Biota Neotropica 22(spe): e20221381, 2022
www.scielo.br/bn

biotaneotropica
ISSN 1676-0611 (online edition)
Thematic Review

Research in education and communication in science: contributions from the Biota-Fapesp program to biodiversity education

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BIZERRA, A., SPEGLICH, E., URSI, S. **Research in education and communication in science: contributions from the Biota-Fapesp program to biodiversity education**. Biota Neotropica 22(spe): e20221381. https://doi.org/10.1590/1676-0611-BN-2022-1381

Abstract: In this article, we aim to understand the contributions of the Biota-Fapesp Program to the research in biodiversity education and communication. Our research questions are: (i) is the Biota-Fapesp Program following or contributing to the significant advances in conceptual, technological/methodological, and management/governance aspects of biodiversity education/communication research?; (ii) if yes, how do the projects contribute to these advances?; and (iii) what are the main expectations for the future of Biota in education and communication research? Our analyzes highlighted a qualitative contribution from the Biota-Fapesp Program at institutional, methodological, conceptual, and educational levels. However, due to the few projects, it can be considered a summative contribution and not a transformative one. Perspectives for the Biota-Fapesp Program in these areas were divided into three approaches: 1. Research lines and concepts that could be encouraged through specific calls or inclusion in other calls of interest to the Program; 2. Innovative methodological approaches for the area that should be encouraged; 3. Suggestions for scientific research management and infrastructure. Through data and discussions presented below, we hope to contribute to the understanding of the role of Biota-Fapesp in the area, and point out ways to develop research, practices and public policies that promote the strengthening of science as culture.
Keywords: *Biota-Fapesp Program; biodiversity education; science education; science communication; research trends.*

Pesquisa em educação e comunicação em ciências: contribuições do programa Biota-Fapesp para a educação em biodiversidade

Resumo: Neste artigo, buscamos compreender as contribuições do Programa Biota-Fapesp para a pesquisa em educação e comunicação em biodiversidade. Nossas questões de pesquisa são: (i) o Programa Biota-Fapesp está acompanhando e/ou contribuindo para os principais avanços nos aspectos conceituais, tecnológicos/metodológicos e/ou de gestão/governança da pesquisa em educação/comunicação em biodiversidade?; (ii) se sim, como os projetos contribuem para esses avanços?; e (iii) quais são as principais expectativas para o futuro do Biota na pesquisa em educação e comunicação? Nossas análises destacaram uma contribuição qualitativa do Programa Biota-Fapesp nos níveis institucional, metodológico, conceitual e educacional. No entanto, devido ao baixo número de projetos, esta contribuição pode ser considerada somativa, mas não transformadora. As perspectivas do Programa Biota-Fapesp para essas áreas foram divididas em três abordagens: 1. Linhas de pesquisa e conceitos que podem ser incentivados por meio de editais específicos ou inclusão em outros editais de interesse do Programa; 2. Abordagens metodológicas inovadoras para a área que devem ser incentivadas; 3. Sugestões para gestão e infraestrutura da pesquisa científica. Por meio dos dados e discussões apresentados a seguir, esperamos contribuir para a compreensão do papel do Biota-Fapesp na área, bem como apontar caminhos para desenvolver pesquisas, práticas e políticas públicas que promovam o fortalecimento da ciência como cultura.
Palavras-chave: *Programa Biota-Fapesp; educação em biodiversidade; educação em ciências; divulgação científica; tendências de pesquisa.*

Introduction

As a specific field of research, science education emerged and developed internationally since the mid-twentieth century (Fensham 2004). Therefore, it is a relatively new research field which has already undergone several transformations. Some trends can be highlighted in the area, with increasing diversity in themes, approaches, subjects, and theoretical background. It is possible to highlight a change in the prevalence of the cognitive research approach to the sociocultural one; an increasing number of studies about learner discourse and argumentation; use of representations and learner identities; and teacher education research focus on collaborative processes and teacher identity (Livingston & Flores 2017, Odden et al. 2021).

Biodiversity education can be considered a relevant part of science education, sharing trends and challenges with this area, but also presenting specific issues and significant intersections with several other knowledge areas, such as environmental education and education for sustainable development. Additionally, dialogues with the biodiversity research area can be promising to inspire new approaches aimed at mitigating the challenges of the environmental crisis we are experiencing. This special volume of Revista Biota Neotropica, which presents a collection of texts produced by researchers in the area, is a good example of this movement and is added to several other actions that position biodiversity as a fundamental asset to be protected to guarantee our maintenance on the planet.

However, despite the increasing knowledge production about biodiversity, awareness about its conservation has not increased in national and international contexts (Navarro-Perez & Tidball 2012). According to the authors, four main challenges are involved in changing this scenario. First, there is an urgent need to define an approach for biodiversity education[1], debating if it should be founded on Environmental Education or Education for Sustainable Development guidelines and which are its core presumptions and primary goals. Secondly, the authors notice that biodiversity is an ill-defined concept and, "in order for people to understand what biodiversity is, they may need to understand what biodiversity means ecologically, culturally, socially or economically and how its loss affects all of these dimensions" (Navarro-Perez & Tidball 2012, p. 20). Besides, the authors present the lack of appropriate communication and the disconnection between people and nature as obstacles to achieving critical educational targets.

This distance between knowledge production and public awareness about biodiversity shows us the importance of understanding science in society. In our view, biodiversity education and communication research can be considered a central action towards this understanding and can contribute to a better approximation of people with the complexity of socio-environmental issues.

In this article, we aim to understand the contributions of the Biota-Fapesp Program to the research in biodiversity education and communication. Our research questions are i) is the Biota-Fapesp Program following or contributing to the main advances in conceptual, technological/methodological, and management/governance aspects of biodiversity education/communication research? ii) if yes, how do the projects contribute to these advances?; and iii) what are the main expectations for the future of Biota in education and communication research? With the data and discussions presented below, we hope to contribute to the understanding of the role of Biota-Fapesp in the area, and point out ways to develop research, practices and public policies that promote the strengthening of science as culture.

Methodological Approach

To better understand the contributions of the Biota Program to research and practice in biodiversity education, it was necessary to survey the research projects approved by FAPESP between 1962 and 2022, inserted in the areas of "education" and "communication" and, among them, to identify those related to natural sciences and, more specifically, biology.

We made this choice because we understand that the areas of knowledge most linked to the Biota-Fapesp Program cover, in general, the major areas of Biological Sciences and Exact and Earth Sciences[2], with greater concentration in areas such as Zoology, Ecology and Botany. Thus, we chose to seek, among the projects in the large area of Education, those related to the main areas of the Biota-Fapesp Program. For this, we used the databases available in the Fapesp Virtual Library[3], including the one covering the period from 1962 to 1991[4]. Furthermore, we chose to consider only research projects[5], disregarding scholarships and grants for participation in events or infrastructure.

For the period from 1992 onwards, we generated a spreadsheet with all the projects in the broad areas of Education and Communication, disregarded the projects that did not meet our search criteria, and, from the rest, analyzed them one by one to relate them (or not) to the rubric of "science education"[6]. Among these, we also identified those specifically related to "biology education".

It was not possible to generate a spreadsheet for projects approved before 1992. We analyzed each of the projects raised from the search for "education"[7], considering only the projects of the regular grant line, since the other grant lines considered here were not found.

[1] It is important to emphasize that the understanding of "biodiversity education" is still open and is sometimes used interchangeably with other terms, such as conservation education, environmental education, education for sustainability, education for sustainable development, among others, both in the literature and in educational and communicational actions. We do not intend to reach a definition of the term in this text, but we clarify that we consider in our analysis the research and actions that focus on education/communication in dialogue with biodiversity and closely related themes.

[2] Of all the projects approved by the Biota-Fapesp Program, 81% correspond to the major areas of Biological Sciences and Exact and Earth Sciences.

[3] Available at: https://bv.fapesp.br/pt/

[4] Available at: https://bv.fapesp.br/pt/proc6291/. This database encompasses the projects approved by Fapesp between 1962 and 1991 and, due to the smaller number of research fields and with different names, it was not integrated into the databases from 1992 onwards, already indexed in the Fapesp Virtual Library.

[5] We considered the following research grants in our analysis: Regular, Thematic, Young Researcher and Public Policies.

[6] For this area, we considered the projects that used the terms "science education" and "science teaching", as well as "teaching of" any topic of Biological Sciences and Exact and Earth Sciences. Projects aimed at math education and environmental education (considering that EE is transdisciplinary) that do not have a clear focus on biology education were not considered.

[7] Communication-related projects were not found before 1992.

 http://dx.doi.org/10.1590/1676-0611-BN-2022-1381

In addition, aimed to represent the researcher's voices better, we send an online questionnaire to project coordinators, seeking to understand specific elements of their projects. We asked them: 1. what have been the major advances in their area of knowledge in conceptual, technological/methodological, and management/governance terms; 2. how have their project contributed to these advances; what are the three main results generated by their research project; 3. what are the main expectations for the future of Biota in our area of research; and 4. what are the main knowledge gaps in the area that Biota could help to address. This information was complemented by field notes made by the authors during an online workshop with 20 invited researchers[8] held on 10/21/2020, and contributed to the elaboration of our final proposal of future perspectives for research on Biodiversity Education and Communication.

Results and Discussion

The number of projects obtained for each line of funding is shown in Table 1. Despite the great effort of the Biota-Fapesp Program concerning its institutional communication about biodiversity research, the communication area was not analyzed as no research project related to science communication and biodiversity was found. At first, it is possible to observe that research in education is extremely little supported by Fapesp. Of the approximately 40,000 projects approved by Fapesp in the Regular, Thematic and Young Researcher grant lines since 1992, 0.9% are projects in education. We consider this number to be extremely meager, given that the area of education historically has a large number of researchers[9].

Table 1. Number of approved regular grant projects related to science education (SE) and biology education (EB), including those linked to the Biota-Fapesp Program.

Research grant	1962–1981			1982–2001			2002–2021		
	ED	SE	BE	ED	SE	BE	ED	SE	BE
Regular	19	3	0	68	8	4	282	39	13
Thematic projects	0	0	0	3	0	0	9	2	1
Young researcher	0	0	0	3	0	0	0	0	0
Improvement in Public Education	0	0	0	45	14	2	4	2	1
Innovative Research in Small Business (PIPE)	0	0	0	0	0	0	10	0	0
Science Centers	0	0	0	0	0	0	4	4	4

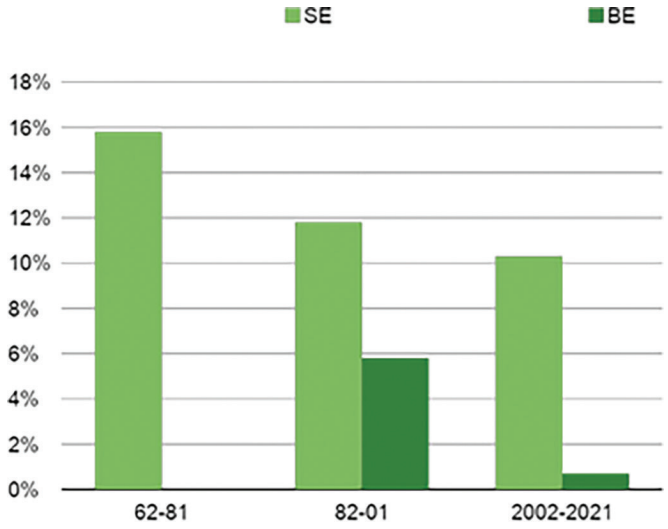

Figure 1. Relative number of projects related to science education (SE) and biology education (BE) in the large area of Education approved by Fapesp between 1962 and 2022, *disregarding Biota projects*. Biology Education projects are contained in the Science Education sample**.**

Bearing in mind this low number of projects, which leads us to understand that the area of education has little funding at Fapesp, it is possible to understand that the subarea "science education" is relatively well represented. However, if we remove, for example, the regular grant projects linked to the Biota-Fapesp Program (n = 11), we see that science education, including biology education, although they have grown enormously since the 1990s[10], show a decrease in the percentage of approved projects in relation to the large area of Education in Fapesp context (Figure 1).

We see, therefore, that science education and, in particular, biology education research were strongly benefited by the Biota-Fapesp Program. In the last ten years, for example, all projects related to biology education were approved under this Program. Corroborating this perception, it is observed that the only thematic project related to education and biology in the entire history of Fapesp's funding was also approved by Biota-Fapesp ("BIOTA-FAPESP Program in basic education: possibilities for curricular integration", Prof. Nélio Bizzo/USP). It is possible to notice that there seems to be a tendency for projects in this area to be linked to special programs, such as Public Education, PIPE and Biota itself, being neglected outside these traditional grant lines.

In addition to the quantitative importance of the Biota-Fapesp Program for science education and biology education research, we highlight its qualitative contributions. In the following section, we will briefly describe the main characteristics of the research projects in education and related areas funded by the Program.

[8] Twenty researchers were invited for a meeting as part of the Program's 20th-anniversary celebrations. These researchers were chosen for having: research projects (or part of) linked to the Program (or biodiversity) in the area of education, communication or social participation.

[9] In the 2016 Census of the CNPq Research Groups Directory, the Education area appears as the largest area, with 9.6% of the groups. Just for comparison, the second largest area is Medicine, with 4.3%. Ecology is the area of 1.6% of the groups, while Zoology (0.9%) and Botany (0.7%), for example, appear with even lower rates.

[10] See, for example, the increasing number of participants in scientific events, the strengthening of important journals and the large qualitative and quantitative increase in postgraduate courses) (Almeida 2018, Slongo et al. 2020).

1. *Brief summary of the projects in education and related areas of the Biota-Fapesp Program*

We organized the projects approved from 1999 to 2022 on a timeline, which helps us to understand the transformations that have occurred over more than two decades (Figure 2).

Since the beginning of the Biota-Fapesp Program, in 1999, concerns about how the knowledge produced by the program could reach different social actors are frequently present. We can find a lot of projects that are focused on biodiversity research, but also on the production of educational and communication materials. The latter projects seek to share the knowledge produced in biodiversity research with society. We continue to pursue these projects in the present and in recent years, as we have seen an increase in the interest of researchers from other areas of Biota in promoting science education and science communication, as the project developed by Prof. Flavio Berchez. However, it is important to note that these projects, at that time, didn't develop research in education.

The first research project in education was approved in 2005. It was proposed by Prof. Osmar Cavassan (UNESP) and entitled "Biodiversity of the Cerrado: a proposal for practical work in the field of the teaching of botany and ecology in the three levels of schooling". The research team carried out a phytosociological study at the university campus, and aimed to investigate how to associate that knowledge production with science teaching. For the first time, there were research questions in education, besides objectives related to biodiversity research. Therefore, it can be considered a "hybrid project".

In 2006, we witnessed the first project focused entirely on research education, applied by Prof. Antonio Carlos Rodrigues de Amorim (Unicamp) and entitled "Education, sciences and culture: territories in borders in the Program BIOTA – FAPESP". This project started a series of 10 projects focused exclusively on research in education, including the approval of 4 projects through the Biota Education Call (2016).

Other areas related to Science in Society perspective were added to the Biota-Fapesp Program. In 2011, a project which examined the interaction between Museology and Biodiversity was approved ("Evolutionary Narratives in Natural History Museums", by Prof. Maria Isabel Pinto Ferreira Landim – MZUSP). Indeed, there were already projects aimed at museum collections approved by Biota, but this is the first with a clear social interaction. In 2013, a project in the area of psychology was approved ("How human primates interact with nonhuman primates in a semi-arid habitat of north-eastern Brazil: an ethnoprimatological approach to preserve cultural biodiversity in primates", by Prof. Noemi Spagnolletti/USP).

Figure 2. Initial dates of each area considered in Biota Program – Education and related areas from 1999 to 2022.

Other areas in social sciences were added to Biota-Fapesp Program, such as conservation management ("Natural resources management in social-ecological systems: integrating environmental conservation and local development", by Cristiana Simão Seixas/Unicamp), in 2015, and participatory research ("Participatory ethnobotany: conservation and local development in Serra do Mar State Park – Picinguaba, Ubatuba, SP, Brazil", by Eliana Rodrigues/Unifesp, with a phase 2), in 2019 (Rodrigues et al. in press). Furthermore, a project about education and geodiversity is at the first time approved in the same year ("Ecosystem services provided by geodiversity and construction of socio-educational processes in protected areas: elaboration of a methodological proposal in the Caraguatatuba Center of the Serra do Mar State Park, by Prof. Maria da Glória Motta Garcia).

The synthesis from now on will be centered on the 17 projects with research in education or related areas (Table 2). Among them are 15 regular grants, 01 young researcher grant and one thematic project. Four public universities were contemplated: USP, UNICAMP, UNESP, and UNIFESP.

In Table 3, we summarized the main research questions, theoretical-methodological references, subjects and institutions that participated in the projects, as well as the leading products and contributions of the projects, based on consultations with the coordinators and information made available by Fapesp.

In these 17 projects, we find research questions established at micro, meso and macro levels of analysis, with different complexities. One of the essential discussions raised between the projects is related to school knowledge and its organization in disciplines, seeking links between science and culture due to the aspects that relate nature and culture. Still in the school dimension, another research question is to understand the mechanisms for optimizing the teaching of biodiversity and evolution. There are also projects that seek to innovate in education for biodiversity, developing new activities and spaces and evaluating them.

Other projects aim to understand the concepts, beliefs and values related to biodiversity expressed by students or other public, promoting subsidies for developing better educational and communicational tools. Some projects also seek to investigate the engagement of different subjects in environmental issues, whether individually or collectively, addressing issues such as participation, ethnobiology and human-animal relations. Talking more specifically about implications for the area, we can say that nowadays we are much more able to understand the concepts, especially related to people's conceptions about biodiversity, in different contexts. We can also better understand how biodiversity is addressed in the curriculum and teaching materials, with focus on the description of the groups characteristics and limited contextualization. Furthermore, we are more able to list the factors involved in the acceptance of evolutionary theory or the differences of perception between the importance of plants and animals, which also have consequences for teaching about biodiversity.

Especially about marine and coastal environments, we noticed, in the last years, an emergency of many studies about it and environmental perception, contributing to the understanding of the relationship between daily life and environments.

Different institutions are investigated, both concerning their speeches about biodiversity or evolution and the potentialities and obstacles of different institutional arrangements for conservation management. Biota-Fapesp projects involve diverse stakeholders in

 http://dx.doi.org/10.1590/1676-0611-BN-2022-1381

Table 2. Biota-Fapesp research grants on Biodiversity Education and related area (1999–2022).

	Research Grants on Biodiversity Education and Related Areas (1999–2022)
Research Grants on Biodiversity Education	Biodiversity of the Cerrado: a proposal for practical work in the field of the teaching of botany and ecology in the three levels of schooling
	Education, sciences and culture: territories in borders in the Program BIOTA – FAPESP
	Marine Biodiversity: didactic activities development and evaluation
	Environmental Perception and Biodiversity: development and evaluation of didactic activities on marine and coastal environments
	Animalcule Project: investigating microscopic biodiversity
	Education and biodiversity: production, validation and evaluation of investigative didactic sequences in ecology
	Biodiversity conservation in zoo and aquarium exhibitions: from information to engagement
	BIOTA-FAPESP Program in basic education: possibilities for curricular integration
	Biodiversity in teaching materials and in the young people's conceptions and interests: reflections for the Biota Education
	Biodiversity in the perspective of students' school performance and in teacher's work: considerations for Biota-Education
	Environmental education and management of São Paulo State conservation units: articulation of knowledge in the construction of learning communities
Research Grants on participatory research, museology and psicology	Participatory ethnobotany: conservation and local development in Serra do Mar State Park – Picinguaba, Ubatuba, SP, Brazil – phase 2
	Ecosystem services provided by geodiversity and construction of socio-educational processes in protected areas: elaboration of a methodological proposal in the Caraguatatuba centre of the Serra do Mar State Park
	Natural resources management in social-ecological systems: integrating environmental conservation and local development
	Participative ethnobotany: conservation and local development in Serra do Mar State Park – Picinguaba, Ubatuba, SP, Brazil
	How human primates interact with nonhuman primates in a semi-arid habitat of north-eastern Brazil: an ethnoprimatological approach to preserve cultural biodiversity in primates
	Evolutionary Narratives in Natural History Museums *(Young Researcher)*

Table 3. Characteristics of Biota Program projects – Education and related areas from 1999 to 2022.

Research questions	Theoretical and methodological framework	Participants	Institutions	Countries	Products
Curriculum studies Teaching improvement Teacher and Educator Education Evaluation Conceptions, values, practices Engagement and social participation Human-animal relations Institutional discourse Institutional arrangement	Specific authors (Gilles Deleuze, Lucie Sauvé…) CHAT – Cultural-historical Activity Theory Design-Based Research Scientific literacy and argumentation Inquiry-based teaching Ethnoprimatological approach Resilience and adaptive capacity Participatory management Ecosystem stewardship Social Learning Critical Environmental Education Participatory Methodologies	Students Teachers Communities Researchers Museum staff Policy makers Ethnic groups	Schools Museums NGOs Social movements Government agencies	Brazil Argentina France Germany Guyana Mozambique Portugal Russia UK USA	Papers School projects Books and e-books Courses Exhibitions Other educational and communication products (e.g., websites, texts, theatre plays, documentaries)

biodiversity conservation, such as schools, universities, protected areas, museums, government representatives, scientists, and local users of natural resources. It is a relevant impact of the Program since the school context largely guided previous science education projects. We can notice, for example, the relevant role of zoos and aquariums in biodiversity education, as well as their recognition by their visitor as a central institution for conservation.

In relation to theoretical-methodological frameworks, we found specific authors, such as Deleuze, related to philosophy and aesthetics, and Sauvé, linked to Environmental Education. In addition, theoretical perspectives recognized in education, such as Cultural-historical Activity-Theory (CHAT), Social Learning, Critical Environmental Education, and Design-Based Research, were also found. Following research in the area of science education, we also find Scientific Literacy, Argumentation, and Inquiry-based Teaching as important topics. Among the works in related areas, ethnoprimatological approach, resilience and adaptive capacity, participatory management, and ecosystem stewardship were cited references.

Although the number of education-oriented projects in the Biota-Fapesp Program does not allow a more robust analysis, it is interesting to note that these projects follow similar transformations observed in research in science education over time. As cited above, educational and communication activities have been carried out as epiphenomenal strategies of many Biota projects: from the results of research in areas such as ecology, zoology and botany, actions or materials are produced as subsidies for the improvement of teaching (e.g., support materials for teachers or students).

However, from the funding of research whose focal object is the educational process on biodiversity (and not biodiversity itself), we see that the focus becomes the development of more participatory processes for the education of educators and learners. Such a transformation was observed by Odden et al. (2021) when analyzing the discourse of Science Education journal in the last 100 years. The authors affirm that the earlier papers published by that journal were primarily concerned with "descriptions of science-teacher content preparation, assessment of teacher training and knowledge, and programmatic aspects of science courses". However, after the mid-1990s, the focus moved to teachers' beliefs, practices, and mentorship.

Biota-Fapesp Program also follows other meaningful transformations in the area, moving from a predominantly cognitive approach to a greater variety of approaches, with a predominance of the sociocultural one and a growing interest in learner discourse and argumentation, use of representations, and learner identities, as noted by Trindade and Rezende (2010) and Odden et al. (2021).

Qualitative research was predominant among the projects analyzed, using ethnography, case studies, participant observation, interviews, focus groups, document analysis, content analysis, among others. Nevertheless, we also found Quantitative research, using mainly surveys. Part of the projects chose mixed methodologies. It is worth mentioning that participatory methodologies were highlighted by some projects, another example that Biota-Fapesp Program follows the major transformations in the area.

Regarding the products of these projects, we have articles published nationally and internationally. We bring as example the article published in Science Advances, resulting from the projects coordinated by Prof. Nelio Bizzo, Prof. Fernanda Franzolin and Prof. Paulo Garcia that shows us differences in students' interests in biodiversity considering the different regions of the country. Other examples are articles written by Eliana Rodrigues published in co-authorship with the quilombolas participating in the project, strengthening a key aspect of recent research about science in society: interculturality.

Interculturality and other themes such as difference, multiculturalism, identity, activism, inclusion, gender, religion, class, and ethnic-racial relations have great potential for a truly transformative educational process.

There is also the elaboration of didactic proposals developed for schools, such as the Educational Technology Lab, from UNICAMP, coordinated by Prof. Eduardo Galembeck. The project aimed at developing low-cost equipment and producing videos explaining the use of the material and suggesting new possibilities. In the project coordinated by Prof. Noemi Spagnoletti, the sub-project "We are all primates!" was a community initiative involving rural schools to promote the conservation of primates.

Teachers and educators from informal learning settings participated in different training initiatives. For example, Prof. Marcelo Motokane promoted local teachers' participation in research group meetings. These teachers actively participated in the production and evaluation of inquiry-based teaching learning sequences. In the project coordinated by Prof. Alessandra Bizerra, training courses were offered for zoo and aquarium educators in cities in the state of São Paulo, while Prof. Rosana Louro Ferreira Silva held courses for educators living nearby Protected Areas.

Books and e-books were also produced. We bring the examples of the book produced by Prof. Cristiana Seixas that was used in undergraduate courses at UNICAMP and USP since its preliminary version. Examples of e-books are those of Prof. Suzana Ursi and collaborators, which focus on didactic strategies and inquired-based sequences for primary and secondary education and have more than 20,000 downloads on average.

We also highlight the exhibitions produced by the projects such as "*Dispersos fragmentos*", resulting from the Prof. Antonio Carlos Amorim project, the expo "Biodiversity, knowing to preserve" by Prof. Maria Isabel Landim, and the "Out Of Water Diving" by Prof. Flavio Berchez and Prof. Suzana Ursi projects.

These are just a few of the many other products generated by the projects.

We see, therefore, that both by processes and products, the projects financed by Biota Education were significant for the area (Table 4). We consider one of the great impacts of the Biota-Fapesp Program to be the promotion of new lines of research. Some of the coordinators mentioned that the program was essential to implement a new line of research in their institution, strengthening graduate programs and training undergraduate and graduate students. Despite the low number of projects in education and related areas, the production of knowledge in the areas is evident. There were also contributions to research methodology, with the development of new methods and protocols.

In the socio-political dimension, we highlight the progress in understanding perceptions, beliefs and behaviors related to biodiversity and the training of teachers and educators. We emphasize that some projects have expanded their reach, promoting engagement and social participation and contributing to public policies. Unfortunately, projects like that are even fewer studies, requiring more investments in this dimension.

2. *Prospects for research on Biodiversity Education and Communication*

As stated previously, 20 researchers were invited on 10/21/2020 to discuss future perspectives for research on Biodiversity Education and Communication inside the Biota-Fapesp Program. The proposals presented here result from this discussion and the analysis carried out in this article.

The perspectives for the future in the research areas of education and communication in the Biota-Fapesp Program were divided into three aspects: 1. Research lines and concepts that could be encouraged through specific calls or inclusion in other calls of interest to the Program; 2. Innovative methodological approaches for the area that should be encouraged; 3. Suggestions for scientific research management and infrastructure.

The contributions are summarized in Table 5.

Table 4. Contributions of Biota Program projects – Education and related areas from 1999 to 2022.

Institucional	Academic	Sociopolitical
New lines of research Strengthening graduate programs Training of undergraduate and graduate students	Innovation in research methods and protocols Strengthening integration between different fields Internationalization Analysis of the Biota Program products	Greater understanding of perceptions, beliefs and values related to biodiversity Professional development of teachers and educators Dialogue between different types of knowledge Empowerment – Local collaborators Public policies

Table 5. Contributions from researchers in education (and related areas) to outline future research perspectives in Education and Communication in Biodiversity within the Biota Program.

	Futures prospects for research on Biodiversity Education and Communication
Research Lines & Concepts	Teacher preparation programs and continuing teacher education for both school and out-of-school contexts
	Curriculum Studies and biodiversity, including its relations with the Brazilian curricular standards and the reduction of the curricular components on biodiversity over the years
	Science Communication and biodiversity
	An expansion on (bio)diversity concepts to inspire education and communication
	To promote a deepening of the specific characteristics on the fields of Environmental Education and Biodiversity Education, which cannot be taken as designating the same epistemological field. As well as for the fields of Conservation Education and Education for Sustainable Development
	Citizen Science and collaborative science (to be analyzed as processes)
	Study of possibilities that allow young people to become more interested in local biodiversity, having access to traditional knowledge and the results of scientific research
	The contributions of Education and Communication in the discussion about Nature's Contributions to People and Ecosystem Services
	Economy of sensations and the commodification of nature
	Aesthetics, Images and Cultures of (bio)diversity
	The relationships of Biodiversity Education and Communication with the epistemologies of the south
	Conceptions, representations and cognitive processes of the learner and the trainer in Environmental Education and Biodiversity Education
	Research related to Education and Environmental Management and Governance, especially in conservation areas and their relationship with local populations
	The role of Biodiversity Education and Communication for the creation of Public Policies
	Environmental perceptions and sensitivities
	The relationships between human, non-human and new modes of sustainability on Planet Earth
	Socio-cultural imaginary and environmental preservation
	The role of ex-situ biodiversity under the tutelage of the State of São Paulo in the production of knowledge about Biodiversity
Methodological Approaches	Co-production of knowledge
	Participatory research and popular knowledge in ethnobiology and in biodiversity conservation research projects
	Citizen Science and Collaborative Science
	Diversification of methodologies: quantitative, qualitative, mixed, participatory, case study, use of software etc

Continue...

...Continuation

	Futures prospects for research on Biodiversity Education and Communication
Management & Infrastructure	The possibility, for the Education and Communication projects, to produce materials and to investigate the materials produced
	To increase the interaction between projects (in the area of Education and between projects in Biodiversity Education), with the promotion of articulations between the areas while maintaining the specificities
	Creation of a Biodiversity Education and Communication Agenda, in a specific and permanent working group, in order to build guiding parameters for the management of public policies related to biodiversity that have Education and Communication as one of the truly significant key pieces
	Specific Calls for Education and Communication but also inclusion of the Education and Communication dimensions in other Calls (not only in an instrumental way, but as a research area)
	Articulation with the coordination of the Education and Communication areas at Fapesp for the creation of an area about Teaching and Learning specific topics ("Ensino de")
	Articulation with the Fapesp's Science Media Program

Conclusion and Implication

From the analysis of thematic, regular and young researchers' projects approved by Fapesp in the last 70 years, it was possible to perceive that the education area had meager number of projects. We understand that this situation may be due to a low submission, which would be reflected in a low number of approvals. However, given the strengthening of research in the area observed in Brazil, mainly in the last 30 years, and the constant demand direct to researchers by their institutions for approval of projects by external funding agencies, it is possible to understand that the low approval is linked to conditions internal to Fapesp, demanding a more careful and in-depth look at the matter. It is necessary to understand better the fact that less than one project in every 100 projects approved by Fapesp is an education project when this area corresponds to almost 10% of the country's research groups.

Regarding science education research, it is possible to understand that, considering the area of education as a whole, this sub-area would be well represented, with almost 20% of education projects focused on the natural sciences. However, we could observe a significant decrease in these projects over time when we removed the Biota-Fapesp Program from the analysis.

Thus, the importance of Biota-Fapesp for research in education is evident, not only in biodiversity education, more related to the Program, but for all biology education and even science education. It shows us the urgent need to strengthen these sub-areas in Fapesp's traditional grant lines, especially biology education projects, in addition to the biodiversity theme.

Our analyzes also point to a qualitative contribution from Biota-Fapesp. At an institutional level, one of the major impacts of the Program was the promotion of new research lines. Some of the coordinators mentioned that the project was fundamental to implement a new line of research in their institution, with the strengthening of postgraduate courses and the training of undergraduate and graduate students.

Regarding scientific advances, despite the low number of projects, the construction of knowledge in the areas is evident. There were also methodological contributions, with the development of new methods and protocols, and some few advances in the internationalization of research lines.

From the sociopolitical perspective, advances in understanding perceptions, beliefs and behaviors related to biodiversity, as well as in the training of teachers and educators, stand out. In addition, some studies have expanded their reach, promoting social engagement and participation and potentially contributing to public policies, while others have promoted a dialogue of knowledge with different participating subjects.

We can observe, therefore, that the approved projects followed the transformations in the area of science education, covering current and socially relevant topics. However, given the small number of projects, we cannot assume that there is a significant contribution to the international or even national scenario. Thus, we emphasize the importance of not only increasing the fomentation of projects but also considering the establishment of partnerships between researchers from São Paulo and institutions from other states and countries.

If Biota-Fapesp followed the changes in research concerning science and biology education, the same did not happen with science communication. It is clear that this area has developed enormously in the country in the last two decades (Barata et al. 2018, Guenther & Joubert 2017), with Brazil included among the ten countries that most published in the area, but this was not reflected in the approved (or submitted) projects. Therefore, understanding the potential of science communication to promote a more extensive social approach to biodiversity issues becomes another important field of action of Biota-Fapesp.

Finally, we highlight three dimensions we deem necessary to included in an innovative Biota-Fapesp policy. The first dimension refers to lines of research and concepts that could be encouraged through specific calls or inclusion in other calls of interest to the Program. Included here are propositions such as critically deepening the understanding of what Education for Biodiversity would be, establishing approximations and distances from areas such as Education for Conservation or Education for Sustainability, in addition to paying attention to the diversity of subjects, institutions, concepts, theoretical perspectives and contexts involved in the biodiversity/society relationship.

A second dimension of promoting research in the area involves support for innovative methodological approaches, such as the co-production of knowledge and citizen science/collaborative science, as well as the valorization of participatory research and popular knowledge, respecting the methodological pluralism characteristic of educational research.

We also proposed a third dimension, focused on scientific research and infrastructure management. Among the proposals in this dimension, we highlight the support for more significant interaction between projects in the areas of education/communication and between projects in these areas and other Biota projects, maintaining their specificities. For example, creating a "teaching of" area at Fapesp, differentiated from the education area or as a sub-area of this, could provide a better composition of evaluation teams or call promoters, which would dialogue more effectively with researchers from biodiversity education and science communication. It does not mean isolating the biodiversity/society relationships, or even science/society ones, from other fields of investigation. On the contrary, it means guaranteeing the density of the area and creating conditions for the elaboration of an education, communication and biodiversity agenda, with a permanent working group, in order to build guiding parameters for the management of public policies related to biodiversity that have education and communication as truly significant vital elements.

Supplementary Material

The following online material is available for this article:

Table S1 – List of 17 projects considered in this analysis, detailing title, abstract, principal investigator, collaborators, host institution, research grant line, research area, keywords, and begin and end dates.

Acknowledgments

We thank the researchers who contributed with their perceptions about the transformations in their research areas, both through a questionnaire (Profs. Antonio Carlos Amorim, Cristiana Simão Seixas, Eliana Rodrigues, Maria Isabel Landim and Nélio Bizzo), and participated in the workshop (Profs. Cristiana Simão Seixas, Eliana Rodrigues, Fernanda Franzolin, Flávio Berchez, Germana Barata, Martha Marandino, Natalia Ghilardi-Lopes, Nélio Bizzo, Noemi Spagnoletti, Paula Drummond de Castro, Rosana Louro Ferreira Silva). We also thank Bruna Cersózimo Arenque Musa for her support in the use of Fapesp's databases and Prof. Carlos Alfredo Joly for inviting us to participate in such an important undertaking.

Associate Editor

Carlos Joly

Conflicts of Interest

The authors declare no conflicts of interest.

Ethics

This study did not involve human beings and/or clinical trials that should be approved by one Institutional Committee.

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Received: 21/06/2022
Accepted: 26/07/2022
Published online: 29/08/2022