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Families Visit the Museum: A Study on Family Interactions and Conversations at the Museum of the Universe – Rio de Janeiro (Brazil)

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In this quantitative and qualitative study, we present our analysis on the interactions and conversations of ten families during a visit to the Museum of the Universe, at the Planetarium Foundation of the City of Rio de Janeiro (Brazil). The study of conversations provides a considerable opportunity to address gaps in our current understanding on how families interact and learn in museum environments. The visits were recorded using a subjective camera, and the audiovisual material was analyzed based on a research protocol that combines theoretical and empirical aspects of the visitors' museum experience. We identified that most of the interactions during the visit occurred between family members and between them and the exhibition, through interactive activities and moments of contemplation. Parents/caregivers played an important role in maximizing the children's learning opportunities as they interacted and talked about the exhibits. The conversations were related to science topics, especially astronomy, as well as aspects on how to operate the exhibition modules. The results suggest that the Museum of the Universe has become a platform for families to share experiences, discuss and develop specific ideas, knowledge and concepts about astronomy, enriching the group members' awareness.

Keywords: science museums, informal education, family interactions, conversations, astronomy

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INTRODUCTION

Visits to science museums are highly complex and potentially rich experiences to study family interactions, actions, conversations and learning (Callanan, 2012; Haden et al., 2014; Shaby et al., 2019). Many of the phenomena, activities and skills related to science learning are observable interactions in museum spaces, such as identification, designation, observation, comparison, generalization, analysis, scientific reasoning, abstraction, peer collaboration, conceptual change, motivation, engagement, identity and metacognition (Allen and Gutwill 2016). In this regard, investigations into the variety of cognitive and social interactions between visitors, between a visitor and an activity, object or experience in science museums are highly revealing about the learning process of families (Davidsson and Jakobsson, 2012; Shaby et al., 2019).

Family learning in a museum is a social and collaborative activity, in which the group works together to build a meaningful experience, learn from each other and develop knowledge while interacting and engaging in a dialogic exchange (Ash, 2003; Ellenbogen et al., 2004). Falk and Dierking (2002) emphasize that the interactive experience in the museum is influenced by three contexts: sociocultural (visitors museum experiences), physical (architecture and organization provided by the museum space) and personal (motivation and expectation, knowledge, experience, beliefs, past interests).

Dierking et al. (2001) define family learning as the process that incorporates social ties and the family's experience with objects, ideas and situations, in essence, the family narrative. As this definition suggests, based on a sociocultural perspective, the developed museum experience is connected to the visitor's life experiences (Almeida and Martínez, 2014). Research investigations with this focus has directed studies of the area beyond what visitors learn from a museum visit and have expanded the investigations to understand what visitors actually do during the visit, examining the visitors' interactions with each other, with the team and exhibitions (Davidsson and Jakobsson, 2012).

According to Ash et al. (2012), interaction is an important part of the museum experience and is fundamental to describe and identify consistencies in how visitors use and engage with the resources of their complex social and material world that integrates actors and objects. In the present article, we understand that interaction comprises human activities, including non-verbal interactions and the relationships established between visitors of the same group, between visitors and the museum staff and between visitors and the exhibition (objects, exhibition modules and themes covered) (Davidsson and Jakobsson, 2012; Massarani et al., 2019c; Shaby et al., 2019).

Family interactions in museums provide evidence about the wide range of personal and cooperative learning strategies (Ellenbogen et al., 2004). Some authors are devoted to investigating the visitors' engagement and learning in museums quantifying their length of stay in the exhibition modules and frequency of physical and verbal behaviors (Block et al., 2015). Others, like Brown (1995), show that parents can take a passive role - monitoring children while interacting, or active - engaging the children in the themes of the exhibitions. Szechter and Carey (2009) demonstrate that it is the children who choose the exhibitions for their families and who most control the interactive devices. Researchers like Riedinger (2012), Zimmerman et al. (2010) also explain that parents tend to significantly influence how children interact with exhibitions and what they learn during visits.

Recent studies have placed considerable focus on the study of conversations in order to better understand family learning. Conversation stimulates thinking and, whether developed with other people or with yourself, it is an essential process in the acquisition of new knowledge and in the expression of feelings (Wagensberg, 2005). As a result, some aspects of the visits have been highlighted, such as which elements of a science exhibition stimulate conversations and how families make connections with scientific content (Allen, 2002; Haden et al., 2014; Callanan et al., 2017); the role of explanation and scientific reasoning in conversations between parent-child (Crowley et al., 2001; Tare et al., 2011) and how families make sense of science-related experiences through conversations about exhibitions and expository modules (Benjamin et al., 2010; Zimmerman et al., 2010; Jant et al., 2014).

For example, Tare et al. (2011) investigated how parents support their school-age children's learning–seven to 12 years old–during a visit to the Explore Evolution exhibition at the Natural History Museum in the Midwest (Illinois, United States). The conversations of 12 families were transcribed and classified into different codes, divided into two main blocks: 1) evolutionary reasoning and intuitive reasoning, and 2) types of conversations. As a result, the authors indicate that parents provided great support for their children's learning about the science process and scientific content, since the expressiveness of the most frequent explanatory codes was to describe scientific evidence (37.3%), ask factual questions (14.2%) and provide causal explanations (13.9%). Most of the conversations about evolution were provided by the text of the exhibition (12.8%), suggesting that the available texts are an important source of information for families. The study also provides evidence that the parents' conversation style is reflected in the children's words. The greater the frequency of explanations and the use of evolutionary terms expressed by adults, the greater the presence of explanatory conversations and the use of terms in the children's words, which indicates the occurrence of a dialogic exchange between parents-children.

Another study example on conversations relevant to science learning was carried out by Callanan et al. (2017) with 82 families, which included children between three and 11 years old during a visit to the Mammoth Discovery Exhibition regarding mammoth bones at the Children's Discovery Museum in San José (California, United States). The authors investigated three main issues: 1) the types of language parents use to involve and promote the construction of meaning in children regarding the exhibition; 2) how an activity individually prepared for the parents changes their language with the children at the exhibitions, and 3) how the conversations of parents-children are developed, comparing different proposals of the exhibition–authentic fossils, replicas of bones and interactive activities with replicas of bones. The results suggest that parents use different types of conversations and the difference is related to the nature of the exhibition, and in that study the interactive activities were more stimulating for science conversations and for the construction of meaning. Comparing the groups of parents who received guidance to establish a focused discussion compared to those who did not receive such guidance, the authors point out that the children's conversations were more engaged in the first groups, given the parents' frequency of critical thinking questions. However, the authors caution that questions can encourage children to engage, however providing explanations can reduce an engaged conversation. They also bring evidence that conversations with personal connections may be more important for the children's involvement and understanding than the parents' scientific

explanatory conversation, behavior that was more strongly related to the parents who were not prepared to initiate conversations with the children. This result is consistent with the work of Benjamin et al. (2010), Jant et al. (2014), which show important associations between personal conversations and children's learning.

Similarly, Zimmerman et al. (2010), who accompanied 15 families visiting the Pacific Science Center in Seattle (Washington, United States) through ethnographic and analytical discourse methods, concluded that the parents showed the children how to use evidence, directed the children's attention to relevant aspects of the exhibition and provided connections with previous knowledge and experience. Family members used their previous knowledge and experience to make sense of the material presented at the exhibition through strategies such as shared memories, storytelling and jokes and the use of analogies. These strategies helped parents to develop children's learning during the museum visit.

In summary, these studies reinforce that families shared knowledge, experiences, beliefs and values that influence the museum experience (Falk and Dierking, 2000; Ellenbogen et al., 2002). They demonstrate that, on a visit to the science museum, family members talk about topics that are relevant to their new and shared learning experiences. This is because during the visit to exhibitions, the conversations are part of a process, which may have started at an earlier time, restarted at the exhibition and could possibly be incorporated in future conversations (Crowley and Jacobs, 2002; Ellenbogen et al., 2002). In addition, the questions and explanations seem to influence how parents-children engage with the exhibition and get involved with the content.

Taken together, these and other studies provide valuable information, but also point to an important gap in the area: the need for more detailed studies on conversations and interactions during family visits to science museums from a Latin American perspective, since most of them took place in North America and Europe. With few exceptions, some investigations have explored family learning experiences from the perspective of socio-cultural theory (e.g., Bizerra, 2009; Briseño-Garzón and Anderson 2012; Rufato and Bizerra, 2014; Cerqueira et al., 2017; Scalfi, 2020). Another gap in the international literature, and particularly in the Brazilian literature, is the interaction of families with astronomy themes in places such as museums, planetariums and astronomical observatories. Astronomy is a science that affects the imagination of children and adults, showing great potential to arouse interest in science (Falcão et al., 2013). However, notwithstanding the consolidated literature on these sites as environments for teaching astronomy, especially for school groups and focused on formal education (e.g., Rusk, 2003; Langhi and Nardi, 2012; Almeida et al., 2017), thus far, there are few studies on how family learning ensues.

Based on the above, in this study, our objective is to understand the learning experience of families visiting a science museum that focuses on astronomy, highlighting the types of interaction and the conversational contents. This study collaborates to understand the family learning in non-formal education environments in the Brazilian context, providing support to expand and deepen the growing literature on families' interactions and conversations regarding practical learning experiences in science museums.

METHODOLOGY

To meet the proposed objective, an exploratory study using quantitative and qualitative methodological approach was carried out to study family interactions during a spontaneous visit to the Museum of the Universe, at the Planetarium Foundation of the City of Rio de Janeiro (Brazil). The methodology employed has been used to develop research in the field of education in museums, as well as by the research group, based on this study, which aims to understand the processes of the experience of visitors to science museums (Massarani et al., 2019a; Massarani et al., 2019b; Massarani et al., 2019c). This study was approved by the Ethics Committee of the Oswaldo Cruz Foundation (CAAE 10663419.0.0000.5241). All participants consented to their participation through the free and informed consent term, which had information about the research procedures and objectives.

Study Location

The Museum of the Universe is located in the Gávea neighborhood, in Rio de Janeiro (Brazil), and receives audiences from different regions of the city and the state. The mission of the museum is to communicate astronomy and related sciences, integrating science, education and culture through an innovative approach, receiving an average of 267,000 visitors per year.

The Museum of the Universe, which is integrated into the structure of the Planetarium, consists of three floors. The first floor comprises the long-term exhibition, which has several expository, interactive modules, with multimedia resources, models, immersive experiences, divided into five areas: "The Earth in Movement" ("*A Terra em Movimento*"), "What Time Is It?" ("*Que Horas São?*"), "Astronomy Yesterday and Today," ("*Astronomia Ontem e Hoje*"), "We and the Universe" ("*Nós e o Universo*") and "School Spaceship." ("*Nave Escola*"). The second and third floors are for short-term exhibitions that during data collection were: "A giant leap: the journey to the Moon" and "The dazzling Universe" (**Table 1**). The first commemorated the 50th anniversary of man's first landing on the Moon, the second honored the 50th anniversary of the European Southern Observatory (Fundação Planetário, 2020). During the research period, the exhibitions did not have museum educators to serve the public.

Procedures and Participants

In this study, a family is understood as a group of individuals biologically related or who considered themselves as a family by affective ties (Briseño-Garzón and Anderson, 2012). The family groups consisted of up to six people and with at least one child

TABLE 1 | Themes covered in the exhibitions of the Museum of the Universe.

Location/Thematic area	Description
1st floor - long-term exhibition	
"The earth in motion"	It introduces the concepts related to the phases of the moon, eclipses, seasons, apparent movement of the sun and tides.
"What time is it?"	It brings astronomical information to discover the location of a point on the surface of planet earth, measurement of time and time zones.
"Astronomy yesterday and today"	In a timeline, it addresses the history of astronomy and the contribution of astronomers, physicists and mathematicians to the area.
"We and the universe"	It introduces concepts of cosmology such as geocentrism and heliocentrism.
"School spaceship"	An installation set as a spaceship that suggests a journey through the universe addressing topics such as the solar system, space research and the evolution of life.
2nd floor - short-term exhibition	
"A giant leap: the journey to the moon"	It features panels and videos about the space race and the apollo program.
3rd floor - short-term exhibition	
"The dazzling universe"	It highlights 38 photographs that illustrate space discoveries and the equipment that enabled expanding astronomical knowledge.

between five and nine years old. The criteria used was designed to optimize the recording with sufficient audiovisual data quality in the interactive process and enable conversations with the children. In this study, the children's age range is representative of childhood, encompassing preschool and school-age children, in order to capture the internal logic of the psychic development process (Elkonin D. B., 1960). It is after preschool age that a child is able to share his impressions with adults, adopting coherent and explanatory language and, at school age, this language is more cognizant and intentional and mental operations are improved (Elkonin D., 1960), which favors the dialogic process in the family relationship.

Data collection took place in February and the first week of March 2020, the period when entry to the museum was free. We focused at families who were spontaneously visit to the museum. When approaching the family groups at the museum entrance, the research assistants informed them about the purpose and procedures of the study, as well as about the ethical conduct. When they agreed to participate, an adult member of each group was asked to complete a questionnaire to summarize the participants' socio-cultural profile and habits in relation to visiting museums and cultural centers. The families' visit took place freely, without interference from research assistants who were at a safe distance so as not to compromise the group's interaction. When the families expressed the wish to end the visit, they approached the research assistant to inform him/her to remove the equipment.

To record the museum experience, we used the "point-of-view camera" method (Lahlou, 2011, Glaveânu and Lahlou, 2012; Massarani et al., 2019c; Massarani et al., 2019a; Massarani et al., 2019b) which consists of capturing video audio through a subjective GoPro-type camera attached to the head of one of the visitors during the visit. In this study, one child from each group was asked to use the camera and the visitors had autonomy in their experience, that is, they visited the spaces they wanted and interacted for as long as they wanted, as they would on any other museum visit. Among the limitations of using the point-of-view camera method, we can highlight the fact that visitors have self-awareness that they are using the camera, which can modify their behavior (Glaveânu and Lahlou, 2012). In addition, when children register the visit at the beginning of the records, some of the tend to focus their attention to the camera. However, this behavior is reduced and even disappear during the visit (Burris, 2017). The duration of the visits ranged from 17 to 59 min (average of 35 min) (**Table 2**).

In total, ten groups of families participated in this study, with 16 children aged five to nine years (nine boys and seven girls), one teenager (male) and 19 adults (10 women and nine men). In the applied questionnaires, it was found that eight families resided in the city of Rio de Janeiro, and two in the metropolitan region of the capital - Niterói and São João de Meriti (**Table 2**). Of the groups approached, who had agreed to participate, for personal reasons two of them dropped out during the visit. We reinforce that the decision was respected, and the audiovisual material was not analyzed.

Based on the data collected from the questionnaires, we identified that the families reported having the habit, although not frequent, of visiting scientific-cultural spaces. For example, more than half of families (6) said they visited science spaces, museums and exhibitions more than once a year; the rest of the participants reported visiting this type of space at least once a year. Pertaining to expectations regarding the visit they would make at the Museum of the Universe, the responses highlighted their interest in additional knowledge, with special motivation in teaching something to the children and the search for leisure, entertainment and enjoyment.

Data Coding and Analysis

The analysis of audiovisual data was facilitated by the software program Dedoose 8.0.23, which allows coding the visitors' interactions (bodily, textual and attitudinal actions) simultaneously. As an analysis tool, we used a protocol–developed and validated by the network of researchers involved in the project–which is used to analyze how the experiences are organized in the museum, since it is used in the relationships between three fundamental actors: the exhibition modules, the visitors and the mediators (Massarani et al., 2019a; Massarani et al., 2019b; Massarani et al., 2019c). The protocol is divided into five dimensions (*Conversations, Types of Interaction, Photos, Change* and *Emotion*) and their respective

TABLE 2 | Information about family groups.

Groups	Location	Members	Gender/age	Visiting time
G1	Rio de janeiro (RJ)	3	2♀ (6, 33); 1♂ (42)	51 min 34 s
G2	São joão de meriti (RJ)	4	2♀ (8, 29); 2♂ (12, 31)	37 min 30 s
G3	Rio de janeiro (RJ)	3	1♀ (39); 2♂ (5, 44)	17 min 40 s
G4	Rio de janeiro (RJ)	4	3♀ (3, 8, not informed); 1♂ (41)	39 min 47 s
G5	Rio de janeiro (RJ)	3	1♀ (7); 2♂ (5, 44)	59 min 05 s
G6	Rio de janeiro (RJ)	5	2♀ (20, 40); 3♂ (6, 14, 45)	40 min
G7	Rio de janeiro (RJ)	2	2♂ (7, 33)	25 min 44 s
G8	Rio de janeiro (RJ)	2	1♀ (35); 1♂ (9)	33 min 34 s
G9	Rio de janeiro (RJ)	6	3♀ (7, 34, 64); 3♂ (1, 5, 37)	32 min 07 s
G10	Niterói (RJ)	4	2♀ (2, 39); 2♂ (8, 39)	21 min 41 s

TABLE 3 | Categories *Types of interaction and Conversations*.

1. TYPES OF INTERACTION	
1.1 Visitor-visitor	When visitors interact and chat with each other, regardless of the content of that conversation.
1.2 Visitor-exhibition module	
1.2.1 Interactive activity	The interaction occurs through: Immersion; experimentation; physical interaction (pressing buttons, turning handles, etc.) necessary for the continuity of the narrative/plot/content of the module; control of variables and interference in the final result/product of the module; and/or game.
1.2.2 Contemplative interaction	Contemplation, observation, non-touch visualization/manipulation of an exhibition module or part of it
1.2.3 Reading the panel/text	The interaction occurs by reading the texts aloud (integral or part) on the information boards, panel, caption, text, of the exhibition modules.
2. CONVERSATIONS	
2.1 Conversations about science topics	Dialogues on a scientific topic, discuss ethical and moral dilemmas of science, social impact of scientific activity, bring about data or scientific content, etc.
2.2 Conversations about the exhibition and non-scientific theme	Dialogues on topics covered by the exhibition, but which do not refer to science topics provided in the above category.
2.3 Conversations about exhibition (operation, design, museum experience)	Dialogue prompted by the visitors' interaction with the exhibition and/or the exhibition modules, whether about its operation, design and/or museum experience.
2.4 Conversations that associate previous experiences and personal experiences.	Mobilization, utilization, questioning their own knowledge, beliefs, rituals, ways of life, in the museum experience, making References to childhood experiences, school knowledge; references to movies, books, TV series and shows, etc.

categories (**Table 3**). The option of this research protocol resides in the fact that it dialogues with the socio-cultural perspectives that we refer to in the theoretical framework, which understands learning as a process, with multiple results that includes motivation, interest, conversations and interactions, and that goes beyond the time that visitors stay in the museum. Having in mind that the interactive experience is fundamentally influenced and shaped by interaction and conversation between visitors, the dimensions and categories that constitutes this instrument of analysis are in line with studies that investigate these themes in museums, such as Allen and Gutwill (2016), Ash (2003), Callanan (2012), Rowe (2005), Wagensberg (2005) among others.

In the present article, we utilized an adapted version of this protocol since some categories and subcategories could not be analyzed (for example, visitor-mediator interaction, as the museum did not have these professionals during the data collection) and which respond to our research objective. Thus, we will discuss the results regarding the most expressive dimensions that emerged from the codification of all collected audiovisual material: *Types of Interaction* and *Conversations*.

The segments were coded according to the duration in which the activity and experience took place. The categories and subcategories are not exclusive; the same video clip can be encoded as many times as necessary in a museum experience. For example, *Conversations about science topics* and *Conversations that associate previous experiences and personal experiences* can take place in the same video clip. Aimed at the research participants' anonymity, to transcribe the conversations, we used letters and numbers (C for child and A for adult. Number 1 was applied to the child with the camera, 2 for the second child belonging to the same group, and so on; and sequential numbers for adults in the same group).

RESULTS AND DISCUSSION

The videos of the ten family groups totaled 5 h 58 min 32 s of recording. Based on its analysis with the adapted research protocol, we identified 1,669 occurrences of categories in activity segments related to the visiting experience. **Table 4** shows the dimensions and categories of analysis with their respective occurrences in absolute numbers and percentage in

TABLE 4 | Categories organized by occurrence, time and percentage in relation to total recording time.

Analysis categories and subcategories	Occurrence	Duration (min)	% In relation to the total visit time
1. TYPES OF INTERACTION			
1.1 Visitor- visitor	127	303	84.5%
1.2 Visitor-exhibition module			
1.2.1 Interactive activity	105	137	41%
1.2.2 Contemplative interaction	239	110	30.8%
1.2.3 Reading the panel/text	157	22	6.2%
2. CONVERSATIONS - Content of conversations			
2.1 Conversations about the exhibition (operation, design, museum experience)	514	82	22.9%
2.2 Conversations about science topics	291	67	18.8%
2.3 Conversations about the exhibition and non-scientific themes	170	23	6.4%
2.4 Conversations that associate previous experiences and personal experiences	66	10	2.8%

relation to the total visit time. It is important to note that, when we are looking at how long each category lasts, it is necessary to have in mind that, in this case, no category will last longer than 5 h 58 min 32 s, which is the total duration of the videos. However, the sum of the times of each section can exceed this value, since at different times the categories can overlap. In the description of the results we also present the co-occurrences, which are the occurrences that overlap.

The *Visitor-visitor* relationship, subcategory of *Types of Interaction*, was coded (N = 127) and showed that families interacted with each other 84% of the total visit time, corresponding to a little over 5 h in duration. In the *Visitor-exhibition module* interaction, the subcategories *Interactive activity* (N = 105, 41%) and *Contemplative interaction* (N = 239, 30.8%) indicate a longer time rate, when compared to the subcategory *Reading the panel/text* (N = 157), which was less expressive in relation to the total visit time (6.2%). However, it is observed that in relation to occurrence, it had more applications than the *Interactive activity* category, which can be explained by the type of difference of these interactions: while reading can occur many times, for brief periods of time, the interactive activities can occur for a longer time, as they are characterized by manipulating objects, immersion and other touch and engagement activities.

In the *Conversations* category, the *Conversations about the exhibition (operation, design, museum experience)* and *Conversations about science themes* are the most frequent, with 514 codifications (corresponding to 22.9% of the total recording time) and 291 (18.8% of the time), respectively. *Conversations about the exhibition and non-scientific theme* (N = 170) correspond to 6.4% of the total visit time, applied in recurring episodes of associations between the constellations and the astrological signs. Less frequently, there were *Conversations that associate previous experiences and personal experiences* (N = 66), corresponding to 2.8% of the total time. We found that despite the small expressiveness of the *Conversations that associate previous experiences and personal experiences*, it was very important to facilitate strategies for a shared understanding of new information on the topic of exhibition between families.

In summary, these results indicate that the dynamics of the groups visiting the Museum of the Universe consisted of the interaction between the family members themselves and their interaction with the exhibition most of the time, through interactive activities, moments of contemplation and reading. In this process, the most frequent conversations were about the use and functioning of the exhibition modules, followed by *conversations about science topics*. Both were facilitated by the reading behavior, both to understand how to interact with the exhibition and to expand the subjects covered. This data can be confirmed when co-occurrence takes place, that is, when two or more categories are marked in the same segment. In the analyzed segments, the category *Reading the panel/text* with *Conversations about the exhibition (operation, design, museum experience)* were identified 61 times, and 75 times with *Conversations about science topics*. In the data analysis, the number of times the co-occurrences happened was divided into four levels, namely: 1) Very low: up to 31 times; 2) Low: 32 to 61 times; 3) High: from 62 to 92; and 4) Very high: above 63.

How do Families Interact?

Blud (1990) argues that "the interaction between visitors can be as important as the interaction between the visitor and the exhibition." In relation to this category (*Visitor-visitor*), we note that some families remain together for the entire duration of the visit, while others split into pairs or trios for short periods, but always return to the group to share their observations. These behaviors that highlight differences in family dynamics were also observed in studies developed by Ash (2003), Falk and Dierking (2000), McManus (1992). McManus (1992) compares the families' behavior to groups of "hunter-gatherers" in search of knowledge.

Other behaviors were recurrent in the families' interaction, among them we highlight the behavior of family members that point to identify the exposed objects and/or direct and call attention to show something that, to a greater extent, was observed in the children's behavior. Most of the time, children were the first to show interest by activating the exhibition modules. However, the behavior of parents/caregivers operating the modules was recurrent while the children participated in a more passive and curious way. When children activated a particular interactive device on their own, they usually failed and had to wait for the adults

TABLE 5 | Examples of *Contemplative interaction* and *Interactive activity*

Ex. 1 (G6) C1: [Looking at the setting in the interactive experiments section] *Look dad*./A1: *It's night, right. Wow... the mountains*./C1: *Look how beautiful that blue looks*!/ A1: *Stay*

Ex. 2 (G4) C1: [Looking at the stars painted on the ceiling] *Wow, dad, did you realize there are stars?*/A1: *Look. There is a sky of stars here*/. C1: *That is so cool!!*

Ex. 3 (G5) A1: [All members of the group on the scale to discover their body mass in the sun] *Wow! Do you know how many kilos we would weigh in the sun? The three of us together?*/C2: *No.*/C1: *No.*/A1: [Reading the scale result] *"3180 kg!"*/C2: [Surprised] *Unbelievable!*

Ex. 4 (G3) A1: [When A1 shows C1 the cryogenics capsule] *This is to cool it down. To slow the astronauts' aging.*/C1: [Inside the capsule] *this is to freeze?*/A1: *Over there it is to freeze. To be able to travel many years*

to help and explain. Szechter and Carey (2009), who investigated parent-child interactions in 38 different exhibitions at the Laser Interferometer Gravitational-Wave Observatory (Los Angeles, United States) showed that children are the ones who choose the exhibitions for their families. In this respect, the data presented, in line with the literature, point to interesting relationships between family members with regard to the choice, indicating that children have an important role in family dynamics to direct the learning experiences.

The Museum of the Universe, through its interactive and contemplative exhibitions, provided families both the presence of moments of esthetic appreciation, admiration and observation, as well as interactive activities by handling the devices, with the intention to explore, test ideas and have fun. The *Contemplative interaction* was present in all spaces of the museum, but it was observed to a greater extent in the exhibitions located on the second and third floors, which displayed their information through resources such as textual panels, videos and photographs. On the first floor, this category was observed when families contemplated objects, including representations of the cosmos (Ex. 1 and 2), replicas of spaceships and equipment used by astronauts.

The expressiveness of the *Interactive activity* category was greater on the first floor of the exhibition, supported by the exhibition "Spaceship School". In this space, all families used interactive devices such as scales to discover the visitor's body mass on different planets (Ex. 3); the representation of the cryogenic capsule (Ex. 4); the spaceship's pilot chair, which is an immersive interaction, and modules with touchscreen panels that encouraged families to discover more information about space exploration achievements. The following (**Table 5**) are some representative examples of these categories. The study was carried in Brazil and, therefore, the language was Portuguese. The quotes were translated into English in the scope of this paper; all the quotes are presented in Tables.

In the examples presented in **Table 5** and at other periods of the visit, we found that the exhibitions are the starting point for family conversations. However, this result should be viewed with caution because the absence of conversation can have different meanings, for example, they can mean lack of engagement and/or it can also mean moments of contemplation (Leinhardt, 2014). In examples 1 and 2, families verbalize their contemplation of the exhibition when C1 of G4 looks at the ceiling painted with stars for a few moments and then remarks to the father "Wow, dad, did you see the stars?" However, most of the codes applied in the category *Contemplative interaction*, were observable through the behaviors explained in the videos by non-verbal and/or corporal expressions.

The *Interactive activities* also provided moments of leisure and family relaxation, as seen in example 3, where all members of the group step on the scale to see what the family's body mass would be in the Sun, as well as important for conversations that addressed an idea, knowledge or curiosity about science, for example, when the father shows the cryogenics capsule to the child (Ex. 4).

Also in relation to the families' interaction with the exhibition, it was found that because the museum is widely marked with texts and panels, it favored the presence of the *Reading the panel/text* category and mobilized the families to interact. In general, the textual resources displayed in the exhibitions were not long and/or complex, which allowed families to read quickly, to understand, for example, the how a specific device functions or to situate themselves on what is being observed and/or exposed–interaction that stands out later in 3.2 What do families visiting the Museum of the Universe talk about? The reading was usually done by the parents/caregivers and occasionally by the children, since the children's age group in the study comprised preschoolers up to 4th grade elementary school children, as observed in the following examples (**Table 6**).

As can be seen in examples 5 and 6, the parents/caregivers did the readings using the panels to talk to the children about scientific concepts and curiosities of the exposed objects, while the children also offered their interpretation of what was read, as for instance the G7 in which the child utters "I won't go in there" when the adult read that the cryogenics capsule cools the temperature of the human body to −120°. According to Crowley and Jacobs (2002), this reading behavior is fundamentally collaborative–the parents read the text, answer the children's questions, ask their own questions and point out interesting parts that are reflected in the text. Tare et al. (2011) also indicate that the parents/caregivers do the reading and, depending on the complexity of the subject, adapt it to explain it to the children.

However, children's readings, for adults and for themselves, were brief and more focused, with no continuity about what they read (Ex. 7 and 8), which may reflect their schooling phase and literacy, as well as general age behavior that results in fragmented focus when the environment has multiple visual and interactive inputs. These data are in line with research that investigated the learning behaviors of families in science museums, which

TABLE 6 | Examples of *Reading the panel/text*.

Ex.5 (G6) A2: [Reading the text from the monitor to C1] "*Our body has an internal clock. It is possible to measure time by counting the heartbeat. Count the pulse beats during the oscillation."*
Ex.6 (G7) A1: [Reading to C1 about the cryogenics capsule] "*To delay the astronauts' aging, the cryogenic capsules cool the human body to a temperature of -120°"/C1: I'm not going in there."*
Ex.7 (G4) C1: [Reading the panel] "*Crown, photosphere, chromosphere, convective layer and nucleus."*
Ex.8 (G2) C2: [Reading the panel] "*Earth's crust formed four billion years ago"* [talking to C1 and pointing to the panel] *Look over there [...]/*C1: *I saw it*

dissipate a view that visitors do not read (Allen, 2002; Tare et al., 2011).

What do the Families Who Visit Museum of the Universe Talk About?

Regarding the experience of visiting the Museum of the Universe, the analysis indicates that overall, the families talked about the exhibition, its operation and contents. Regarding the conversations about the exhibition, we highlight the dialogues where the parents/caregivers explained to the children how the exhibition modules worked (*Conversations about the exhibition–operation, design, museum experience*). The following are examples (**Table 7**) from this category, highlighting Example 9, which occurs in the expository module "The Earth in Movement", which, among other issues, addresses how tides are formed. In this interaction, the adult explains to the child how the Moon moves using the touchscreen.

Interactive exhibitions, such as those at the Museum of the Universe, can elicit productive conversations because they are able to show and represent complex and abstract phenomena in action (Tscholl and Lindgren, 2016). The expectation is that, when interacting with the devices, families not only talk about how it works ("press a button", "lift a handle" etc.), but also discuss beyond what is immediately observable, including discussing ideas, logical reasoning and/or underlying scientific knowledge.

However, our study indicated there were few *Conversations about science topics* that resulted from the *Interactive activity*. About this, Gutwill and Allen (2010) argue there is generally insufficient alternative hands-on interactive exhibitions to stimulate prolonged and personalized involvement in order to keep children and parents/caregivers interested in exploring and talking about a phenomenon. Even so, we recognize that the *Conversations about the exhibition* (*operation, design, museum experience*) presented important structures for understanding the families' learning experiences, viewed as scaffolding for the construction of collective knowledge about astronomy.

In the category *Conversations about science topics*, we verified how the families in this study approached and/or appropriated scientific terms, concepts, ideas and procedures, and we also identified the contribution of the exhibitions in dialogues that included questions related to the nature of science. Ash (2003) states that the conversations show how families use the content of an exhibition as a springboard for extended reasoning. Thus, we present below some examples of these conversations (**Table 8**).

The episodes presented above indicate that the parents/caregivers, in addition to reading the texts, asked questions and provided explanations about astronomy to guide their children's understanding during the conversations throughout the visit, in some cases also correlating it with the *Interactive activity*, such as in example 12. Adults stimulated the children's skills such as identification, naming and comparison, asking concrete questions in order to keep the children involved, for example, when in G3 A1 asks C1: "what planet is that little one there? Do you know?" or in G2, when A1 asks the children (C1 and C2): "Did you track the order (of the planets)?" Skills such as inference, logical reasoning, comparison, abstraction and generalization were also observed in scenes like in example 12, in the interaction with the body mass scale on the different planets (Ex. 13). In general, families also made associations and personal connections with scientific knowledge to facilitate understanding the topics exposed (Ex. 14, 15, and 16), and established initial conclusions after observation, reading and analysis (Ex. 13).

Research has shown that as conversational partners, parents/caregivers can focus their attention, provide explanation and interpretation, and organize display material to support children's learning (Leinhardt et al., 2002; Crowley et al., 2014). These studies indicate that explanations provided by

TABLE 7 | Examples of *Conversations about the exhibition (operation, design, museum experience)*.

Ex.9 (G1) A1: [Reading the text in the "earth in movement" module to C1] "*Tides are produced by the attraction of the Moon and the Sun over the ocean waters. Touch and move the moon to see the tide rise and fall." Look, daughter! [...] when you touch the moon"* [moving the moon with his finger on the touchscreen] *"the tide goes down* [moves the moon in the opposite direction] *and here it goes up. See?*
Ex.10 (G4) A1: [In the interactive module with astronomical information] *I still don't understand this thing here./*C1: [Going in the direction of A1] *where is it?/*A2: [Going in the direction of A1] *Let me see/*. A1: [When the other two visitors approach] *What is it supposed to do?/*C1: *OK, I got it now. Cool!/*A2: *Hum, he (the character) will find out where he is. Finding a sextant and a watch. But I don't know if he's looking for that now./*A1: *But what is he supposed to do?/*C1: [Starts playing by moving the character] *Like this. He has to find the watch./*A2: [...]*This one is complicated, huh*
Ex.11 (G7) A1: [in the interactive experiments section] *Look,* [reading the module text] *the "Configuration of the Planets. You know that the planets traverse the constellations of the zodiac as they move around the Sun ..."/*C1: [Interrupting] *let's go see other awesome things*

TABLE 8 | Examples of *Conversations about science topics*.

Ex.12 (G4) A1: [Talking to C1 in the interactive module with scales to see their body mass on different planets] *Come and see what your weight is on Pluto. Stay here in the middle of the scale to see.* [Looking at the scale display] *On Pluto you only weigh 1.3 kg./*C1: [Impressed with the result] *What?!/*C2: [Stepping on the scale] *I also want to see./*C1: [Referring to C2] *You must weigh some grams./*A1: [Looking again at the scale display] *Less than a kilo. 0.9 kg./*C1: [Moving the model that demonstrates the layers of pluto] *Here, folks, it's inside Pluto. Really cool.* [Pointing to the core]*. Dad, what is this ball for?/*A2: *These are the layers inside the planet*. [...] *this layer here is the crust./*C1: [Referring to the core] *And this one controls everything?/*A2: *No. this one is the crust, it has an ice sheet and here is a solid rocky core* [pointing to the text] *It's written here. "It's the structure of Pluto."*

Ex.13 (G7) A1: [Reading the panel to C1] *Look at this, "one rotation of the Sun corresponds to 26.8 days on Earth." Did you understand what that is?/C1: [uncertain] Yes .../A1: It takes 26 days for the Earth to move around the Sun*

Ex.14 (G1) A2: [Watching the video of men on the moon] *Look, daughter, they over there on the moon.* [Imitating the astronauts' movements] *They have to walk like this, because there is no pressure for them to stay on the floor.* [Pointing to the video] *They walk like that, leaping./*C1: *But why, dad?* [Imitating a person walking normally] *why don't they walk like this?/*A1: *Because there is no atmospheric pressure, daughter*

Ex.15 (G3) A1: [Pointing to the solar system model] [...] *Look at the planets, the Sun ... what planet is that little one there? Do you know?/C1: Yes. It's Mercury./A1: And then?/C1: Venus./A1: [...] and then?/C1: Earth ./A1: [...] and then?/C1: Mars./*A1: [Pointing to jupiter] *And this one here?/*C1: *Jupiter!/*A1: *Wow!* [pointing to jupiter] *And this one here?/*C1: *Saturn/*A1: *That's right.* [Pointing to uranus] *And that one over there?/*C1: *Uranus*!/A1: *And the last one?/*C1: *Neptune!/*A1: *Very good!/*C1: *Daddy, where's Jupiter's rings?/*A1: [...]*but does Jupiter have a ring?/*C1: *Yes./*A1: *Oh, but it's very thin. You can't see it, right.* [...]*Did you see how big the sun is? The Earth is tiny there. Mercury is tiny, right?/*C1: *É. [...] Yes. [...] And where's Neptune's rings?/*A1: [Looking at the representation uranus and rings] *Hey, isn't that one over there? No, that one is Uranus, right?/C1: Yeah. What about Neptune?/*A1: *Neptune also has a ring, right? We saw it the other day. When they did that, I think they didn't even know that Neptune had a ring. Or it is because Neptune's ring is also very tiny?* [Pointing to saturn] *The one with the most ring is Saturn.* [When A2 joins the group] *Do you want to teach mom the names of the planets?*

Ex.16 (G2) A1: [Talking to C1 and C2] *Did you memorize the order (of the planets)? I'll teach you a trick and you will never forget the order: "My Old woman Bring My Dinner, soup, grape, turnip and bread. There is no more bread, right ... Mine is mercury, Old* [in Portuguese, velho] *is venus, Bring* [in Portuguese, traga] *is Earth* [in Portuguese, Terra], *Mine is Mars, Dinner* [*in portuguese, jantar*) *is jupiter, soup is saturn, Grape* [in Portuguese, uva] *is uranus and Turnip* [in Portuguese, nabo] *is neptune". Now you will always know the order [...]/*C2: *What about bread?/*A1: *Bread (Pluto) is no longer a planet.*

adults, even when brief and informal (called "explanatoids"), as noted in examples 13: "A1: It takes 26 days for Earth to go around the Sun" and 16: "A1: Pluto is no longer a planet", can help children process the exhibition material, serve for the initial understanding of scientific concepts and foster subsequent skills (Fender and Crowley, 2007; Tenebaum et al., 2010). These results suggest that the strategies used by parents/caregivers to talk about science with children can facilitate the construction of meaning, promote reflection and/or change what they understand about science.

The data on *Conversations about science topics* also provide evidence that the exhibition "A giant leap: the journey to the Moon," located on the second floor of the museum, provided dialogues that contributed to issues related to the history of science. In other spaces, although less frequently, reference was also made to researchers involved in the process of producing science (Ex. 17 and 18) and the identification of equipment and instruments in the scientific field used by scientists (Ex. 18) in **Table 9**.

The examples presented above are representative of an approximation of families to the idea of science, especially astronomy and astronautics, as a human, historical and social process (Lederman, 2006). As an example, the G4 family (Ex.17) had a dialogue on how science was built in relation to the space race in the second half of the 20th century between the Union of Soviet Socialist Republics and the United States of America for supremacy in the space exploration and technology. In this conversation, family members comment, citing the names of the first astronauts who reached the Moon and use personal experience information ("Your grandmother was ten years old") to make sense of the conversation. The strategy used by this family leads to the discussion of another category that was less expressive in this study–*Conversations that associated previous experiences and personal experiences*–but that demonstrated relevance to the analyzed families' learning experiences. As strategies to facilitate and approximate the exposed theme, some dialogues, albeit brief, mention music and films, children's school content and families' personal experiences (**Table 10**).

Conversations that involve associations and comparisons with past events and previous individual experiences, as in examples 19 to 22, which reinforce family history and shared understanding among family members (Zimmerman et al., 2010). Allen (2002) defines this type of strategy as "connecting

TABLE 9 | Examples of *Conversations about science topics*.

Ex.17 (G4) A2: [Looking at the panel about man's journey to the moon with C1] *Let me tell you. Come on, look how cool this is. The first spaceship launched was Mercury 7. Then years later this guy here, President Kennedy, said that man would be on the Moon by the end of 1969./*C1: *OK, got it./*A2: *Then they tested it. They made the Gemini 3 rocket and then launched this astronaut here, Virgil Grisson and John Young. Then they did the first spacewalk, that is, they left the ship and managed to wonder outside the ship. Then they completed, "what beauty," then he goes back to Earth. Then in 1966, his grandmother was ten years old./*C1: *Wow!/*A2: [...]*they landed a probe on the Moon, without people./C1: Is it still there on the Moon?/A2: It should be. In 1967, Apollo 1 caught fire.* [Pointing to a picture on the panel] *These guys died./* C1: *Oh no/A2: Yeah. Then they made a flight around the Moon and returned to Earth, they did not land. It was these guys here, (from) Apollo 8, James Lovell, William Anders and Frank Borman. Then, on July 21, 1969 they landed on the Moon and this guy was the first guy to walk on the Moon, Neil Armstrong, later it was Buzz Aldrin ./*C1*: Wow! That's so cool*

Ex.18 (G5) A1: [Showing children the panel and the miniatures in the area with interactive devices–1st floor] *"Here, daughter, look ... the first telescope, Galileo did it . . . Galileo Galilei aimed the telescope at the sky and observed wonders never before imagined. His discoveries sparked a revolution in understanding"* [...].

TABLE 10 | Examples of *Conversations that associated previous experiences and personal experiences*.

Ex.19 (G1) A2: [Positions himself as if he is working on the spaceship's controls] *It's Captain Kirk's ship* [referring to the star trek movie]
Ex.20 (G1) A2: [Talking to A1 and pointing to the satellite model] *What's the name of that one over there?*/A1*: What?*/A2: [Remembering the name] *Satellite!*/C1: *Satellite? I never studied what is a satellite*/A2: *Never studied about it?*/C1: *No*
Ex.21 (G4) A1: *You know that on your birthday [...]. your 8 year-old birthday, marked 50 years since mankind first stepped on the Moon.*/C1: *Wow! I'm honored!*
Ex.22 (G5) *Do you remember that Aunt Dri went to Japan?*/C1: *Yes.*/A1: *So, Aunt Dri went to Japan and when the sun was up in Japan the sun was down here in Brazil.*/C1: *Then when the Sun came here, there was no sun in Japan*

conversations" and adds that they are relevant to make sense of the content of the exhibition. In addition, Callanan et al. (2017) and Jant et al. (2014) point out that the parents' connection with previous experiences in conversations with their children is positively associated with the children's scientific understanding. In this regard, the personal, social and cultural background of the families is mixed with the contents of the exhibition, favoring the learning experiences in science.

Final Remarks

In the present study, our objective was to understand the families' interactions and learning experiences during a visit to a science museum with astronomical content, with a focus on conversational content and interactions. By observing the aspects mentioned in this study, we understand that, during the visit to the exhibitions of the Museum of the Universe, the families demonstrate to be very motivated, interested and focused on the experiences provided, such as the interactive, immersive and contemplative activities.

The interactions and conversations bring evidence that families use the exhibitions as resources to make observations and comparisons, and also serve as a source for sharing knowledge about astronomy among family members. In addition, they use their cultural knowledge and daily activities to contextualize and facilitate understanding a more complex subject that was addressed, in order to comprehend the exhibition. The exhibitions also provide historical contexts so that, to some extent, families are brought closer to the nature of science. The data also show that parents/caregivers played an important role in maximizing the learning opportunities available, offering support and guidance, encouraging questions and providing explanations as the children interacted with the exhibits in order to introduce or improve science knowledge, strategies that were observed in different episodes.

Thus, this study brings evidence that the Museum of the Universe was a platform for families to share experiences, talk and develop, often for the first time, specific ideas, knowledge and concepts about astronomy, enriching the group members' knowledge. In addition, it signals that the experience of the visit can offer subsequent opportunities to broaden and expand the family conversation concerning the topic.

In summary, our study confirms data from the previously mentioned studies, in reference to how families are interacting, the role of parents/caregivers in children's learning, and how reading is an important resource for deepening science topics. We emphasize that, in the Brazilian context, children play an important role in the dynamics of family orientation during visits and, therefore, we consider important that science museums favor their participation in a significant way, with attractive design and easy-to-read texts for who just learned our to read and, when possible, linked to daily life, providing greater autonomy in dialogues with their parents/caregivers. Collaborative exhibits, in which families get involved for a longer time in discussions that value not only the cognitive but the social domain, also show themselves as potential to stimulate deeper conversations in science that are, to a lesser extent, observed in these spaces.

We hope that our study can contribute to theoretical perspectives that will help to better understand the processes about Latin Americans families' learning conversations in informal education spaces. In addition, the study of conversations and interactions through the adopted protocol contributes to provide the educational sectors of the museum institutions to understand the needs, interests and identities of visiting families, in order to stimulate the cognitive and social learning experiences.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/Supplementary Material, further inquiries can be directed to the corresponding author.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by this study was approved by the Ethics Committee of the Oswaldo Cruz Foundation (CAAE 10663419.0.0000.5241). All participants consented to their participation through the free and informed consent term, which had information about the research procedures and objectives. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

AUTHOR CONTRIBUTIONS

Equal contribuition & Senior autorship – LM. Equal contribuition – JR and GS. Equal contribuition and Last autorship – YS, WC, and LG.

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