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THE TRANSDISCIPLINARY NATURE OF ASTROBIOLOGY AS A TRANSVERSAL AXIS OF THE EDUCATIONAL PROCESSES AT THE PLANETARIUM OF BOGOTA

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RESUMEN

Abordar las preguntas fundamentales de la astrobiología requiere de una interacción de diferentes áreas del conocimiento, las cuales se integran e incluso sobrepasan los límites entre estas, dando a la astrobiología una naturaleza interdisciplinar y transdisciplinar. Esto puede constituirse en una fortaleza para el trabajo de educación en ciencias, tecnología y arte, que permite desarrollar comprensiones en el contexto de problemas reales y llevarlo a desempeños auténticos. Por su parte, el Planetario de Bogotá como escenario de educación no formal, brinda espacios que permiten el diálogo entre diferentes campos disciplinares, articulando estos con diferentes públicos y sus contextos. Dentro del quehacer de esta institución se plantean múltiples proyectos educativos que incorporan diversos enfoques que confluyen a través de la astrobiología como eje transversal, siendo esto una de las apuestas pedagógicas a desarrollar dentro del plan educativo de este escenario de la capital de Colombia.

ABSTRACT

Addressing fundamental questions in astrobiology requires interaction from different areas of knowledge, which integrate and even exceed the limits between them, giving astrobiology an interdisciplinary and transdisciplinary nature. This characteristic can become a strength for education in science, technology, and arts, in a context that deals with real problems where authentic performances are needed. The Planetarium of Bogota, can be visualized as a place for non-formal education, but that provides spaces that facilitate a dialogue between different disciplinary fields, articulating them with different audiences and their contexts. Within the work of this institution, multiple educational projects are proposed that incorporate various approaches that converge through astrobiology as a transversal axis, this being one of the pedagogical bets to be developed within the educational plan of this scenario in the capital of Colombia.

Key Words: astronomy — constructivism — education — natural sciences — science center

1. INTRODUCTION

The Planetarium of Bogota is a setting integrated into the Instituto Distrital de las Artes (IDARTES) of the Secretariat of Culture, Recreation, and Sports of the Mayor's Office of Bogota, which seeks to guarantee the exercise of cultural rights through the social appropriation of scientific knowledge. Likewise, it is a science center recognized by the Ministry of Science, Technology, and Innovation (MinCiencias), where the possibility of intentional processes for understanding science, technology, and society is opened (Planetario de Bogotá 2019).

On the other hand, this scenario has an education team whose objective is the construction of understandings in the face of scientific thought. In this sense, the work is proposed from a constructivist perspective that allows starting from the contexts of different audiences. In the constant interaction with communities, dialogues are developed that lead to understandings from the different disciplinary views that converge in the Planetarium, making a transdisciplinary view of the pedagogical processes necessary. Within the modalities of knowledge integration, transdisciplinarity establishes an interrelation and interconnection between the parts that generate comprehension, understanding, and deepening, thus allowing to address complex problems of today's world (Delgado 2009). Related to this and understanding that in order to achieve the educational objectives of the Planetarium, contextualizations of time and place are carried out, the current space missions with their scientific objectives that include

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the evaluation of places in the Universe that could facilitate (or could have facilitated) the emergence of life in other places than Earth, offers a current contextual framework for complex problems such as the search for life in the Universe, being this one of the fundamental questions in astrobiology.

In addition, it is necessary to consider that problems in astrobiology are so complex that the only way to approach them is from a transdisciplinary perspective (Santos et al. 2016). Considering this and the need to have a disciplinary axis of work that allows the construction of understandings in the Planetarium of Bogota, astrobiology becomes one of the best disciplinary fields to be used transversally in the educational aspects of this scenario. that allows an organic transdisciplinary work. Thus, during the tours by the museum exhibition halls, the interest in astronomy topics by the students from the district schools, and from the Planetarium program for teachers, astrobiology allows the integration of concepts typical of the natural sciences. The different arguments that support the educational proposal of the Planetarium of Bogota with astrobiology as a transversal axis, the opportunities in pedagogical research, and the educational challenges for the coming years are exposed.

2. TRANSDISCIPLINARITY OF ASTROBIOLOGY

Since the beginning of human thought itself, the human being has wondered about the cosmos and has tried to find the origin of its existence (Leal et al. 2015) (Chela-Flores 2001). In addition, humanity has questioned its solitude in a vast universe, being Giordano Bruno (1548-1600) one of the primary historical references who also published texts about how the Universe could be full of life (Crowe & Dowd 2013). However, it was not until 1953 that Gavriil Adrianovich Tikhov proposed the term Astrobiology for first time in the academic field (Tikhov 1953). On the other hand, the term astrobiology has not been the only one used to refer to the possibilities of life in the Universe, even beyond our planet. Other terms include exobiology, bioastronomy, and cosmobiology, each one having its etymological and application (Brack 2012).

As far as research in astrobiology is concerned, in order to approach its research problems, it is necessary to raise questions about the emergence of life on Earth, its evolution, the geological environments in which it can develop, the bodies of the Solar System or outside of it in which it would be possible to find living beings, among many others (Fairen 2003; Pizzarello 2007; Brack 2012; Blaustein 2015; Vera 2019). In order to orientate research towards common objectives, various strategies and programs have been proposed to define work routes and research priorities, such as Nasa Astrobiology Roadmap (Des Marais et al. 2008), Astrobiology Strategy (NASA 2015) and the European Astrobiology Roadmap (Horneck et al. 2016).

This integration cannot happen in a random way, thus raising the need for multidisciplinarity (Des Marais et al. 2008), which can cause the different disciplines not to interact towards the same objectives or fail to recognize the role of each. One of them is simply the sum of the individual disciplines (Unesco 1998; Santos et al. 2016). For its part, an interdisciplinary interaction, which has been widely used to refer to astrobiology, seeks to nurture the discipline itself with integration, which can lead to reductionism or hyper-specialization that finally solves problems of the discipline but not those that belong to Astrobiology (Chon 2015). One of the risks derived from this interdisciplinary work that is evident to a great extent in Latin America, where Astrobiology is still unknown to many scientists who do not work in it, is reaching the level of reduction to the point of thinking that Astrobiology is a subdiscipline, for example, from biology or astronomy. This approach is impossible since the research problems are on a scale that requires integration between disciplines.

Thus, transdisciplinarity emerges as the best alternative for integration between disciplines since it transcends borders and provides a higher level of understanding developed without bridges and fixed limits between disciplines. This property is similar to what happens in the natural world between the interaction of biology, chemistry, or physics in a living organism: the limits are diffuse, and we could even say that they are unnecessary (Santos et al. 2016). If this model is presented by one of the objects of study of astrobiology, why not extrapolate the interactions that we already know to the levels of integration between the disciplines and the scientists who address their study?

It is also necessary to reinforce that within the disciplines around astrobiology; natural sciences must converge as well as social sciences, engineering, the arts, human sciences, political sciences, and medical sciences. It may seem that everything can be included in astrobiology, and if life is conceived within the object of study, the question arises: Shouldn't it be included in all levels of organization that we know? If so, then the disciplines that allow us to understand human life should also be included. On

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the other hand, astrobiology also approaches problems such as the conception of the human species as an interplanetary species and the implicit challenges to said condition. So, problems such as the human physiological adaptation to new conditions, the legislation of space, the social implications of finding life beyond our planet must undoubtedly be addressed (Dick 2013; Taskin & Aydinoglu 2015).

3. EDUCATION AND SCIENCE CENTERS

Science education in Bogota city responds to current legislation, based on three significant commitments: basic competency standards (MEN 2006), fundamental learning rights (SED 2014) and competencies for the 21st century (DiCerbo 2014). On the other hand, science education is developed differently between private and public institutions, one of the main differences being the number of students who are impacted. This difference made that the Secretary of Education of the District (SED) proposed some guidelines that allow improving the educational quality in public district institutions, expanding the academic day and generating extended days, which are developed with the support of allies under agreements institutional inter-administrative processes, which allows generating new forms of pedagogical work (SED 2017a).

However, beyond legislation and public initiatives, the way science is approached in the classroom remains the total responsibility of the creativity and resources of teachers, who in some cases do not have the best available elements or go beyond the classroom boundaries. Thus, unconventional spaces for learning constitute fundamental support as a co-builder of educational processes in science, understanding these unconventional spaces as informal settings (libraries, museums, planetariums) (Fujimoto 2016). On the other hand, within the formal setting, we also find the Institutions of Higher Education, which, in general, develop three main objectives: education, research, and extension (social projection); being the non-conventional spaces for learning potential allies of the three proposed objectives (Camilloni et al. 2013).

In terms of educational processes, one of the most significant current challenges is the integration of different disciplines as well as responding to real contextualized problems, which lead to the development of authentic performances (Ordoñez 2010). In the case of the natural and exact sciences, the challenge is even more significant, especially in countries where these subjects are not part of the economic engines. This problem generates an even greater gap between educational processes and the natural world where the usefulness of this knowledge is not evident. Thus, non-conventional spaces for learning constitute a fundamental ally that allows to recognize and generate connections between the pedagogical and science work in the context. Science Centers stand out within the different non-conventional spaces that can strengthen formal educational science processes. In the case of Colombia, today's Minciencias recognizes and certifies Science Centers according to their mission and trajectory. These Science Centers correspond to institutions with a physical plant permanently open to the public and that have the social appropriation of science, technology, and innovation (ASCTI) as a fundamental part of their mission. As part of this ASCTI, relations of understanding and dialogue are woven between science, technology, and society, generating joint constructions that can lead to the generation of knowledge (Colciencias 2015).

Therefore, it is worth mentioning that Planetarium of Bogota was recognized as a Science Center in 2018, since it is an institution that offers visitors scientific experiences. In addition, it allows playful interactions, interactive explorations, and pedagogical alternatives to experience knowledge on space science topics (Colciencias 2018a; Colciencias 2018b). Additionally, the Planetarium of Bogota is also a stage for the Instituto Distrital de las Artes (IDARTES), which seeks to guarantee the whole exercise and enjoyment of cultural rights by citizens, bringing artistic practices and the experience of its different dimensions closer to people's daily lives. This objective is achieved by executing public policies, projects, plans, and programs that contribute to constructing a new social contract that contributes to the development of people as creative, sensitive, supportive, and co-responsible beings with the other living beings that surround them (Planetario de Bogotá 2019).

4. CHALLENGES AND EDUCATIONAL OPPORTUNITIES OF THE PLANETARIUM OF BOGOTA

As has been evidenced, the Planetarium of Bogota has a mission aligned with the educational and informative processes in science and arts and a physical plant that supports these activities. To achieve these mission objectives, in 2020 two large teams were consolidated within the scenario: public outreach and education. In the case of the education team of the Planetarium of Bogota, the following purposes were proposed to be developed during a 3-year plan: 1) foster spaces for dialogue, construction, and generation of new knowledge between art,

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science and technology, 2) demonstrate how scientific thinking has practical relevance and interference in daily decisions, 3) generate projects, spaces, and strategies that are conducive to the inclusion of all types of audiences, 4) relate cultural knowledge with the disciplinary knowledge of the exact and natural sciences, 5) provide a satisfying, memorable experience that fosters processes of understanding and construction of knowledge in science, art, and technology in all audiences of the Planetarium, 6) redefine the educational processes that occur in the Planetarium of Bogota, promoting active pedagogies, where the public is the leading actor in the construction of their knowledge and experiences, 7) promote reading as a critical tool in the learning processes of the public of the Planetarium of Bogota, 8) strengthen the team of the Planetarium of Bogota in the new dynamics as a Science Center, seeking disciplinary, pedagogical and process updating of research, 9) support educational processes in school spaces and 10) promote habits and spaces for reading, ideation and writing with the team of the Planetarium of Bogota.

For the development of these purposes, the Planetarium of Bogota has been leveraged based on its projects such as the Planetarium for teachers, courses for all audiences, spaces for team building, and activities with people with functional diversity. In addition, it has managed various alliances that allow it to become an ally of formal education processes, such as the inter-administrative agreement 001-2017 with the Universidad Pedagógica Nacional, the inter-administrative agreement 2412-2020 with the Universidad Nacional de Colombia Grupo de Ciencias Planetarias y Astrobiología GCPA, the inter-administrative agreement 2397115 of 2021 with the Secretaría de Educación del Distrito and the inter-administrative agreement 1445-2021 with the Universidad Distrital Francisco José de Caldas. Likewise, it has advanced in the pedagogical model for the Planetarium of Bogota, which is contextualized to the reality of the scenario and responds to its needs. Regarding its pedagogical model, the Planetarium of Bogota, recognizing its audiences and the problems of current education, has raised the need to take a constructivist model, in such a way that the principles of identity can become a reality: 1) recognize the difference, 2) discuss cultural knowledge about the cosmos, 3) seek for the visitor to live a meaningful experience, 4) build understandings and not certainties and 5) everyone is part of the experience (Leal 2021).

However, a question arises: how to decant this constructivist view into concrete actions? For this, the appropriation of various approaches has been used, which, when integrated, give foundation to the pedagogy of the Planetarium of Bogota. The first of these corresponds to the approach defined as interdisciplinary STEM (Science-Technology-Engineering-Mathematics), which integrates all areas of the curriculum into its activities and connects them with authentic experiences relevant to the student (Comer et al. 2013)). Additionally, within the framework of this approach and based on other integrations with STEM, such as Art (Katz-Buonincontro 2018; Marmon 2019). In the case of the Planetarium of Bogota, it is necessary to talk about STEM+A since its institutionality and mission directly involve Art (Planetario de Bogotá 2019). However, the scenario proposal considers the reflections made by leading institutions in STEM education, such as Siemens-Stiftung, which appropriate Inquiry-based learning to improve the STEM approach and increase interest in science and technology as it promotes the application of knowledge, the development of critical thinking, and the generation of new ideas (Siemens-Stiftung 2021). Inquiry-based learning is based on asking questions that are based on the interest of the person who asks them to approach or delve into a topic, improving how questions are posed and in this way proposing methods that allow us to approach the answer (Pedaste et al. 2015; Murphy et al. 2021).

The second approach is the Universal Design Learning, which seeks to generate pedagogical plans that are so flexible that they allow the most significant number of people (Díez & Sánchez 2015; Espada et al. 2016). For its part, the differential approach seeks to give access to all human beings, eliminating any barrier that may exist to appropriate and generate knowledge (Vásquez & Cifuentes 2021). These two approaches are intertwined to respond to the attention of diverse audiences and align the Planetarium of Bogota, as a public setting, with the policies and goals of the city of Bogota, allowing access to all its citizens. A third approach that should be considered is Visible Thought, which tries to highlight the constructions that a person develops in their comprehension processes, externalizing these and strengthening their learning to the extent that they share and interact with others (Ritchhart & Church 2020). This perspective responds directly to the principles of the Planetarium of Bogota, dialoguing, building experiences, and recognizing the difference. The last approach responds to research, carrying out studies that allow us to reflect on the pedagogical work of the Science Centers and provide

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feedback on the day-to-day work of the Planetarium of Bogota, to the extent that as a Science Center, it articulates the knowledge and interactions to generate new knowledge.

5. ASTROBIOLOGY AS A TRANSVERSAL AXIS IN THE PLANETARIUM OF BOGOTA

In such a diverse scenario with broad pedagogical commitments and great potential, astrobiology constitutes a transversal axis that will allow all these elements to be effectively articulated. This premise is based on the transdisciplinary nature of astrobiology, which allows structuring all the areas that correspond to the Planetarium of Bogota around the resolution of problems and striking questions for the public. This answers to the identity principles of the scenario and to generating contextualized constructions in natural environments that lead them to the development of authentic performances and thus speak of objectives achieved in terms of ASCTI.

From a work perspective in the short and medium-term, four great work routes have been proposed where astrobiology is constituted in the transversal axis, which will allow evaluating the effectiveness of its transdisciplinary character in educational activities. The first bet corresponds to the cooperation with Grupo de Ciencias Planetarias y Astrobiología (GCPA) of the Universidad Nacional de Colombia for the work with teachers, workers of the Planetarium of Bogota, and some of its audiences, seeking to a great extent the disciplinary and investigative strengthening of the scenario and the pedagogical strengthening of the group. A second bet corresponds to the articulation with the Secretaría de Educación del Distrito to execute the Centers of Interest in Astronomy, where the conversations, experiences, and constructions will revolve around astrobiology. As a third bet, it is proposed to incorporate reflections on some central astrobiology issues in the framework of teaching practices with the Universidad Pedagógica Nacional and the Universidad Distrital Francisco José de Caldas. Finally, the bet regarding the intervention of the physical plant, seeking to renew the museum's exhibition rooms, where astrobiology will be the generator of conversations.

Thus, the incorporation of astrobiology as an integrator of disciplines and educational processes in the short and medium-term is proposed, for which the reflections and feedbacks that take place over time will be supplied, thus allowing the experience of the Planetarium of Bogota serves as an experience for other spaces of social appropriation of knowledge both in the country and in Latin America.

6. CONCLUSIONS

Approaching the fundamental problems in astrobiology from a single perspective can become simplistic, thus limiting the exploration of possible solutions to these problems. Therefore, in astrobiology, given its nature of inquiry and the need to address problems related to the emergence of life on Earth and the search for it in the Universe, requires various areas of knowledge. Therefore, transdisciplinarity is inherent to astrobiology and its research questions. This characteristic of astrobiology contributes significantly to the elaboration of comprehensive educational plans that favor science teaching and interaction between different types of audiences, with the Planetarium of Bogota being the place for propitious experimentation of astrobiology as a transversal axis. In the short and medium-term, that, together with constructivism, contributes to the teaching of natural sciences in unconventional spaces.

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