Questions about the knowledges

Q12	What is Astronomy?	**Q16**	What is a comet?
Q13	What is a star?	**Q17**	Have you ever heard about solstice and equinox? How do you describe them?
Q14	Do you consider the Sun a star?	**Q18**	What do you think that explains the seasons?
Q15	Do you consider the Moon a star?		

Source: the author

After the questionnaire was applied, the teachers' answers were tabulated and analyzed. The analyzed answers were compared with the literature about the theme in order to extract new information and considerations to future studies.

RESULTS AND DISCUSSIONS

The analysis of the first part of the questionnaire provided a general characterization of the participants' profile. It was verified that 29 of 36 participants were working in Municipal Public Schools, and only 1 participant was also working in a Private School. It was noted that 32 participants were female, and have their teaching time between 0 and 16,6 years.

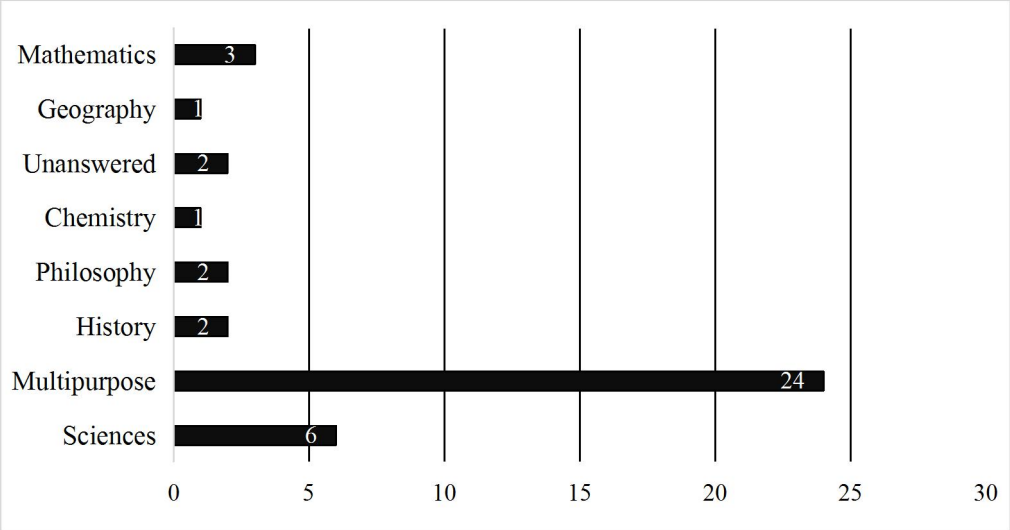

Fig 1 – Teaching Area
Source: the author

It was also observed a large predominance of participants who work in a multipurpose way, i.e. graduated in pedagogy that teach many disciplines, followed by those who teach Sciences with only 6 participants (Langhi; Nardi, 2009). It was noticed the presence of two participants who teach Philosophy, which reinforces the importance of Astronomy as a philosophical component, that can make the rescue of its historical roots possible.

The obtained answers pointed out, unanimously, the importance of working with Astronomy; even though most of the teachers have answered that they had almost no contact with the theme in the initial teacher training. The lack of contact with the subject in teacher training is also pointed out in other researches (Aroca; Silva, 2011; Bretones, 1999; Langhi; Nardi, 2009), and can lead to "teachers' inability to reach their own expectations and of their students" (Costa; Euzébio; Damasio, 2016, p.61).

Despite the lack of contact with the theme in their initial teacher training, 32 participants stated that they had already worked with Astronomy in their practices, mainly in science classes, and 25 participants indicated that they had already worked or made some material about the theme. In line with that, it was found that most of the participants took their last update course in 2016. In this context, these factors may represent a search for courses about Astronomy by the teachers, once they deem it important.

As for the questions about astronomical knowledge, it was pointed out several conceptual errors and little use of scientific language, which "[...] also show a teaching that is conducted by terms without scientific knowledge, impregnated with alternative conceptions, and sometimes fostering banal errors" (Costa; Euzébio; Damasio, 2016, p.60).

Among the errors that were found, the most recurrent were conceptual errors, lack of depth in sentences and incoherence in the presented definitions. Some of the conceptual errors were about the definitions of comet and star, where participants named it as 'rock', 'star with tail' and 'radiant light that moves'.

As for the stars, some participants have defined them as a 'point that shines in the sky' and 'a very bright light', definitions that are very similar to what is observed in the sky, so it is possible that these conceptions have derived from experiential knowledges. However, the presence of not so clear definitions of comets and stars, which often lead to confusion among them, are also found in didactic books (Canalle; Trevisan; Lattari, 1997).

Despite these presented definitions, the most recurrent answer about the star was that it is a 'celestial object that has its own light', such answer served as a justification for the answers of Q14 and Q15, where most participants pointed to the Sun as a star and not the Moon.

Another aspect that attracted attention was the succinct form of some answers, for example Q12, where most participants defined Astronomy only as 'study of the stars', which does not make clear what is their understanding about stars and it does not generate any significant data to this analysis.

As for Q18, most part of the participants' explanations was given very succinctly, referring only to the movement of the Earth and the Sun. The answers to Q17 were permeated by unfamiliarity about the asked topic, and often they were justified by conceptual errors. Such misconceptions about these topics are commonly found in didactic books as pointed out by Langhi and Nardi (2005).

CONCLUSIONS

It was verified a poor understanding by the participants regarding their disciplinary knowledges about Astronomy, since many misconceptions or incomplete conceptions were found in their answers about the basic topics the theme. Some references, presented in the discussion, point out that this may be due to a fragile initial training, the timid insertion of the theme into post-initial training courses and the presence of conceptual errors in didactic books.

For the improvement of the current panorama of the Teaching of Astronomy, two points were highlighted. The first one regard to post-initial training courses, which should be promoted in greater quantity, focusing on concepts and methodological referrals, since the teachers had little contact in their initial training.

The second point of great importance is to stimulate a more attentive study of the teachers' initial training from the point of view of Astronomy, mainly in the area of Sciences, in order to study with greater depth the causes of the little development of the disciplinary knowledges about the theme. Such study can help in the proposition of new paths to be followed in order to change the current panorama of the Teaching of Astronomy in Basic Education.

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