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Social participation in science museums: A concept under construction

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Abstract

The term social participation is widely used and has various meanings in different contexts. This article aims to enhance the understanding of social participation in science museums. The research was conducted using a cultural-historical perspective in six steps: (1) survey to identify the meanings attributed to the term social participation and actions considered participatory in Brazilian science museums; (2) content analysis with coding; (3) literature review on social participation meanings; (4) analysis and revision of categories; (5) survey for educators from Brazilian science museums to validate the dimensions emerged in the first survey; (6) final analysis: synthesis of the dimensions of social participation and proposal of a model. As a result, we recognized five dimensions that contribute to the concept of social participation in science museums: "access"—removing barriers to participation that promote social exclusion; "identity and diversity"—creating a multicultural space that examines and redefines oppressive and unequal relationships; "co-creation and authorship"—fostering different forms of collaboration with audiences; "interaction and dialogue"—expanding opportunities for interaction with exhibitions; "exercise of citizenship"—empowering the audiences to participate in social change. Although these dimensions provide insights into social participation

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in science museums, limitations exist. These dimensions can contribute to developing museum practices that dialogue with communities and strengthen social participation in science museums.

KEYWORDS
cultural-historical perspective, museum educators, science museums, social participation

1 | INTRODUCTION

Museums play a crucial role in preserving scientific and cultural heritage, and, with their expanding educational and social functions, they could be relevant spaces to bridge the gap between science and society. In societies where science and technology are integral to daily life, it is crucial to democratize this knowledge and put it in dialogue with the knowledge and cultural expressions of different social groups to promote equity and social justice.

However, considering science museums as platforms for dialogue requires reflection on the relationships between museums, science, and society. It also includes understanding how social participation can occur in these institutions and acknowledging emerging conflicts and contradictions.

It is well-known that participation in museums has tensions in different countries. For instance, in the United Kingdom, science museums have been observed to exclude certain groups, such as low-income and minority ethnic communities (Dawson, 2014a).

However, promoting participation in museums may be even more challenging in countries outside the northern hemisphere. In South Africa, for example, despite recent efforts to increase access to science for the black population, a history of exclusion has resulted in a generation growing up without access to museum institutions (Lelliot, 2017).

In Brazil, the causes and consequences of stark and long-standing socioeconomic inequalities include difficulties accessing education and other essential public services, such as leisure and culture (Gohn, 2019), including museums. Currently, these inequalities are being highlighted due to the severe health, political, and economic crisis. In addition, the gap between Science and society is exacerbated by the promotion of antiscientific thoughts by certain government actors.

The following data could illustrate the tensions related to museums, science, and society. Approximately 80% of Brazilian municipalities do not have museums, while only 1.2% have six or more institutions. Despite comprising 56% of the population (Instituto Brasileiro de Geografia e Estatística, 2010), the Southeast and South regions of the country have the highest number of museums, accounting for around 67% of Brazilian museums (Instituto Brasileiro de Museus, 2011). These regions also receive more investments, have a more robust administrative structure, and are home to higher-income populations, which could both determine and be determined by better educational performance (Bizzo et al., 2021).

According to a governmental survey on public perception of science and technology conducted in Brazil since 2006, only 6%–13% of respondents had visited a science museum in the past 12 months, despite 61% expressing interest in science and technology (Ministério da Ciência, Tecnologia e Inovações, 2019). Other studies indicate that the majority of museum visitors in Brazil are individuals who identify as White, have higher levels of education, and belong to higher social classes (Observatório de Museus e Centros de Ciências [OMCC], 2008; OMCC, 2015).

Similar scenarios of unequal access to science, influenced by economic, social, racial, and gender factors observed in various countries, prompt researchers. Scholars are investigating the motivations behind different social groups' involvement (or lack thereof) in science-related issues, their participation (or lack thereof) in science-related

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spaces, and their decisions (or lack thereof) to pursue scientific careers, taking into account their racial, gender, educational, and socioeconomic diversity (Archer et al., 2015; Chappell & Varelas, 2019; Dawson, 2017; Shea & Sandoval, 2019; Schenkel & Calabrese Barton, 2020).

These studies indicate that factors such as a sense of belonging, recognition, and validation of cultural values concerning science influence participation in this field. Consequently, addressing these issues requires confronting complex and historical challenges, such as structural racism and heteronormativity in the sciences. Therefore, discussions on social participation in science museums involve reflecting on a complex scenario of inequalities.

However, despite the relevance and frequent use of the term social participation, its definition remains unclear. On the contrary, it is attributed with different senses and meanings, representing a wide range of actions and values that occur in science museums and involve the publics[1] in various ways.

The term has become polysemic and plural, which is not inherently problematic. However, establishing a shared understanding of social participation can significantly improve communication among peers, putting tensions in evidence and developing museum policies and practices.

In this article, our objective is to enhance the understanding of the term social participation in science museums by considering it as a concept under construction. To achieve this, we put into dialogue the senses and meanings attributed to social participation by Brazilian museum educators and science education scholars from various countries. Through this dialogue, we aim to contribute to a more comprehensive conceptualization of social participation in science museums and to strengthen transformative educational practices within museums.

It is important to note that our intention in this article is not to analyze whether social participation is occurring in Brazilian science museums or not. Instead, we focus on studying the understanding of social participation among Brazilian museum educators.

The article is structured as follows: after this introduction, we highlight the cultural-historical perspective that underpins our work. In the third section, we describe our methodology. In the fourth section, we present the process of constructing each dimension that we consider integral to the concept of social participation. Subsequently, in the fifth section, we synthesize our analysis and discuss the challenges of social participation in science museums. In the sixth section, we present our model of social participation, and in the seventh section, we provide our final considerations on the study.

2 | THE CULTURAL-HISTORICAL PERSPECTIVE AS A THEORETICAL FRAMEWORK

We begin by acknowledging that concepts are socially constructed and shaped by the cultural and historical context in which they emerged. Therefore, we have chosen to study social participation through the lens of the cultural-historical perspective. This theoretical framework allows for a deeper understanding of the processes involved in forming personal and social meanings, including the contradictions and negotiation of senses that occur.

The cultural-historical perspective is rooted in the work of Lev Semyonovich Vygotsky, a Russian theorist who drew on dialectical materialism to explore the origins and development of human behavior and consciousness from a historical and social standpoint (Cole & Scribner, 2007). Despite this theory encompasses a broad scope and complexity, this article will primarily focus on Vygotskian ideas of "signs" and "concepts," which help us analyze social participation as a concept under construction.

2.1 | Concepts as a social construction

According to Vygotsky (2007), signs, including terms, are psychological tools that enable the coordination of mental processes and, as a result, modify individuals' minds and behavior. In other words, signs are psychological

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instruments that modify the psyche. Additionally, Vygotsky argues that signs serve as mediators between human beings and the objects and phenomena in the world around them.

Building on Vygotsky's work, Leontiev (2004) emphasizes the social nature of signs. According to Leontiev, the emergence of language can only be understood concerning the need that humans experience in their work to express something. Through their productive activities, individuals appropriate particular objects in the world to satisfy their needs and begin to designate them through language, attributing meaning to these objects based on practical experiences.

By assigning meaning to something, words distinguish and generalize objects or phenomena in their objective and social relationship with individual consciousness. In this way, the meanings of words become fixed in language and are available for future generations to appropriate. Through meaning, a realm of possibilities opens, allowing the social experiences of humanity to become the experiences of individuals (Leontiev, 2004).

While meanings represent a relatively stable and shared understanding of a word within sociocultural groups, Vygotsky emphasizes that meanings also undergo dynamic formation, known as senses. Senses are associated with the experiences individuals have and the relationships they establish. In a collective-oriented logic, from the meanings already stabilized in a social group, senses are constructed by articulating multiple motivations during interactions, considering individuals' conditions, experiences, positions, attitudes, and decisions (Barros et al., 2009).

Due to this diversity, the meanings of words are constantly negotiated as individuals appropriate and use them in their material relationships. It means that words can differ from the senses expressed in them, and they can change their meaning over time. Additionally, new phenomena and objects that emerge in socio-historical development are also designated by words, leading to variations and semantic nuances, and the emergence of new social concepts.

From this understanding, it becomes clear that the formation of concepts is not solely an act of internalizing culturally established concepts but also involves externalization, which is the construction of culturally new concepts. Engeström et al. (2006) highlight that the term “concept” in different languages, such as German and English, carries the dual meaning of grasping objects and phenomena and imagining or conceiving future-oriented ways of creating the world.

Thus, socially constructed concepts play a essential role not only as mediating elements in activities but also in facilitating the transition from current individual actions to new forms of collective activity. However, this process is not linear or consensual, as human relations in material activities are shaped by different voices, structures, and norms, and different individuals conceive partially conflicting versions of the same concept.

For example, Leontiev (2004) explains that while there may be differences and opposition in how different individuals, such as enslaved people and enslavers, peasants and feudal lords, or workers and capitalists, imagine the world, these differences do not necessarily manifest in their language or the verbal meanings they possess. As a result, some concepts are laden with ethical and ideological challenges, incorporating emotions, perspectives, hopes, insecurities, and intentions. The construction of these concepts also involves confrontation, contestation, and negotiation, as occurs in concepts such as globalization, global warming, or the human genome (Engeström et al., 2006; Engeström & Sannino, 2012).

Engeström et al. (2006) refer to these concepts as complex concepts. According to the authors, complex concepts are (1) best understood as products and tools of collective activities that evolve historically (2) inherently debated and dynamic; (3) future oriented as they embody collective intentions, hopes, and fears; (4) best learned through implementation, debate, and construction in practice.

Engeström et al. (2006) provide an example of the “care agreement” concept analysis in Helsinki's healthcare system. The authors explain that in the late 1990s, the healthcare system in Helsinki was expensive and inefficient, particularly for patients with multiple chronic illnesses. The existing administrative concept of “critical pathways” used by health professionals was not suitable for patients with multiple diseases, resulting in fragmented care. In response to this issue, patients, families, and various healthcare professionals collaborated and learned together to develop long-term, well-coordinated, and highly adaptable care approaches for patients with multiple diagnoses.

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As a result, a new concept was being constructed: "care agreement." During this process, the authors identify several emerging elements or dimensions, such as "responsibility," "arrangement," and "parental involvement," which contribute to understanding the collaborative formation and utilization of the new healthcare concept.

In this example, the formation of the concept of "care agreement" involved a horizontal movement between different perspectives and worldviews of various professionals and families through prolonged collaborative discussions, analysis, and testing. From this process, a model was developed to capture the relationships and internal tensions within the activity in a simplified manner, enabling participants to understand its history and work towards possible changes in their activity systems.

In addition to this main model, other interconnected levels of conceptual instrumentalities can be developed throughout the process. In the work of Engeström et al. (2006), these levels were elaborated through the relationships between patients and health professionals, resulting in the development of care calendars, care maps, and individual care instruments. These examples illustrate the continuous movement of meanings, where the different appropriation levels of the concept under construction are invested with meaning and bridge the gaps between situational and new conceptualizations.

2.2 | Social participation as a concept under construction

Studying the concept of social participation as a concept under construction, entails understanding its history and complexity and recognizing that it is both used and simultaneously constructed through the various actions carried out in science museums. It is also important to acknowledge that the so-called participatory[2] actions and the concept of social participation itself are built through the material relationships between individuals who share the need to democratize science and technology and promote social justice, equity, and diversity in museums. However, the meanings and senses attributed to the term have a dynamic and nonconsensual formation, including conflicting and contradictory views. Therefore, it is necessary to negotiate this diversity of voices. This study aims to contribute by formulating and proposing a model of the concept of "social participation" in science museums based on the analysis of responses from Brazilian professionals to two surveys and a literature review.

3 | METHODOLOGICAL DESIGN

The methodological design on the cultural-historical perspective is based on the dialectical historical materialism approach rooted in the works of Marx and Engels. In this approach, the researcher begins by examining the empirical appearance of the phenomenon being studied, representing a concrete level of reality, to understand its essence. The essence refers to the structure and dynamics of the phenomenon and is apprehended through processes of abstraction and analysis. Subsequently, the researcher operates a synthesis, which means reproducing the phenomenon essence in the realm of thought to a concrete thought[3] (Netto, 2011).

Considering the cultural-historical perspective, the limitations and challenges encountered during the research, and the dynamic of our research object, we made methodological choices that allowed us to approach the concept of social participation in science museums, considering its diversity. It is important to note that our intention is not to exhaustively define or fully capture the term but rather to contribute to the ongoing construction of the concept. We also employed a qualitative content analysis approach (Bardin, 1977) to detail our analytical categories further.

This investigation consists of six steps, as summarized below: three steps of data collection (survey 1, literature research, and survey 2) and three steps of analysis processes.

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3.1 | Step 1—Museum survey

We understand that social participation in museums is materialized in the institution's relationship with the publics, mainly from the educational actions promoted by these institutions. Then the research began with a survey referred to as survey 1, which aimed to determine "if" and "how" museum professionals considered their educational actions to be participatory and to map these actions.

Survey 1 was conducted between July and August 2017 via email, reaching out to the 268 institutions listed in the Guide of Brazilian Science Centers and Museums (Associação Brasileira de Centros e Museus de Ciências, 2015). Out of the 268 institutions, 39 had outdated email addresses, resulting in contact being made with 229 institutions. The response rate for survey 1 was 20%. The survey included an open-ended main question: "Does the institution where you work develop any educational project or action with the objective of promoting social participation of socially vulnerable communities?"

Contrary to expectations, the responses to this question revealed a vast, rich, diverse range of meanings attributed to social participation.

It is important to note that survey 1 was anonymous and sent to the institutional email addresses of science museums in Brazil. Therefore, it was answered by representatives of the institutions, chosen internally, without indicating their specific roles within the institution.

3.2 | Step 2—Initial analysis

The responses obtained from survey 1 were subjected to an inductive content analysis, with the emergence of categories during data analysis (a posteriori). The answers were read and separated into recording units, resulting in a total of 58 units. These units were then grouped based on their similarities to each other. Through this process of abstraction, eight distinct groupings of meanings related to the concept of "social participation" emerged. These groupings and their specific meanings are presented in Table 1.

3.3 | Step 3—Literature research

Literature research was conducted to validate and deepen the emerging categories. It was recognized that researchers, in their praxis, also contribute to constructing meanings about the term under study, in addition to museum professionals. The literature databases Web of Science, ERIC, Scielo (Latin American platform), and CAPES Database of Thesis and Dissertations (Brazilian platform) were searched using the terms: "social participation" and "museums" or "science museums," "participation" and "museums" or "science museums," "participatory" and "museums" or "science museums." Initially, the focus was on finding studies specifically related to science museums. However, we expanded the research scope to include papers that presented meanings of social participation in museums, regardless of their typology. This decision was made to gain insights from participatory actions in other museum typologies that could contribute to the understanding of social participation in science museums.

This literature review did not aim to conduct a comprehensive state-of-the-art analysis but to identify the meanings presented by authors regarding the term "social participation." We found a total of 219 texts, and after excluding papers that focused on specific actions for audiences with disabilities or school visits to museums, as well as removing duplicates, 78 texts remained. These included dissertations, theses, papers, conference proceedings, books, and reports. While 38 papers expressly referred to science museums, the others covered various fields such as education in museums, museology, history, arts, and sociology, all presenting meanings related to social participation in museums. In some cases, we also considered theoretical references used by the authors to understand their meanings better.

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TABLE 1 Initial categories of social participation in science museums.

Categories	Description: Social participation means	Example
Access	Eliminating barriers to publics entry into museums	"Schools in the municipality of Piçarra gain exemption to visit our exhibition, and schools in other municipalities that have low-income children are also served free of charge, as our idea is not to exclude but to include these children, regardless of their situation." (R29)
Publics at the center	Developing actions or projects that aim to meet the needs of the publics	"Every week, we serve children who live in a socially vulnerable region in Brasília. That is, instead of staying at home after the school shift (referring to public schools that have not yet adopted full-time education), they visit the Science Room every Wednesday, and on Monday and Friday they carry out other activities." (R1)
Collaboration	Involving publics in contributing to the museums' actions, such as providing ideas, feedback, or objects	"A year ago, the Weekend at the Museum Project was created, where people from the community are invited to prepare an exhibition according to the month's theme and under the supervision of one of our employees." (R12)
Co-creation	Creating actions with the communities surrounding the museum	"We partnered with an association that serves young students from a remote neighborhood, considered the largest illegal settlement in Latin America. The objective is to elaborate and develop joint socio-educational actions with the leaders and professionals who work in the association, based on themes related to the problems and needs of the community and the environment. For example, open sewage disposal and revitalizing the surroundings of springs in the neighborhood." (R34)
Interactivities	Creating social objects in the exposition that enable the publics to interact with each other and connect with their daily lives.	"It seeks not only to disseminate scientific information but also to bring science closer to visitors' daily lives, offering a space for discovery, reflection and enchantment by science and technology through interactive activities." (R30)
Labor positions	Developing actions that assist vulnerable groups in acquiring the technical skills and abilities necessary to secure employment.	"We have three main projects in our Social Action: • Jardim da Ciência Project, which works with training in gardening for low-income people • Gepetto Project, which forms groups of teenagers from the communities surrounding the Museum to work in the manufacture of toys and pedagogical craft games • CLICidadão, which works with digital inclusion, offering computer courses for low-income communities." (R9)

(Continues)

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TABLE 1 (Continued)

Categories	Description: Social participation means	Example
Science literacy	Facilitating public understanding of various aspects of science, including concepts, values, and skills required to involve in socioscientific issues.	"Our programs aim to awaken young talents to scientific research and artistic activities and involve them, from an early age, in practical activities where there is contact with the current challenges of science, the methodology of scientific work, the human environment of Research laboratories and the different forms of artistic expression." (R3)
Belonging	Establishing relations that enable the publics to develop a strong connection with museums and/or their respective regions/locations	"The exposed organisms occur in the region, so the exhibition is inserted in the reality of the visitors. The project team produces Part of the collection from animals killed in roadkill on local roads, transforming these specimens into a powerful means of disseminating information about biology and the importance of biodiversity. The region has a unique biological diversity that is little known by the local population. In addition, the region has experienced unbridled demographic growth in recent decades, which has been reflected in severe socio-environmental degradation. The main objective of this exhibition is to make the population feel closer to biological diversity so that environmental and ecological awareness can be developed." (R11)

The selected texts were published between 1999 and 2018, with 36 originating from research in Latin American countries (including Brazil), 19 from North America (primarily the United States), 17 from Europe (mainly the United Kingdom), three from Asian countries, and two from Australia. Unfortunately, we found no papers from African countries. The analysis of these texts focused on descriptions of participatory actions, the meanings attributed to these actions, and the conceptions expressed by the authors regarding social participation, as interpreted by the researchers. This analysis resulted in 117 excerpts, considered as units of context. They were carefully read to identify particularities[4] and underwent open coding.

3.4 | Step 4—Deeper analysis

In the second stage of abstraction, the units from the literature were grouped based on their similarities. We then established relationships between these groups and the eight categories emerged in the second step. We aimed to identify conflicts, tensions, contradictions, and complementarities. By articulating and negotiating the recording units from both the survey 1 and literature research data sets, the description of the emerging categories was enriched and deepened.

Through this analytical process, we understand that the category "publics at the center" could be integrated into the "access" category, as access encompasses not only entry but also the sense of welcome and permanence in the institution (Chiovatto et al., 2010). The category of "collaboration" was identified as one of the "co-creation and authorship" levels, leading to the decision to merge these two categories (Simon, 2010). The category of "interaction" was found to be closely related to the idea of "dialogue," resulting in the expansion of the category to

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"interaction and dialogue." The categories of "labor positions" and "science literacy," which both involve helping the publics exercise their rights as citizens, were combined and expanded into the category of "exercise of citizenship[5]."

Furthermore, the category of "belonging" was disassembled. When the recording unit referred to feeling welcome at the institution, it was regrouped under the "access" category. However, when it referred to generating a sense of belonging to a place or group, recognition, and legitimation of identity, it was included in another category called "identity and diversity," which also encompasses other senses and meanings found in the literature.

As a result of reorganizing and consolidating the initial categories, five groupings (named dimensions) emerged: access, identity and diversity, co-creation and authorship, exercise of citizenship, and interaction and dialogue. We considered these dimensions to form the concept of social participation in science museums. A synthesis of these five dimensions is presented in Table 2.

Based on the cultural-historical perspective, phenomena are understood in their dynamic nature. Then, it is possible to revisit the central problem using new approaches and incorporating additional content (Davidov, 1988). This approach allows us to return to concrete to consider the subjects in their material activity, keeping in mind the emerging dimensions.

3.5 | Step 5—Educators survey (survey 2)

To further explore the concept of social participation, we conducted a survey (survey 2) targeting educators from Brazilian science museums. We chose to focus on educators as they are directly involved in implementing participatory educational actions. Their perspectives and experiences are crucial for understanding the concept, although they alone are not sufficient.

TABLE 2 The meanings and senses attributed to social participation in five dimensions.

From the perspective of:	Social participation is related to:
Access	• Equity in the use of space • Strategies that allow audiences to enter museums • Language comprehension
Identity and diversity	• Agency in memories construction and sharing • Legitimation of identities • Activism • Denunciation of injustices • Review of power dynamics
Co-creation and authorship	• Creativity • Visitors' contribution with objects and ideas • Power sharing • Connections between people • Shared curation
Exercise of citizenship	• Social and/or local transformation • Action on social issues • Scientific literacy • Formulation of public policies • Influence on the research agenda
Interaction and dialogue	• 'Hands-on' exhibitions • Use of technological resources and social media • Multi-directional experiences with content • Alterity and modification of opinions • Institution as a social place

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It is important to acknowledge the limitations of this approach. Our understanding of social participation is at an intermediate level, which may not capture the specificities of individual situations or include the voices of other stakeholders such as the publics, coordinators, or policymakers. Additionally, we did not provide opportunities for direct dialogue among educators, as Engeström et al. (2006) suggested in their research.

As researchers, we took on the responsibility of articulating and facilitating dialogue among the different meanings and senses expressed by the participants. Then, we recognize that the concept of social participation, under construction in this research, is a result of the articulation of educators' voices from Brazilian science museums in their praxis and of scholars on the subject and their meanings presented in theoretical works, including the authors of this study.

To ensure a diverse representation of educators from various museum contexts in Brazil, we distributed survey 2 via email to educators or educational departments of museums listed in the ABCMC guide during the first semester of 2018, clearly indicating that it was intended for educators and asked about their positions or roles within the institution, as well as their direct involvement with the publics. For institutions that had already participated in survey 1, we made a separate contact remembering their responses from the first survey.

The objective of survey 2 was to validate the five dimensions of social participation based on the educators' voices and the meanings and senses expressed by them. The survey 2 aimed to deepen our understanding of these dimensions, reinforce their importance, and potentially modify them based on the insights provided by educators. Additionally, we sought to examine the relationships between the dimensions to gain a comprehensive understanding of how they interact with each other.

During the development of survey 2, the questions were modified based on ongoing dialogue between the researchers and a pilot study involving two educators from science museums in São Paulo.

The survey 2 consisted of a presentation, six open-ended questions, and one closed-ended question related to the topic of social participation. Sociodemographic questions and a consent form followed these.

The first and second questions ("In your opinion, what is the importance of museums for society?" and "How could museums contribute to a greater approximation and involvement between the publics and the sciences?") aimed to explore if and how the educators integrated participatory processes into their vision of the relationship between museums and society. The use of the terms "approximation" and "involvement" in the second question aimed to guide the respondents' views toward participatory processes.

The third question ("Is there any action or project in the institution where you work that has the explicit objective of promoting social participation? If so, please describe it briefly") introduced the term "participation." The goal was to encourage reflection on their current praxis and identify elements related to social participation. The fourth ("If you answered affirmatively to the previous question, for which publics are targeted the actions described?") allowed for reflection on the social groups involved in the participatory activities.

The fifth question ("In your opinion, what would be the necessary changes in a science museum to make it more participatory?") aimed to capture the contradictions that educators perceive in their current practices and uncover the meanings and senses for the future, in which new systems of activities with social participation as a central element could be developed.

The aim of the sixth question ("What do the following terms mean to you: social participation, social inclusion and engagement?") was to directly capture the educators' meanings and senses about these terms.

Finally, in the seventh and final question, educators were asked to select depictions related to the dimensions that best aligned with their meanings and senses of a participatory museum in order of preference. This question aimed to validate the dimensions developed and highlight them for the respondents.

3.6 | Survey 2 respondents

In survey 2, all respondents declared themselves educators, but their roles vary. Among the respondents are those who occupy positions of educators or technicians in education (18), but other professional categories are also

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present among the respondents: directors (5) or coordinators (6) of the educational sector, lecturers (4), trainees (4), sector heads (3), supervisors (1), and others. This indicates that there are hierarchical divisions of work within the educational sector of these institutions. Although a comparative analysis between the answers and the positions or functions of the respondents was not conducted, it is recognized as a relevant factor for the diversity of meanings and senses presented and the potential contradictions that may arise.

Regarding gender, 31 respondents identified as female educators, 25 as male educators, and five did not specify their gender. The majority of respondents were biologists (20), followed by physicists (6), pedagogues (5), and chemists (4). The level of training varied, ranging from undergraduates to post-docs. Eighteen educators reported having specific training in the field of education, while five had training in Communication. This diversity highlights the range of subjects who work as educators in Brazilian science museums.

3.7 | Considerations between survey 1 and survey 2 participants

In survey 1, 46 Brazilian science museums were represented, while survey 2 had 61 participating educators. However, since four educators worked at the same institutions, survey 2 represented 59 science museums. Out of these 59 institutions, 26 were also represented in survey 1. Therefore, when combining the results of both surveys, a total of 79 Brazilian science museums were involved in this research.

During our analysis, we did not observe significant variations in the descriptions of participatory activities, meanings and senses expressed by educators from the same institution. We also found that the professionals from the same museum who responded to both surveys had similar perspectives. Based on these findings, we considered the institution as a respondent and the professionals as representatives of the actions and their meanings and senses. Thus, the total number of participants in this research is 79. To maintain the confidentiality of the respondents and the museums involved, we will identify the respondents using the letter "R" followed by a number.

It is important to note that all regions of Brazil were proportionally represented in the distribution of museum institutions, reflecting the political and economic disparities between different regions of the country. The participating institutions represent various scientific areas and encompass a wide range of typologies, including natural history museums, science centers, zoos, planetariums, botanical gardens, butterfly houses, and ecomuseums.

Table 3 provides an overview of the number of institutions/individuals contacted, the number of respondents, and the response rates for both survey 1 and survey 2.

3.8 | Step 6—Final analysis

The responses to the open-ended questions of survey 2 resulted in a total of 434 recording units. We used NVIVO software to organize and code them. We conducted a deductive content analysis using the dimensions (access, identity and diversity, co-creation and authorship, exercise of citizenship, interaction and dialogue) as categories to

TABLE 3 Number of involved institutions and individuals.

Research tool	Number of email submissions	Number of respondent institutions	Number of respondent individuals	Return rate
Survey 1	229	46	46	20%
Survey 2	260	59	61	23%

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code the recording units and interpret the meanings expressed by educators in survey 2. This process allowed us to identify, reinforce and validate the dimensions under construction.

To ensure the validity of our analysis, we randomly selected approximately 20% of the responses from survey 2 and analyzed them individually, relating them to the dimensions. Then, the three researchers involved in the analysis discussed, seeking consensus. The remaining responses were analyzed by one researcher, considering the consensus established by the group.

We generated a text based on the complete data analysis (Survey 1, literature research and Survey 2), representing our "concrete thought." It includes the description of the data, the interpretation of our findings, an explanation of how we combined the recording units in the dimensions, and a synthesis of the proposed dimensions and their relationships. Ultimately, this analysis culminates in a social participation model.

4 | THE EMERGING DIMENSIONS FROM A DIALOGUE AMONG DIFFERENT VOICES

In this section, we will discuss our findings, reproducing the process of emerging the dimensions of the social participation concept through our analysis. The dimensions will be described regarding the relations between the meanings and senses identified from the data of all research steps. We chose to include examples of responses from educators that illustrate the particularities of the proposed dimensions and meanings from the literature that dialogue with these particularities, complement, and expand them. When the example represented a sense expressed by different respondents, we quantified the percentage of respondents who shared it to reinforce its importance in our data.

4.1 | A very noticeable dimension: Access

According to Brazilian educators, social participation begins with facilitating the publics' entry into museums. Approximately 19% of the respondents in this study identified barriers to entry and discussed the concept of social participation in museums as a means of overcoming these barriers. They implement various actions, such as providing free or reduced-price tickets, partnering with companies and volunteers to fund workshops and exhibitions for those who cannot afford admission fees, and collaborating with schools, universities, and government departments. With these actions, the respondents aim to facilitate people's entry into museums, considering economic difficulties.

Some respondents also highlighted the financial barriers faced by specific communities in accessing museums, mainly due to the concentration of science museums in central and urbanized areas. This centralization reflects the unequal distribution of resources in science and technology across Brazil (Moreira & Massarani, 2002). These respondents criticized the unequal distribution and suggested that public policies should be implemented to encourage establishing museums in towns further away from major urban centers to increase social participation. Other respondents mentioned the partnering with transportation companies or city governments to provide transportation for groups residing far from museums, thus overcoming this geographical barrier.

On the other hand, approximately 16% of the respondents engage in activities outside the museum to disseminate knowledge, artifacts, and interactive objects to communities located further away from the museums. The Brazilian Department of Popularization and Dissemination of Science and Technology has supported these initiatives since 2005 through specific public notices that promote the creation of Mobile Science Projects (Adam, 2018; Silva, 2015). Although governmental support for these projects was interrupted during the period when this research was conducted, some of these projects managed to continue operating, underscoring the importance of such public policies.

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These examples illustrate the possibility of expanding physical access (Chiovatto et al., 2010) to science museums or informal setting infrastructure (Dawson, 2014b) by overcoming tangible barriers. Other authors (Archer et al., 2016; Chiovatto et al., 2010; Chittenden, 2011; Dawson (2014a); Feinstein & Meshoulam, 2013; Kinsley, 2016; Lourenço, 2016; Silva, 2015) also acknowledge the existence of barriers and limitations within institutions that hinder the strengthening of the relationship between museums and public and expand the meaning and senses related to the access.

While the initiatives mentioned by the respondents are crucial, given the large proportion of the population that does not attend museums, ensuring admission to museums is just one step towards achieving broader social participation. Archer et al. (2016) and Dawson (2014a) provide examples where offering free admission to science centers in the United Kingdom did not result in diversifying and expanding the audience but increased attendance among the regular audience.

In the United States, Kinsley (2016) highlights the increase in efforts to promote social inclusion in museums to ensure public access to their activities and services. However, demographic studies on museum visitors in the US reveal that these efforts have not significantly extended beyond a privileged group. Despite the increase in projects aimed at promoting social participation and inclusion, the profile of visitors to science museums remains essentially the same. According to Dawson (2014a), this may be due to the cycle of social disadvantage in which these actions are embedded, making the more subjective aspects of science museums inaccessible to specific groups. Some individuals may perceive science museums as places not designed for people like them, leading to a sense of non-belonging.

Dawson (2014b) proposes a framework for access and equity in science museums that goes beyond physical infrastructure and includes literacy and community acceptance as additional elements. Literacy refers to the various skills and abilities required for visitors to participate in museum activities and the power dynamics implicit in these requirements.

To participate, visitors must possess a variety of skills and abilities. These include knowing how to conduct oneself within the museum, understanding where to go and what to do, and being able to read and interpret the dioramas. Additionally, visitors should have a basic understanding of scientific knowledge to comprehend the informational content and be familiar with the formal language used in written and spoken communication. It implies that the exhibits are designed and presented in a way that may be more or less accessible, depending on the specific skills required to interpret them.

In this sense, around 5% of the respondents suggest simplifying the language used in museums or providing explanations to make the content more accessible to a broader audience. For example, R71 recommends: "give more attention to the language, to the form of displaying," as "the use of excessive technical terms and the lack of contact with society is a major gap." Chiovatto et al. (2010) also recognize that the expositive discourses, when not understood by the public, act as a barrier that limit *cognitive access* to the museum.

In addition to physical and cognitive access, Chiovatto et al. (2010) describe a third dimension of museum accessibility called attitudinal access, which encompasses publics well-being and trust. We could bring this meaning closer to some responses, such as the one by E50, for whom museums can "Stimulate through science fairs the presence of schools within museums, provide guided tours to appreciate the history behind each object or animal, address how each individual is responsible for that place, providing mechanisms for society to belong to these places." (R50)

This meaning also aligns with the concept of community acceptance discussed by Dawson (2014b). However, although Chiovatto et al. (2010) think of identification and trust at an individual level, Dawson (2014b) focuses on how diverse social groups may feel welcome. For the author, access to museums also encompasses the development of relationships that give new meaning to power relations in museums and meet the community's needs and collaborative ways of working.

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Approaching Dawson (2014b) understanding, a few respondents express the importance of communities enjoying the museum and developing projects that take into account their needs, as expressed in the following excerpt:

> To produce exhibitions and educational actions, I see that most of the time, the issue is to think about what curators, educators, among others, believe is relevant to exhibit and then evaluate with the publics. I believe that publics have their desires, curiosities, and specific needs that must be met, heard in the process of building the discourses and actions of museums. (R81)

In the view of the respondents, these processes result in a significant level of participation, making the scientific content understandable and relevant.

The efforts of the research participants to overcome tangible and subjective barriers in the relationship between museums and the publics are evident. It is also discussed in the literature as a means to promote social justice and equity in science. Therefore, we understand that "access" is essential for the concept of social participation in science museums, constituting its first formative element.

From the perspective of access, a participatory museum includes strategies or changes in the infrastructure that allow physical or virtual access. It also involves creating expositive discourses that recognize diversity and seek to respect different audiences. Additionally, it requires changes in the power relations established in the institution and the creation of strategies to make more people feel welcome, comfortable, and represented in these spaces.

4.2 | How visitors perceive themselves in relation to museums: Identity and diversity

Approximately 12% of professionals attribute meaning to social participation in their responses that go beyond the experiences of individuals while involved in museum actions. For example, according to R30, museums provide experiences that:

> Mark them as individuals and touch their circumstances (regarding the publics)… I believe an experience like this generates an organic involvement between the publics, the institution, and the displayed sciences, something lasting and strong. (R30)

In this sense, social participation influences how individuals perceive themselves. This understanding aligns with the perspectives of Biasutti (2014), Monaco (2013), and Piqueras and Achiam (2019) on participation.

The researchers mentioned focus on studying how communities of practice are formed by educators in informal learning settings. From communities of practice perspective, our sense of identity is shaped by our personal experiences of participation and by how we and others perceive ourselves. Therefore, participation is viewed as a complex, individual, and social process. Through participation, individuals recognize themselves as active participants and negotiate the meanings of their practices, ultimately forming identities of participation (Wenger, 1998). Additionally, identities of "nonparticipation" can also be constructed. It can clarify why specific social groups do not recognize museums as spaces "for them," as discussed in the access dimension.

In this sense, promoting participation processes that consider the diversity of identities among the publics and non-publics individuals is crucial. It ensures that more people feel comfortable and encouraged to participate, creating participation identities. Initiatives like these contribute to developing inclusive, diverse, and multicultural institutions (Anila, 2017). From this perspective, a participatory museum can be seen as a space that embraces and respects multiple identities and diversities.

To foster a more diverse environment, Ng et al. (2017) propose forming alliances with community leaders or local institutions. This collaboration would involve joint efforts in building relationships between the

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museum and the community. Educator R28 presents an example that can be related to the action proposed by the authors:

> Often, groups of 50 to 100 young people wearing municipal public-school uniforms were seen walking around the park (where the museum is located) on Thursdays and Fridays during school hours. In those days, episodes of robberies allegedly carried out by them were also recorded. This scenario led to increased policing by the municipal guard and the military police, which began to "surround" the students and expel them from the park. To combat this reality, a group was created that brought together several institutions related to the park: museum, circus school, municipal guard, cooperatives, soccer school, Foundation of parks and gardens, samba school, among others. We are articulating to promote educational, artistic, cultural, and sports activities aimed at adolescent students from the municipal school system who attend the park. (R28)

In this example, several institutions collaborate to address a local social issue through a collective effort. The museum engages in dialogue with other spaces with diverse languages and knowledge, thereby transforming its relationship with the community. Brazilian museum professionals and authors provide further examples of participatory processes associated with diversity.

To institutionalize museum diversity, Morais and Reis (2018) propose developing a management plan that prioritizes diversity and promotes intercultural mediation. It involves creating opportunities for different social groups to develop and share knowledge and raising awareness about their differences and similarities. Similarly, R51 suggests "inserting into the organizational structure the creation of a commission formed by technicians from the museum and the community to opine on exhibition projects and educational actions."

In addressing the challenges of a diverse space, Hindley and Olsen Edwards (2017) discuss a project undertaken by a European museum aimed at helping children with the discomfort and losses caused by prejudice and racial discrimination. The authors recommend creating spaces for dialogue where individuals can express themselves honestly and be heard, fostering a greater understanding of different viewpoints.

Furthermore, to create spaces where multiple identities are equally valued, it is necessary to review the narratives presented in museums and recognize the power dynamics that perpetuate the dominance of certain ethnic groups and social classes over others (Dewhurst & Hendrick, 2017; Taylor, 2017). Anila (2017) emphasizes the importance of museum professionals identifying the stories being told in museums, the groups excluded from these narratives, and the power dynamics implicit in these forms of representation. From the recognition of these inequality structures and relationships, it is possible to reformulate them.

For example, the recognition that male scientists are predominantly represented in exhibitions prompted Brazilian museums to initiate workshops, panels, and lectures featuring accomplished women in the field. These efforts aim to inspire girls and help them realize their potential in pursuing scientific careers and recognize their rights to occupy spaces in scientific production, historically denied to them (Araújo, 2020). While this example focuses on gender representation, reviewing representations of race, class, and other identities is also essential.

Another crucial aspect related to representation is the diversification of human resources within museums. Brown (2018), Greenberg and Levinsky-Raskin (2017) and Ng et al. (2017) propose creating opportunities for individuals from diverse identities (ethnicity, gender, social class, and disability) to work in museums. According to these authors, diversifying the staff would bring new perspectives, ideas, and networks to museums, ultimately broadening engagement and demonstrating their relevance to the community.

Two educators describe practices in Brazilian museums that aim to increase staff diversity. For instance, R16 mentions that blind individuals are responsible for guiding visitors in the "sensory medicinal garden" at their institution. R29 discusses opening volunteer education and curator positions to young students from the community, with the potential for future employment.

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Projects like those mentioned by the research participants and found in the literature are not only about increasing diversity in Brazilian museums but also about promoting social justice and historical reparation. It is because the groups considered minorities in European or North American contexts actually constitute the majority of the population in Brazil.

Moreover, these groups of people, such as black and indigenous communities, are still underrepresented in science museums. Their stories are often told, and their identities are portrayed through the lens of the dominant ideology. These communities have historically been exploited and oppressed during the colonization process, and they continue to face marginalization. They are continually fighting for their rights, including those related to culture, food, housing, religion, employment, and education.

According to Bordenave (1994), the opposite of participation (or "nonparticipation") is marginality. Marginality is not a result of community backwardness but rather a consequence of modernizing development in a society where access to benefits is unequally distributed. From this perspective, social participation means actively intervening in social construction instead of being integrated into a system. It is a collective, transformative, and contesting process in which marginalized sectors are incorporated into society, scientific and cultural construction in their own right, rather than being treated as mere guests. This understanding of social participation has always existed in the Brazilian context, including in social movements related to race and gender issues. However, it gained strength in the 1990s, rooted in popular movements against the previous totalitarian regime. At this time, the struggle of popular movements gained visibility during the re-democratization of Brazil after the dictatorial period. It was also supported by public policies that institutionalized social participation (Bordenave, 1994).

Although during the period in which this research was conducted, many established channels of social participation were facing retaliation from a new wave of totalitarian thoughts, remnants of this interpretation of social participation are still perceptible in the meanings and senses expressed by the research participants. For example, the educator (R28) emphasizes the importance of the "protagonist of different social actors and representatives of different social groups" in her understanding of social participation. We also observe educators identifying dominant narratives in museums and highlighting the need to consider the voices of the publics to avoid "accommodating to the status quo" (R30) and to review these narratives while also "amplifying the voices of the subjects" (R81).

Nevertheless, from a more radical viewpoint, social participation in museums can be seen as a way to express previously silenced identities, challenging traditional museum typologies. In the Brazilian context, some communities have chosen to use agency to construct their memories through museological practices or by creating their own communication strategies with the publics. These initiatives denounce social inequalities and value regional and local identities, reinforcing diversity (Moraes, 2018; Soares, 2018). Through a sense of belonging and representation, these communities become advocates for historical, social, and cultural diversity, strengthening their identities and building new collective identities. "Several favelas (which are slum communities in the periphery of the cities) have been using the label 'museum' to implement a resistance device and to reclaim cultural and social rights. The museum is, then, a political instrument for invisible local groups to become political agents, existing socially through the museum agency" (Soares, 2018, p. 164).

Ecomuseums, community museums, favela museums, and other similar initiatives are examples of agencies that emerge from community groups or partnerships between museologists and the community. While different typologies and models exist, collaborative and creative participation and collective appropriation of heritage are standard features in these settings (Kaeseker, 2014).

In this sense, forms of social participation enable the denunciation of arbitrary practices and oppressions present in societies, showcasing the activism of communities that create platforms to amplify different voices, peoples, and practices.

From these discussions, it becomes evident that museum experiences can either facilitate dialogue between different identities toward diversity or erect barriers that reinforce inequalities. Therefore, the discussion about social participation in museums necessitates examining and reevaluating the power relations inherent in our society,

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which are also present in science museums. Consequently, the decision to participate or not in a museum is more than merely a random choice limited to the time individuals spend within the institution. However, instead, it pertains to processes that contribute to the formation and expression of their identities.

Hence, we consider "identity and diversity" as the second formative dimension of the concept of social participation. From this perspective, social participation involves highlighting differences and addressing inequalities. By critically analyzing these relationships and collectively working towards their redefinition, museums can contribute to becoming more diverse and inclusive.

4.3 | Inviting the publics to create: Co-creation and authorship

In this research, 21% of the respondents expressed that social participation occurs in processes where the publics are invited to collaborate in various ways and at different times in the history of an institution, even before it is implemented.

> Since the beginning of the planning and construction of the museum here in the region, we have tried to add the local population to our work. They were guides, we stayed in the homes of families who had gardens close to the archeological sites, we hired people to help with the excavations and transport the equipment with mules. After the institution was created, we even had a program that allowed the construction of five schools in the rural area around the park. The school team, managers and teachers, were people from the region, trained by a team from the university in partnership with the institution. (R13)

In this example, the community was involved in creating the museum and conducting research in the region. This shows the collaborative work and mutual benefits. On one hand, community members contributed to the institution as guides and transporters, or by hosting professionals as guests. On the other hand, the joint efforts resulted in improvements within the community, such as the establishment of parks and schools, professional training, and job opportunities.

Additionally, R12 presents a project called "Weekend at the Museum," where community members are invited to develop programs based on the monthly theme, under the supervision of an institution employee. R8 describes a project focused on a river in the region, aiming to create exhibitions and educational activities with community support. The community contributes by providing information about the river and visiting the exhibition circuit, which is based on the data they provided.

In these examples, the institution determines the theme or the form of community contribution, exerting a certain level of control. In other cases, projects emerge from collaborative work based on the community's needs. The actions are not predetermined but negotiated throughout the process. For instance, R34 describes a project developed in an illegal settlement, where a local nongovernmental organization (NGO) and the community identify relevant environmental issues and collaborate on socio-educational initiatives with leaders and professionals in the area. R22 presents projects organized by students, where they act as curators, conducting research on the objects to be exhibited and preparing exhibitions with minimal control from the institution.

Similarly, Brown and Novak-Leonard (2011) and Simon (2010) describe different models of participation, ranging from a category where the institution has more control and the audience has less involvement, to a category where the institution has little control. According to Brown and Novak-Leonard (2011), the ideal model for participatory practice is the one where the community has maximum expression, and the institution has minimum control. They view the other categories as steps towards achieving this ideal model. However, Simon (2010) argues that none of the proposed models is inherently better, and institutions should choose the models that align with their goals and interests. The author uses the term "participatory museum" with the following definition:

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> I define a participatory cultural institution as a place where visitors can create, share, and connect with each other around content. *Create* means that visitors contribute their own ideas, objects, and creative expression to the institution and to each other. *Share* means that people discuss, take home, remix, and redistribute both what they see and what they make during their visit. *Connect* means that visitors socialize with other people—staff and visitors—who share their particular interests. *Around content* means that visitors' conversations and creations focus on the evidence, objects, and ideas most important to the institution in question. (Simon, 2010, pp. ii–iii)

Another important aspect of this participatory model is that exhibitions are created and managed in collaboration with the publics, rather than being created "for" or "about" them. This blurs the line between museum professionals and the publics within the context of participatory practice. This approach helps to avoid exhibitions that represent "the other" from the perspective of the dominant identity, as criticized by Moraes (2018).

Other authors (Anila, 2017; Brown, et al., 2017; Gauvin, 2015; Gordillo Martorell, 2017; Greenberg & Levinsky-Raskin, 2017) also emphasize that participation in museums means involving people in multiple systems of creation and authorship. These authors highlight the importance of power sharing in participatory actions, as a form of activism and decolonization of exhibition discourses.

Based on the presented meanings and examples, we understood "co-creation and authorship" as another dimension of the concept of social participation in science museums. In survey 2, this dimension was attributed 56 times (12.9%). From this dimension, Science museums promote participation by developing actions that prioritize different forms of cooperation with their publics, giving importance to their creative expression and authorship, with varying degrees of control by the institution.

4.4 | Society as a participatory locus: Exercise of citizenship

R17 describes an environmental course for children. The children participate in the training offered by the museum, and then they are invited to develop actions about environmental issues in their communities. They may share the content they have learned and use the skills they have developed. In this experience, the children propose actions and make decisions about their local environmental problems. The central idea of this project is that by assuming active and participatory roles within museums or in actions promoted by these institutions, people develop skills that enable their participation in other situations or social issues outside the museums.

Some examples of actions described by 28% of the respondents include discussions about controversial issues that provide reflection on themes of interest to society, promotion of debates on current issues in science and technology, participation in decision-making processes involving science and technology, deliberative activities, citizen juries, and public hearings. In these examples, social participation focuses on helping people to think about science, understand what is done, solve problems, face new situations, question widespread knowledge, and consciously interact with the world around them (Bandelli & Konijn, 2015; Irwin, 2001).

These attributes can be related to current ideas of scientific literacy. For example, Rocha (2018) establishes a double relationship between social participation and scientific literacy. According to the author, scientific literacy processes provide subjects with the knowledge and skills necessary to participate, and participation is necessary to develop scientific literacy. In this sense and based on the mutual recognition of the contributions that both scientists and non-specialists can offer, decisions that concern society, in general, could be taken jointly (Navas, 2008; Souza & Rizzatti, 2015; Valente et al., 2005).

By assuming the role of bringing the publics closer to instances of public policy making, participatory museums become settings for publics hearings and other events where the actors of society meet to think about and debate interests, concerns, values, and ideas about the motives and purposes of scientific research (Meij et al., 2017). In

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this context, participatory museums can play a role as intermediaries between society, research institutions, and public policymakers, becoming platforms for scientific citizenship (Bandelli, 2016).

However, in countries with high levels of inequality, such as Brazil, the concept of citizenship, as a democratic ideal that includes all "citizens" in theory, must be questioned. Ribeiro (2017) remind us that the term "citizen" is not universally inclusive. On the contrary, it differentiates between "typical citizens" whose rights are assured and those "others" who need to fight to be considered citizens and to be able to exercise their rights. Therefore, it is not feasible to think about exercising citizenship in science museums without considering attributes related to access and identity and without reference to social conflicts.

In this sense, museums can be seen as tools in which participatory praxis and education for participation are developed and expanded, not as an end in themselves, but as a formative part for social participation and intervention in social, political, and economic struggles of the time (Bordenave, 1994; Moraes, 2021).

In this view, knowledge of science and the development of scientific skills play a fundamental role in understanding the complexity of society and the world we live in, especially in understanding the possibilities of social change. For example, R6 attributes the following meaning to social participation in science museums: "Individuals who organize themselves to carry out a process of change in favor of society." We can relate this sense of participation to the Science Technology Society (STS) international movement, which also gained strength in Brazil in the 1980s. This movement problematizes the history, use, and impacts of the science and technology on society in combination with Paulo Freire's liberatory pedagogy. It inspires practices and research in Science Education, especially in Latin America, and adds the transformation of social reality to the problematizing of science and technology (Kauano & Marandino, 2021).

We have noticed that Freire's thought influences some educators' answers that describe participatory actions to promote local transformations, as they assume a problem-centered and contextualized approaches. Moving in the same direction, Carvalho et al. (2015) and Mauricio and Teodoro (2011) propose and analyze actions that go beyond the walls of museums carried out in communities. They conclude that discussions on socio-scientific and controversial issues, such as pollution, the spread of diseases, food contamination, or natural resources conservation, can be conducted within communities based on local problems to promote social transformation.

In summary, science museums create opportunities for participation, which support audiences in formulating and expressing opinions, developing argumentative skills, and fostering critical thinking. These attributes are essential for the exercise of citizenship. Thus, we consider the exercise of citizenship the fourth dimension of the concept of social participation. By participating, individuals develop scientific skills and contribute to social transformation processes. It can be achieved by influencing public science-related policies, acting in their communities, and participating in individual or collective decision-making processes involving science and technology.

4.5 | Museums as networks of multiple possibilities: Interaction and dialogue

While some meanings and senses associate social participation with the broader scope of the museum institution and its impact on society, about 17% of the respondents expressed a narrower understanding of social participation within the context of museum exhibitions. According to Simon (2010), in a traditional institution, the exhibition content is transmitted to the publics in a one-way manner, with the institution providing content for people to consume. The exhibition design aims to ensure a consistent experience for all visitors, regardless of their interests or background.

In contrast, a participatory institution, as Simon (2010) describes, allows for diverse forms of interaction, and considers the content multidirectional. It means that the interaction can occur between the institution and the publics, among visitors, or between visitors and mediators. A participatory institution is the one that supports

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multidirectional experiences with content. The institution cannot guarantee the same visitor experiences, rather it provides opportunities for different visitor experiences.

R20 describes an exhibition space in her institution that exemplifies multidirectional experiences. It is a garden where workshops are developed to expand the concept of a family garden. These workshops facilitate participants directly interacting with plants, dialogue among themselves and educators, and sharing their knowledge and workshop experiences with their families and the community. The garden workshops also allow the creation of proposals by educators based on participants' input and background. This garden is the exhibition's focal point that sustains shared social experiences. Using Simon's (2010) words, the garden is a "social object" around which conversation takes place, enabling social participation.

> [in this exhibition] real human and animal pieces were preserved with the Plastination technique… This method allows the visitor and researchers to manipulate the pieces, something powerful and striking, like holding a human brain in their hands… the visitor can touch, pick up, feel, and compare real pieces such as human and animal brains, complete skulls, different bones and even bones with metallic prostheses… The interaction is so great that we allow the visitor to take photos and videos of the moment, as long as they respect the fact that they are real pieces. (E30)

In this example, social participation is evident in the publics' decisions regarding their interaction with exhibition objects: Is it ethically correct to manipulate authentic human body pieces? Is it ethical getting photographs or films of human bodies?

Similarly, considering artifacts in museum collections and their relevance to the publics, R1 and E45 discuss the practice of observing the sky using telescopes and promoting amateur astronomy. R49 mentions the use of microscopes, creating slides, and conducting experiments with glassware and chemicals. R57 involves interactive activities with domestic and wild animals to stimulate discussions on sustainability. Overall, these objects can be understood as "social objects" because they encourage interaction either with the objects or among people. In this sense, science museums play a crucial role in promoting social participation by offering diverse opportunities for engagement and interaction with content.

> Mediations are developed by educators oriented to encourage public participation, whether in person (in the exhibitions) or interactively (on social media). On Instagram, for example… we launch challenges and propose research and debate among participants. (R28)

Furthermore, as seen in the response given by R28, 6% of the respondents consider participatory actions that involve interactivity through the use of technologies and social media. Brazilian museums commonly use social media as an interactive platform for visitors to provide feedback, share their perceptions, and ask questions about their visits. Social media is also used to promote museums' projects and events.

Santana (2016) also points out the use of information and communication technologies as a means to encourage participation. According to the author, these technologies allow visitors to express their opinions, share knowledge, engage in creative activities, and interact with other visitors and professionals.

During the COVID-19 pandemic, museums have made significant changes in how they utilize digital technologies. These technologies had become in many cases the primary means of communication between museums and their audiences. Additionally, it is essential to highlight that many Brazilian museums have prioritized addressing the immediate needs of their audiences, such as providing food and information on prevention and treatments.

Brown et al. (2017) and Katrikh (2018) also discuss participatory actions that encourage social interactions for challenging conversations where multiple perspectives can be shared and discussed. In this context, participants are

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encouraged to ask questions and share their ideas and interpretations, while educators facilitate and create a safe and courageous space (Katrikh, 2018).

Some studies emphasize the benefits of interaction, including increased audience motivation, support for conceptual learning, and cognitive gains. For example, Judson (2011) analyzed a practical activity in which children interacted with displayed objects and worked in groups in a museum setting. The author found that children gained important conceptual understanding by participating in this activity. Yoon et al. (2013) describe technological systems in science museums that support collaborative learning, creating computational systems that enhance individual interactions. Shaby et al. (2016) argue that these forms of participation effectively engage visitors with museum exhibitions and the scientific issues they present.

It aligns with the objective of R30, who aims to bring science closer to visitors' daily lives through an interactive mobile science project, providing a space for discovery, reflection, and fascination with science and technology.

However, the experience of participation depends on visitors' familiarity with the objects, their ease of interaction, the clarity of instructions provided by the museum, and participants' prior knowledge. Therefore, attention must be given to these aspects to ensure the exhibition is user-friendly and comfortable for visitors.

In this understanding of social participation, individuals can engage in various ways: by manipulating physical objects in the exhibition, including technological devices; by interacting with virtual objects through the internet; or by having conversations with other visitors and museum professionals. This shift from a passive role of observing and absorbing content to an active role of interacting and dialoguing with the content is what we consider the "interaction and dialogue" dimension, which is the fifth component of the concept of social participation in science museums.

5 | SOCIAL PARTICIPATION: SYNTHESIS AND TENSIONS

We proposed five dimensions from our data set analysis representing the social meanings constructed during our analysis process. These dimensions are summarized and presented in Table 4. We consider access, identity and diversity, co-creation and authorship, exercise of citizenship, and interaction and dialogue essential in the construction of the concept of social participation.

Table 5 presents the dimensions of social participation and their corresponding frequency in each data set. In the first column, we featured the five dimensions; in the second column ("Respondents"), the percentage of respondents who expressed meanings and senses related to that dimension at least once and their answers to the two surveys. It is necessary to highlight that the same respondent may have expressed meanings related to one or more dimensions in different data sets. Columns 3–5 refer to occurrences of each dimension in the data sets and their respective percentages.

The dimension "access" is prominent in the responses of museum professionals in surveys 1 and 2. It demonstrates the efforts of Brazilian professionals to approach the publics. It also highlights that access is a significant issue in the Brazilian context when discussing social participation in science museums, particularly concerning regional and class inequalities.

The dimension "identity and diversity" is well-represented in the literature studied and has helped us understand the meanings and senses expressed by educators in their responses, particularly in survey 2. Based on our data, discussions about this dimension of social participation are still in the early stages of Brazilian science museums' educational praxis, because the attributes related to this dimension are generic and still need to be fully evident in their current educational actions. For example, to refer to the target audience, in general, educators use terms such as "general public," "interested public," "all publics," or "everyone."

Ribeiro (2017) is a Brazilian author and black feminist activist. She questions who and how many people are included in the term "everyone" when referring to specific public policies. Venâncio (2023), who studied public policies in science and technology, argues that failing to recognize our different starting points leads to legitimizing

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TABLE 4 The participatory museum and the five dimensions of social participation.

From the perspective of dimension:	A participatory museum seeks to:
Access	eliminate barriers to participation that promote social exclusion; develop strategies that allow people to enter the institution; build an expositive discourse based on the recognition of diversity; respect and represent different publics; and make changes in the power relations established in the institution to create strategies so that more people feel welcome, comfortable and represented in these spaces.
Identity and diversity	establish itself as a multicultural space that investigates and re-signifies oppressive and inequalities-generating relationships and integrates social actors of multiple identities, institutions, and community segments so that they can dialogue. Through participation, new personal and social identities are being built. In addition, participation is essential to represent, hear and challenge different memories, knowledge, stories, and voices, providing different interpretations of the world and promoting equity and social justice.
Co-creation and authorship	develop its actions from different forms of cooperation with its publics, prioritizing its creative expression and authorship, considering, for example, an invitation to express opinions and criticisms and to contribute with objects or ideas; establish partnerships in the creation of institutional projects or works developed since their conception with the publics, defining collective objectives and generating a program or exhibition based on the interests of the community; provide resources, space and tools for visitors to develop their own projects with little or no control of the process.
Exercise of citizenship	act as a citizenship platform, developing educational actions to develop citizenship skills, helping the publics to participate in social change, in decision-making processes in society and formulation of public policies; promote, for example, debates and dialogues on socio-scientific issues, or involve communities in collaborative processes of local transformation that start from community demands.
Interaction and dialogue	support multidirectional experiences with content; use technological resources or practical activities to expand the possibilities of interaction with the exhibition, with other visitors or with museum educators. The design of exhibitions or educational actions favors interaction by stimulating questioning, dialogue, and the collective use of objects or exhibition devices.

TABLE 5 Occurrence of mentions of the five dimensions of science participation in the three data sets analyzed.

		Survey 1 (n = 58)		Literature (n = 117)		Survey 2 (n = 434)	
Dimension	**Respondents (n = 79)**	***n***	**%**	***n***	**%**	***n***	**%**
Access	60%	28	48.3	17	14.5	131	30.2
identity and diversity	12%	4	6.9	30	25.6	87	20
co-creation and authorship	21%	14	24.1	15	12.8	56	12.9
exercise of citizenship	28%	6	10.4	32	27.4	62	14.3
Interaction and dialogue	17%	6	10.4	23	19.7	98	22.6

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an exclusionary discourse. Therefore, according to these authors, it is necessary to name and re-signify gender, race, and class identities to deconstruct the dominant normalization based on the visibility and voices of subjects hidden in the expression "everyone."

Declaring that educational museum activities are for "everyone" can lead to the homogenization of audiences and disregarding their specificities. As a result, those who do not have access to museums may be made invisible. Consequently, we mistakenly assume that those interested in museums can easily access these spaces. Thus, museums should be more accurate in their evaluations of the publics because, ignoring these discussions can limit museum actions to specific audiences and perpetuate patterns of social inequality.

However, when asked how museums can become more participatory, the educators understood that they should consider identity and diversity to promote effective social participation in future activities. These considerations are essential because Brazilian culture and ethnicity are diverse and differ from the European origins of traditional museums, which often represent science and scientists from a Eurocentric and hierarchical perspective.

The dimension of "exercise of citizenship," mentioned by nearly 28% of our respondents, is widely discussed in the literature, particularly concerning science museums. These papers often connect social participation with other essential topics in Science Education, such as the STS movement, scientific literacy, and the influence of Freirean thought in Latin America.

The dimension of "co-creation and authorship" is more commonly discussed in literature about museums of other typologies than science museums. However, the elements of this dimension could be valuable for expanding discussions on social participation in science museums.

Lastly, the dimension "interaction and dialogue" was the second most frequently mentioned in survey 2, indicating that the respondents in this research place great importance on participation within the museum setting. For instance, respondents R49 and R66 believe that a participatory museum should utilize technology to engage with the publics and generate interest. They argue that the communication between visitors and exhibitions needs to be modified, and interactive technologies should be employed, drawing inspiration from successful initiatives in North American and European museums.

However, the senses of these two educators contradict other senses present. For example, R62 and R81 educators express "co-creation and authorship" ideas when discussing communication between visitors and exhibitions. They emphasize the importance of considering the interests of the publics in the elaboration and construction of museum discourse and actions. Thus, we notice a tension between stimulating the publics' interest or taking their interests into account.

Furthermore, it is essential to question a specific aspect of R49 e R66 responses. Some North American and European museums serve as references for participatory initiatives in Brazil. However, simply imitating their exhibitions without considering the various aspects in which European and North American realities differ from the Brazilian context, can increase barriers to social participation due to the lack of resonance with the Brazilian specificities, needs, and interests.

On the other hand, the presence of meanings related to the dimension of "co-creation and authorship" in the R62 and R81 responses demonstrates their recognition of the importance, and even the necessity, of collaborative processes to justify the social significance and sustainability of museums. This idea is connected to the central tension highlighted by the educators: the lack of financial resources and training for expanding participatory initiatives.

Educators propose strengthening museums through public policies to overcome financial difficulties. For instance, one educator is concerned about securing resources for maintaining exhibitions, particularly interactive ones, and emphasizes the significance of specific government initiatives in this field.

> We lack financial resources for maintaining exhibitions and interactive installations, especially electronic and computerized ones (which require frequent updates and maintenance). We lack specific calls for this in museums, so creating an exhibition can be easier than maintaining it. (R15)

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Educators of science museums encounter complex challenges when attempting to implement participatory initiatives. These challenges often involve interactions with governmental institutions. When considering the concept of social participation in museums as constructed in a system of collective activities, the governmental sphere and its subjects play an essential role in formulating, incentivizing, and regulating policies for social participation.

Returning to the voices of educators, it is important to note that the presence of dimensions in the educators' responses does not imply that they have a comprehensive understanding of all the aspects that each dimension encompasses. For example, suppose a respondent mentions "free admission to increase social participation," related to the "access dimension." In that case, it does not necessarily mean that they recognize or have mentioned the "need for revising the language used in science exhibitions." Therefore, the educators' understanding of social participation in science museums is not exhaustive.

This tension highlights another issue in the Brazilian context: the disparity between what is conceptually considered in terms of social participation and what is feasible and possible on the floor of Brazilian science museums. Extreme inequalities, historical factors, and the traditional banking model of education (Freire, 2018) influence this tension. Furthermore, the importation of a hierarchical and Eurocentric vision in science museum education in Brazil, coupled with the resurgence of totalitarian and neoliberal ideologies, makes social participation challenging to achieve.

However, tensions, conflicts, and contradictions are expected to arise in multivocal activities. While these tensions pose obstacles to social participation in science museums, they can also serve as catalysts for transformative agency. The issues discussed in this section are some of the tensions and contradictions observed in our data. These contradictions are not new, but the proposal to use "social participation" as a concept under construction brings them to the forefront of current activities. Therefore, we emphasize the importance of constructing and utilizing the concept to raise awareness of these contradictions. This consciousness can mediate the formulation of new social relationships and tools that enable the transition from the subjects' current actions to other more participatory future practices.

However, the occurrence of all dimensions in the responses of the surveys demonstrates that these dimensions resonate in professional praxis. These tensions are inherent to the dimensions of social participation, highlighting its complexity and reinforcing the importance of expanding the analysis.

Furthermore, another point of complexity is that the same idea expressed by educators or authors may relate to more than one of the proposed dimensions. It occurs because the dimensions are not rigid categories with fixed conceptions. Instead, they are interconnected with the senses and meanings attributed to "social participation" and the practices that embody this term. Although we have presented the dimensions separately to clarify their construction process, they can overlap, complement each other, and present contradictions in certain aspects.

6 | PROPOSAL OF A SOCIAL PARTICIPATION MODEL IN SCIENCE MUSEUMS

In Figure 1, we present a systematization of some central attributes regarding the meanings expressed by educators and authors and the attributes that we consider to be in the borders between dimensions.

According to the proposed model, a specific interpretation of social participation can be connected to multiple dimensions and other relationships can be established. For instance, "reviewing power dynamics" (a characteristic of the identity and diversity dimension) is also crucial for discussing access and facilitating creative and authorial processes. Similarly, the "connection between people," which is fundamental in the dimension of interaction and dialogue, can also contribute to the well-being of individuals in the museum context. This connection can address issues of access and the recognition of individuals as active agents in processes of social transformation, thereby relating to aspects of exercising citizenship. This multiple relationship demonstrates the dynamic nature of the concept, where the key attributes of each dimension are interconnected with the others, forming a network.

This dynamic model can enrich the meanings of people involved in participatory processes in science museums and stimulate the appropriation of these phenomena. Additionally, the model can mediate the relationships and

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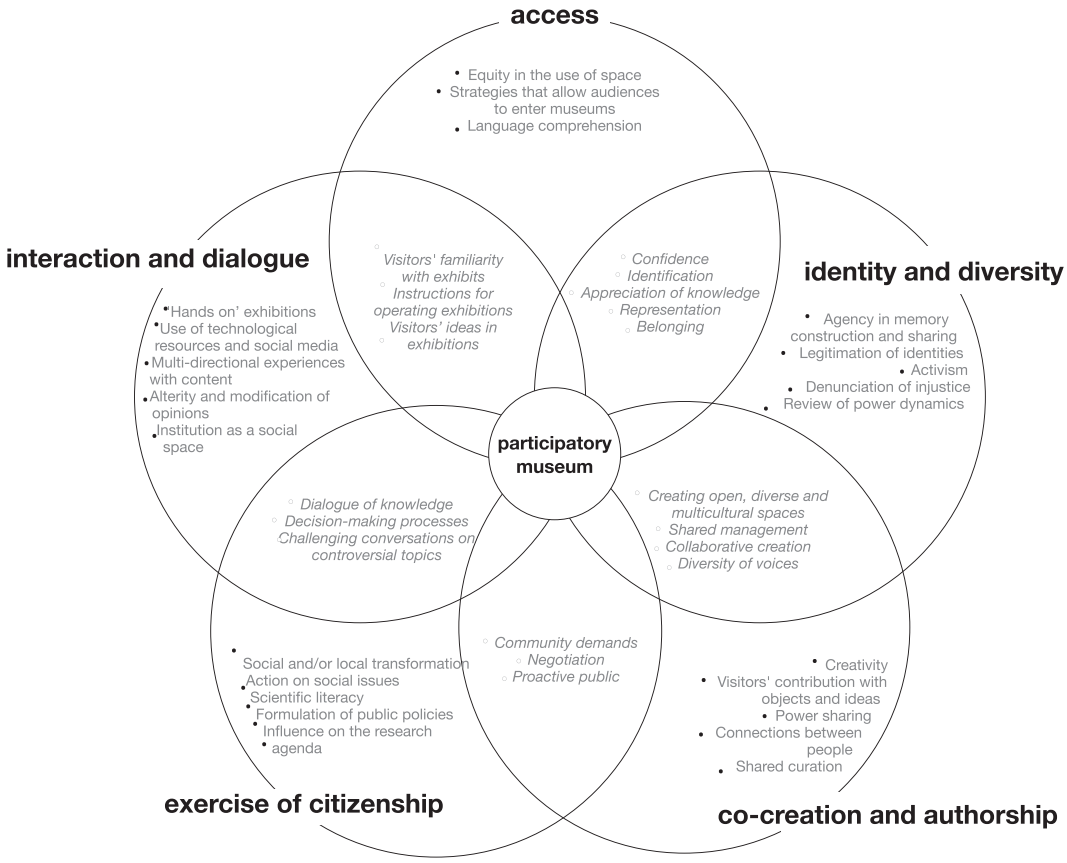

FIGURE 1 Participatory Museum model.

communication among individuals in their collectives, strengthening the construction of new meanings and senses that lead to participatory praxis in science museums and new historical forms of collective activities that transform social reality—and museums themselves.

7 | CONCLUDING THOUGHTS

Through statements of research participants and examining relevant literature, we have identified key dimensions that are essential to understanding social participation in science museums: "access," "identity and diversity," "exercise of citizenship," "co-creation and authorship," and "interaction and dialogue." These dimensions embrace various aspects of the concept in the context of science museums. Moreover, they include attributes highlighting different ways people can participate in these spaces.

7.1 | Limits of the study

The voices composing this analysis's results are essential because the educators and researchers in the field are active subjects in museum praxis. However, more is needed to embrace all the nuances of social participation. Participatory museums are about more than just creating exhibitions and educational programs towards

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participation. They involve the institution's knowledge-sharing, decision-making, and governance approach. It requires a review of power relations and a reconsideration of the sciences presented in museums. Additionally, it depends on external subsidies and policies.

The present research did not consider other participants' contributions, such as publics and non-publics, directors, curators, policymakers, and researchers, who are also involved in constructing the concept of social participation through participatory projects and actions.

Furthermore, the dimensions created for social participation in Brazilian science museums were on a meso level, based on different educators' input and did not consider local nuances or broader generalizations. Future research should focus on conducting more specific studies that account for the unique characteristics of each sociocultural context. To thoroughly understand social participation processes, it is essential to analyze them at both micro levels, such as through museum case studies, and macro levels, such as through public policies and international relations. In future research, we suggest incorporating interviews and focus groups to understand the phenomena better and more profoundly.

7.2 | Consideration for the praxis

In the present study, we conclude that social participation in Brazilian science museums is a process under implementation rather than a fact. Nevertheless, we recognize that building a shared understanding of the terminology through the lens of an epistemology of praxis can enhance communication among all stakeholders, not just educators and researchers, and improve social, political, and cultural approaches in the field. Ultimately, this can enhance equity and social justice in science and technology.

We do not expect educators and institutions to accept and implement the proposed model as a standard protocol. Instead, we recognize that educators are active agents in their context, capable of problem-solving and transforming their surroundings through praxis.

The dialectical relationship between educators and objective reality is a premise of educational praxis. In this relationship, the world is an object to be transformed through conscious action in the unity of theory and practice.

Thus, the proposed model, which results from a construction between theory and practice that emerges from our praxical activity as researchers, can constitute a new synthetic theoretical element for educational practices in science museums.

Therefore, we suggest that teams, including members of the publics and staff, especially educators, define the objectives, values, and premises of the participatory actions they want to develop in their territories and seek elements of the model that best suit their realities, demands and desires. We do not have predetermined methods for utilizing the model because we value the importance of individual and collective autonomy in contextualized and transformative educational praxis.

Although the voices in this study are Brazilian, the literature from several countries supports the dimensions constructed. Additionally, political and social movements from other countries also impact the practices and policies in Brazilian museums.

Studying social participation in Brazilian science museums, particularly considering Brazil's unique characteristics, such as intense inequalities, colonialist heritage, and cultural diversity, is crucial to broaden discussions about the preservation and communication of science and heritage in museums. We must ask ourselves “what for,” “for whom,” “why,” and “by whom” these museums are built and shared. Engaging in these discussions can help avoid further instances of epistemic violence in Brazil and Latin America and, conversely, open space for constructing shared and participatory experiences by different countries.

Hence, the dialogic process does not conclude at this point. Instead, the concept of social participation remains an ongoing construction.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

ETHICS STATEMENT

The research described in this paper was registered on "Plataforma Brasil," with the number of Presentation Certificate for Ethical Assessment: 97798718.4.0000.5464 and was approved by the Ethics Committee 5464—USP—Institute of Biosciences of the University of São Paulo—IBUSP and had funding through the CAPES Social Demand Program, effective from May 2018 to February 2020.

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ENDNOTES

[1] We chose to use the term "publics" in the plural instead of "public" in accordance with Bucchi and Trench (2014), who support the use of the term in the plural when it comes to Science and Society discussions, to emphasize that the public is diverse and even fragmented.

[2] We consider "participatory" the act of promoting participation and "participative" the act of participating in a given action. In general, these terms are used synonymously in English-language literature. In Portuguese, the term participatory can be considered a neologism.

[3] "Concrete thought" is a philosophical concept in dialectical materialism, signifying a mature way of thinking closely connected to reality. It is constructed through the comprehensive examination of an object or phenomenon, considering its development and interconnections (Netto, 2011).

[4] In dialectical materialism, the term "particularity" refers to simple but interrelated concepts that emerge from the analysis (abstraction) of the phenomenon under study (Netto, 2011).

[5] The term citizenship—polysemic and full of conflicts—is widely used both in the texts studied and in the educators' statements. However, it was not the aim of this research to carry out an analyzes of the meanings attributed to the term. We consider it necessary in future research to better understand how the conception of citizenship assumed by educators and researchers can influence educational praxis.

REFERENCES

Adam, J. R. (2018). Da rede ao rastro: aspectos da trajetória da política museológica brasileira. *Anais do Museu Histórico Nacional*, *50*, 167–183.

Anila, S. (2017). Inclusion requires fracturing. *Journal of Museum Education*, *42*(2), 108–119. https://doi.org/10.1080/10598650.2017.1306996

Araújo, N. (2020). *Museus de ciência e as questões de gênero e etnico-raciais: um estudo sobre o dia internacional das mulheres e meninas na ciência* [Especialization's Thesis, Fundação Oswaldo Cruz]. Trabalhos de Conclusão de Curso—Especialização em Divulgação e Popularização da Ciência. https://www.arca.fiocruz.br/handle/icict/46235

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Archer, L., Dawson, E., Seakins, A., & Wong, B. (2016). Disorientating, fun or meaningful? Disadvantaged families' experiences of a science museum visit. *Cultural Studies of Science Education*, *11*(4), 917–939. https://doi.org/10.1007/s11422-015-9667-7

Archer, L., Dewitt, J., & Osborne, J. (2015). Is science for us? Black students' and parents' views of science and science careers. *Science Education*, *99*(2), 199–237. https://doi.org/10.1002/sce.21146

Associação Brasileira de Centros e Museus de Ciências. (2015). *Centros e museus de ciências do Brasil, 2015*. http://www.museudavida.fiocruz.br/media/centros-e-museus-de-ciencia-do-brasil-2015%20novaversao.pdf.

Bandelli, A. (2016). *Contextualizing visitor participation: European science centers as a platform for scientific citizenship*. [PhD thesis, Vrije Universiteit]. Ecsite https://www.ecsite.eu/sites/default/files/dissertation_bandelli.pdf

Bandelli, A., & Konijn, E. A. (2015). Public participation and scientific citizenship in the science museum in London: visitors' perceptions of the museum as a broker. *Visitor Studies*, *18*(2), 131–149. https://doi.org/10.1080/10645578.2015.1079089

Bardin, L. (1977). *Análise de conteúdo*. Lisboa Edições.

Barros, J. P. P., Paula, L. R. C., Pascual, J. G., Colaço, V. F. R., & Ximenes, V. M. (2009). O conceito de "sentido" em Vygotsky: considerações epistemológicas e suas implicações para a investigação psicológica. *Psicologia & Sociedade*, *21*(2), 174–181. https://doi.org/10.1590/S0102-71822009000200004

Biasutti, L. D. (2014). *O engajamento mútuo como elemento formativo de mediadores em espaço de educação não-formal* [Master's Thesis, Universidade de São Paulo]. Biblioteca Digital da USP. https://doi.org/10.11606/D.81.2016.tde-24062016-145910

Bizzo, E., Furst, R., Antunes, J. J. M., Wanke, P., & Mixon, Jr. F. G. (2021). State-level educational performance in Brazil: A MCDM approach taking a governance perspective. *Journal of Multi-Criteria Decision Analysis*, *29*(3–4), 1–19. https://doi.org/10.1002/mcda.1765

Bordenave, J. E. D. (1994). *O que é participação* (8th ed.). Brasiliense.

Brown, A. S., & Novak-Leonard, J. L. (2011). *Getting in on the act*: *How arts groups are creating opportunities for active participation*. James Irvine Foundation. SITE

Brown, J. A. (2018). The case for an inclusive museum: a perspective from excluded groups and communities. In B. B. Soares, K. Brown, & O. Nazor (Eds.), *ICOFOM Symposium. Defining Museums of the 21 Century: Plural Experiences* (pp. 119–128).

Brown, L., Gutierrez, C., Okmin, J., & McCullough, S. (2017). Desegregating conversations about race and identity in culturally specific museums. *Journal of Museum Education*, *42*(2), 120–131. https://doi.org/10.1080/10598650.2017.1303602

Bucchi, M., & Trench, B. (2014). Science communication research: Themes and challenges. In M. Bucchi & B. Trench (Eds.), *Routledge handbook of public communication of science and technology* (2nd ed., pp. 1–14). Routledge.

Carvalho, R. S., Silva, F. H. A., & Carmo, C. C. (2015). *Mostras de ciências (itinerante) no assentamento Vila Amazônia: popularização da ciência em diferentes espaços educativos*. Encontro Nacional de Pesquisa em Educação em Ciências. Abrapec. https://abrapec.com/enpec/xii-enpec/anais/listaresumos_1.htm

Chappell, M. J., & Varelas, M. (2019). Ethnodance and identity: black students representing science identities in the making. *Science Education*, *104*(2), 193–221. https://doi.org/10.1002/sce.21558

Chiovatto, M., Aidar, G., Soares, L. R., & Amaro, D. (2010). Repensando a acessibilidade em museus: a experiência do núcleo de ação educativa da pinacoteca do estado de São Paulo. In A. P. Santos (Ed.), *Diálogos entre arte e público: Caderno de textos* (3th ed., pp. 8–21). Fundação de Cultura da Cidade do Recife.

Chittenden, D. (2011). Commentary: Roles, opportunities, and challenges—Science museums engaging the public in emerging science and technology. *Journal of Nanoparticle Research*, *13*(4), 1549–1556. https://doi.org/10.1007/s11051-011-0311-5

Cole, M., & Scribner, S. (2007). Introdução. In L. S. Vigotski (Ed.), *A formação social da mente* (pp. 20–30). Martins Fontes.

Davidov, V. V. (1988). *La enseñanza escolar y el desarrollo psíquico: investigación psicológica teórica y experimental*. Progreso.

Dawson, E. (2014a). "Not designed for us": How science museums and science centers socially exclude low-income, minority ethnic groups. *Science Education*, *98*(6), 981–1008. https://doi.org/10.1002/sce.21133

Dawson, E. (2014b). Equity in informal science education: Developing an access and equity framework for science museums and science centres. *Studies In Science Education*, *50*(2), 209–247. https://doi.org/10.1080/03057267.2014.957558

Dawson, E. (2017). Social justice and out-of-school science learning: Exploring equity in science television, science clubs and maker spaces. *Science Education*, *101*(4), 539–547. https://doi.org/10.1002/sce.21288

Dewhurst, M., & Hendrick, K. (2017). Identifying and transforming racism in museum education. *Journal of Museum Education*, *42*(2), 102–107. https://doi.org/10.1080/10598650.2017.1311745

Engeström, Y., Pasanin, A., Foiviainin, H., & Haavisto, V. (2006). Expansive learning as collaborative concept formation at work. In K. Yamazumi, Y. Engeström, & H. Daniels (Eds.), *New learning challenges: going beyond the industrial age system of school and work* (pp. 47–77). Kansai University.

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Engeström, Y., & Sannino, A. (2012). Concept formation in the wild. *Mind, Culture, and Activity*, *19*(3), 201–206. https://doi.org/10.1080/10749039.2012.690813

Feinstein, N. W., & Meshoulam, D. (2013). Science for what public? Addressing equity in American science museums and science centers. *Journal of Research in Science Teaching*, *51*(3), 368–394. https://doi.org/10.1002/tea.21130

Freire, P. (2018). *Pedagogia do oprimido*. Paz e Terra.

Gauvin, J. F. (2015). Les musées de sciences, la présence des objets et les défis pédagogiques de l'habitus. *Éducation Et Francophonie*, *43*(1), 29–44. https://doi.org/10.7202/1030179ar

Gohn, M. G. (2019). Teorias sobre participação social: desafios para a compreensão das desigualdades sociais. *Caderno CRH*, *Salvador*, *32*(85), 63–81. https://periodicos.ufba.br/index.php/crh/article/view/27655

Gordillo Martorell, J. A. (2017). Involving the child in the management of science museums: A tool of social transformation. *Journal of Museum Education*, *42*(1), 81–86. https://doi.org/10.1080/10598650.2016.1263041

Greenberg, A., & Levinsky-Raskin, S. (2017). Supporting transitions: Cultural connections for adults with autism spectrum disorders. *Journal Of Museum Education*, *42*(4), 332–344. https://doi.org/10.1080/10598650.2017.1376268

Hindley, A. F., & Olsen Edwards, J. (2017). Early childhood racial identity—The potential powerful role for museum programing. *Journal Of Museum Education*, *42*(1), 13–21. https://doi.org/10.1080/10598650.2016.1265851

Instituto Brasileiro de Geografia e Estatística. (2010). *Censo demográfico*. Instituto Brasileiro de Geografia e Estatística. https://www.ibge.gov.br/estatisticas/sociais/populacao/9662-censo-demografico-2010.html?=&t=resultados

Instituto Brasileiro de Museus. (2011). *Museus em números/Instituto Brasileiro de Museus*. Instituto Brasileiro de Museus. https://www.museus.gov.br/wp-content/uploads/2011/11/Museus_em_Numeros_Volume_2A.pdf

Irwin, A. (2001). Constructing the scientific citizen: Science and democracy in the biosciences. *Public Understanding of Science*, *10*(1), 1–18. https://doi.org/10.1088/09636625/10/1/301

Judson, E. (2011). Learning about bones at a science museum: Examining the alternate hypotheses of ceiling effect and prior knowledge. *Instructional Science*, *40*(6), 957–973. https://doi.org/10.1007/s11251-011-9201-6

Kaeseker, D. P. (2014). *Museu, território, desenvolvimento: Diretrizes do processo de musealização na gestão do patrimônio de Itapeva (SP)*. [Master's Thesis, Universidade de São Paulo] Biblioteca Digital da USP. https://doi.org/10.11606/D.103.2014.tde-09022015-115653

Katrikh, M. (2018). Creating safe(r) spaces for visitors and staff in museum programs. *Journal of Museum Education*, *43*(1), 7–15. https://doi.org/10.1080/10598650.2017.1410673

Kauano, R. V., & Marandino, M. (2021). Paulo Freire na Educação em Ciências Naturais: Tendências e Articulações com a Alfabetização Científica e o Movimento CTSA. *Revista Brasileira de Pesquisa em Educação em Ciências*, *22*(35064), 1–28. https://doi.org/10.28976/1984-2686rbpec2022u521548

Kinsley, R. P. (2016). Inclusion in museums: A matter of social justice. *Museum management and Curatorship*, *31*(5), 474–490. https://doi.org/10.1080/09647775.2016.1211960

Lelliot, A. (2017). Recent research on science communication and engagement in informal settings in South Africa. In C. Leggon & M. Gaines (Eds.), *STEM and social justice: Teaching and learning in diverse settings: A global perspective*. Springer. https://doi.org/10.1007/978-3-319-56297-1

Leontiev, A. (2004). O desenvolvimento do psiquismo (R. E. Frias, Trans.). Centauro (Original work published 1978).

Lourenço, M. F., Fares, D. C., Rodrigues, J., Kistler, F. L. V., & Sarraf, V. P. (2016). Estudo exploratório sobre o acesso aos museus da Universidade de São Paulo. Museologia e Patrimônio. *Revista Eletrônica do Programa de Pós-Graduação em Museologia e Patrimônio*, *9*(1), 91–113.

Mauricio, P., & Teodoro, A. (2011). Qualified intervention/Qualifying formation: the socio-cultural animator in a Science based Society. *4th International Conference of Education, Research and Innovation*. https://www.researchgate.net/publication/225076660

Meij, M. G. D., Broerse, J. E. W., & Kupper, F. (2017). RRI & science museums; prototyping an exhibit for reflection on emerging and potentially controversial research and innovation. *Journal Of Science Communication*, *16*(4), 91–113.

Ministério da Ciência, Tecnologia e Inovações. (2019). *Publicações*. www.mctic.gov.br/mctic/opencms/publicacao/publicacoes.html

Monaco, L. M. (2013). *O setor educativo de um museu de ciências: um diálogo com as comunidades de prática*. [PhD's Thesis, Universidade de São Paulo] Biblioteca Digital da USP. https://doi.org/10.11606/T.482013.tde-14102013-131236

Moraes, L. G. N. (2018). A redefinição do Museu do Índio a partir da experiência dos indígenas. In B. B. Soares, K. Brown, & O. Nazor (Eds.), *ICOFOM Symposium. Defining Museums of the 21 Century: Plural Experiences* (pp. 127–133).

Moraes, J. N. L. (2021). Public participation's horizons and itineraries in museums. *Museologia & Interdisciplinaridade*, *10*(20), 168–190. https://doi.org/10.26512/museologia.v10i19.39053

Morais, S. B. R., & Reis, M. A. G. S. (2018). Inclusion vs. exclusion in museums: The invisibility of people with disability. In B. B. Soares, K. Brown, & O. Nazor (Eds.), *ICOFOM Symposium. Defining Museums of the 21 Century: Plural Experiences* (pp. 146–152).

1098237x, 0, Downloaded from https://onlinelibrary.wiley.com/doi/10.1002/sce.21829 by Univ of Sao Paulo - Brazil, Wiley Online Library on [06/11/2023]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

Moreira, I. C., & Massarani, L. (2002). Aspectos históricos da divulgação científica no Brasil. In L. Massarani, I. C. Moreira, & F. Brito (Eds.), *Ciência e Público: caminhos para a divulgação científica no Brasil* (pp. 43–64). Casa da Ciência—Centro Cultural de Ciência e Tecnologia da Universidade Federal do Rio de Janeiro.

Navas, A. M. (2008). *Concepções de popularização da ciência e da tecnologia no discurso político: impactos nos museus de Ciências* [Master's Thesis, Universidade de São Paulo]. Biblioteca Digital da USP. https://doi.org/10.11606/D.48.2008.tde-24062008-151543

Netto, J. P. (2011). *Introdução ao estudo do método de Marx*. Expressão Popular.

Ng, W., Ware, S. M., & Greenberg, A. (2017). Activating diversity and inclusion: A blueprint for museum educators as allies and change makers. *Journal of Museum Education*, *42*(2), 142–154. https://doi.org/10.1080/10598650.2017.1306664

Observatório de Museus e Centros Culturais (OMCC). (2008). *Museus e seus visitantes: relatório de pesquisa perfil-opinião 2006-2007*. http://www.fiocruz.br/omcc/media/relatorio0607_sp.pdf

Observatório de Museus e Centros Culturais (OMCC). (2015). *Museus e seus visitantes: pesquisa perfil-opinião 2013*. https://www.museudavida.fiocruz.br/images/Publicacoes_Educacao/PDFs/MuseusdecienciaeseusvisitantesOMCCT2013.pdf

Piqueras, J., & Achiam, M. (2019). Science museum educators' professional growth: Dynamics of changes in research–practitioner collaboration. *Science Education*, *103*(2), 389–417. https://doi.org/10.1002/sce.21495

Ribeiro, D. (2017). *O que é lugar de fala?* Letramento.

Rocha, J. N. (2018). *Museus e centros de ciências itinerantes: análise das exposições na perspectiva da alfabetização científica* [PhD's Thesis, Universidade de São Paulo]. Biblioteca Digital da USP. https://doi.org/10.11606/T.48.2018.tde-03122018-122740

Santana, C. B. (2016). *De(legando) o futuro: mediações e educomunicações nas relações entre museus e públicos* [PhD's Thesis, Universidade de São Paulo]. Biblioteca Digital da USP. https://doi.org/10.11606/D.27.2017.tde-20022017-144925

Schenkel, K., & Calabrese Barton, A. (2020). Critical science agency and power hierarchies: Restructuring power within groups to address injustice beyond them. *Science Education*, *104*(3), 500–529. https://doi.org/10.1002/sce.21564

Shaby, N., Assaraf, O. B. Z., & Tal, T. (2016). The particular aspects of Science Museum exhibits that encourage students' engagement. *Journal of Science Education and Technology*, *26*(3), 253–268. https://doi.org/10.1007/s10956-016-9676-7

Shea, M. V., & Sandoval, J. (2019). Using historical and political understanding to design for equity in science education. *Science Education*, *104*(1), 27–49. https://doi.org/10.1002/sce.21555

Silva, D. F. (2015). A política de divulgação e popularização de ciência e tecnologia do Ministério da Ciência, Tecnologia e Inovação: alguns destaques e desafios. In M. E. Valente & S. Cazelli (Eds.), *Educação e divulgação da ciência: A dimensão política da popularização e divulgação da ciência e da tecnologia no Brasil* (pp. 50–65). http://site.mast.br/hotsite_mast_30_anos/pdf_02/volume_02.pdf

Simon, N. (2010). *The participatory museum*. Museum 20.

Soares, B. B. (2018). Museum in colonial contexts: The politics of defining an imported definition. In B. B. Soares, K. Brown, & O. Nazor (Eds.), *ICOFOM Symposium. Defining Museums of the 21 Century: Plural Experiences* (pp. 163–168).

Souza, J. S., & Rizzatti, I. M. (2015). *Experimentação com materiais alternativos: uma proposta de divulgação científica em comunidades ribeirinhas* (pp. 1–8). Encontro Nacional de Pesquisa em Educação em Ciências. Abrapec. https://abrapec.com/enpec/xii-enpec/anais/listaresumos_1.htm

Taylor, C. (2017). From systemic exclusion to systemic inclusion: A critical look at museums. *Journal of Museum Education*, *42*(2), 155–162. https://doi.org/10.1080/10598650.2017.1305864

Valente, M. E., Cazelli, S., & Alves, F. (2005). Museus, ciência e educação: novos desafios. *História, Ciências, Saúde-Manguinhos*, *12*(Suppl.), 183–203.

Venâncio, T. M. (2023). *Mobilização social por meio de políticas públicas de comunicação científica: uma perspectiva histórico-cultural* [PhD's Thesis, Universidade de São Paulo]. https://www.teses.usp.br/teses/disponiveis/48/48136/tde-16062023-143933/publico/TATIANA_MARTINS_VENANCIO_rev.pdf

Vygotsky, L. S. (2007). *A formação social da mente* (J. C. Neto, Trans.). Martins Fontes.

Wenger, E. (1998). *Communities of practice: Learning, meaning, and identity*. Cambridge University Press.

Yoon, S. A., Elinich, K., Wang, J., Van Schooneveld, J. B., & Anderson, E. (2013). Scaffolding informal learning in Science Museums: How much is too much? *Science Education*, *97*(6), 848–877. https://doi.org/10.1002/sce.21079

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