Chapter 13
Teaching and Learning Biodiversity with Dioramas

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13.1 Introduction

Natural history museums are historically places that collect, conserve, research and disseminate aspects of the diversity of life. Facing the biodiversity problems that have become acute in recent decades, museums are called upon more than ever before to propose strategies that help tackle conservation challenges. In addition to their traditional functions related to collections and research, museums' education and communication initiatives are thus increasingly focused on biodiversity and its preservation.

Biodiversity represents a unique challenge for education. The general public seems to recognize the term "biodiversity" even though their knowledge about it may be simplistic or confused. Recently, a study was conducted on public opinion about biodiversity by the Biodiversity Barometer (2009–2015) from the Union for Ethical BioTrade (UEBT 2015). It was carried out from 2009 to 2015 with 47.000 consumers in 16 countries (USA, Mexico, Colombia, Ecuador, Peru, Brazil, UK, Netherlands, France, Germany, Switzerland, China, India, Vietnam, South Korea and Japan). The results indicate that the term "biodiversity" was relatively well known among respondents, and that a growing number (although in all cases less than 50%) defined biodiversity as the variety of plants and animals. Some

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respondents gave examples of ecosystems (e.g. the Amazon), or of the danger of monocultures. Others confused biodiversity with organic agriculture, environmental protection, global warming, or environmentally friendly products and technologies. Biodiversity was considered to be essential for one out of every two people interviewed in nine of the countries and for 74% of the respondents from Brazil, Ecuador, Mexico, and India.

> Many respondents around the world are familiar with biodiversity, particularly in Latin America and Asia. Yet, the meaning of biodiversity is not well understood still: on average 1 out of 3 could provide a correct description. While awareness and understanding of biodiversity are slowly growing, governments will need to step up efforts to increase awareness among their citizens to reach the 2020 targets of the United Nations (UEBT 2015, p.3).

Another important finding of the study is that TV and radio programs, school, and newspapers and magazines are the main sources of awareness of biodiversity, with differences in the order of importance per country. These findings prompt us to consider the role of museums in promoting an effective comprehension of biodiversity.

The diversity of meanings held by the public of the term biodiversity is a particular challenge for the field of education (Gayford 2000; Weelie and Wals 2002). Several authors have emphasized the importance of developing this subject in schools and the necessity of changing the relationship between humans and the environment (Gayford 2000; Vilches and Gil Peres 2003). In addition to school, other educational environments such as museums are called to collaborate in this effort (Brown 1997; Mehrhoff 1997; Davis 1999).

Today, museums are important educational resources, and one of their biggest challenges is to exhibit and disseminate issues related to biodiversity to arouse interest in visitors and improve their understanding and their attitude toward conservation. Exhibitions are the most important and well-recognized communication and education media in museums (Van-Praët and Poucet 1992; Dean 1994; Marandino 2005), and throughout their history, different perspectives have influenced the way organism diversity has been exhibited in natural history exhibitions. From a *biocentric* perspective in which nature was understood simply as its collective biotic and abiotic components, the development of the conceptions of ecology and ecological communities promoted a new way of representing biodiversity. Between the nineteenth and twentieth century, this *eco-centric* perspective influenced exhibition practices. Dioramas appeared that illustrated the natural interactions between the plants, animals, topography, and climate of a given environment. In the late twentieth century, anthropogenic impacts on the natural world began to be felt and prompted concerns about loss of biodiversity, climate change and conservation. As a result, in the beginning of the twenty-first century the *anthropocentric* perspective began to influence representations of nature and the relation between organisms and human beings in exhibitions (Fortin-Debart 2003). Knowledge about conservation and the role of humans in both causing problems and effectuating change began to be more explicitly represented and discussed in museums.

Even though the way biodiversity was represented changed substantially during this period of time, it continues to be a relevant issue in museum exhibitions and

essential content for museum education and science communication activities. As discussed by Krishtalka and Humphrey (2000), natural history museums face a number of fundamental challenges for the twenty-first century related to both collection and education. Natural history collections represent the three-dimensional historical records necessary to understand biological diversity and sustain plants, animals, microbes, and natural environments. It is thus crucial to promote museum dissemination such as exhibitions and educational programs that engage people in becoming the environmental conscience of their respective nations.

The subject of biodiversity seems to fit well with certain kinds of displays such as dioramas and immersion exhibits. Dioramas, conceived as scenarios that simulate a natural environment with models or taxidermied animals and plants, are the traditional way to explore ecological ideas in museums, because they allow the audience to perceive the relationships between the flora and fauna of an environment. As Morris (2009) elaborates, good dioramas embody information about ecological context, habitat, behavior, structure, and movement; this means that dioramas have considerable potential to transmit messages. Furthermore, dioramas are considered as important teaching objects in museums, especially with regards to biodiversity-related content (Bueno 2015). In the following, we shall discuss this diorama content in terms of *expositive discourse*, namely the narrative that emerges from the staging of the content. We shall discuss what the audience understands about biodiversity when they interact with dioramas, and what kinds of biodiversity-related knowledge they acquire when they are contemplating dioramas in museums.

In the following, we share empirical results from a program of research developed in partnership between the University of São Paulo, Brazil and the University of Copenhagen, Denmark. This partnership focuses on the analysis of teaching and learning processes in museums, and is the basis of the work presented in the first Springer volume on natural history dioramas (cf. Marandino et al. 2014). In the present text, we elaborate and expand on some of the findings discussed there.

In the first part of our account, we discuss the potential of dioramas to represent and teach aspects of biodiversity. This discussion is based on a thorough analysis of the biological content of the Amazon Forest diorama from the Zoology Museum of the University of São Paulo. In the second part, we share the results of a study of the biodiversity-related knowledge constructed by adult visitors while visiting dioramas, both at the Zoology Museum of University of São Paulo (ZMUSP) and the Zoology Museum of the University of Copenhagen (ZMUC). Finally, we discuss more generally the potentials and challenges of teaching and learning biodiversity using dioramas in museums.

13.2 Methodological Aspects

The analysis of the Amazon Forest diorama in the Zoology Museum of the University of São Paulo was based on museum documents, observations, and interviews with exhibition designers and the audience (Bueno 2015; Bueno and Marandino 2017).

The analysis was structured by the Anthropological Theory of Didactics (ATD) in order to identify aspects of biodiversity that are present in the diorama, especially in the objects, text, and supporting images. Specifically, the notion of praxeology was used as a tool to identify and understand the elements related to ecology and biodiversity presented in the Amazon Forest diorama, as well as how the visitor's acquisition of those elements was intended to take place (cf. Mortensen 2011; Achiam 2013). This analysis allowed us to identify the *tasks* embodied in the design of the diorama, as well as the *techniques* proposed by this design. These two elements comprise the practical component (or *praxis*) of the praxeology related to the diorama; that is, they describe the perceivable characteristics of the diorama and the actions afforded to visitors by those characteristics. Furthermore, we identified the cognitive components (or *logos*) of the praxeology related to the diorama: The *technology* (or discourse about the technique) describes the ways the interaction with the diorama can be understood by a visitor in relation to biodiversity, while the *theory* component comprises the more overarching inferences about biodiversity that can be made. In this chapter, we will present results from this praxeological analysis, illustrating which concepts and ideas of biodiversity are shown in the diorama, and how those concepts and ideas can be taken up by visitors. In other words, the praxeological analysis presented here serves to clarify the potential of the diorama of disseminating biodiversity to visitors.

The second study we refer to here focuses on adult visitors to dioramas in two zoological museums, the Zoology Museum of the University of São Paulo and Zoology Museum of the University of Copenhagen. We collected data from 15 adult subjects from Brazil and Denmark. In each museum, the subjects observed two dioramas, while at the same time verbalizing their thoughts (the *thinking aloud* method). The observation session was followed by a semi-structured interview. Both the thinking aloud session and the interview were audio and video recorded. This method is based on research on psychology (Ericsson and Simon 1993) and has been adapted to study learning in a museum (Dufresné-Tasse et al. 1998; Émond 2002). In the present case, it was used to understand what kinds of biodiversity-related knowledge the adult audience constructed when observing dioramas. The analysis of the data collected in this way was guided by the categories of approaches of biodiversity (Marandino and Diaz Rocha 2011), namely *levels of biodiversity organization*, *biogeography*, *evolution*, *conservationist* and *human*. The definition of each approach is set out in Table 24.1 and is based on discussions about the aspects involved in the idea of biodiversity and biodiversity education (Levêque 1999; Gayford 2000; Weelie and Wals 2002; Brandão 2010).

13.3 Dioramas as Teaching Objects in Museums

As described in the preceding section, dioramas are carefully constructed scenarios that have been used in museums since the nineteenth century to promote a realistic perception of nature. To this end, dioramas combine reproduction techniques with

Table 24.1 Approaches of biodiversity

Categories of approach of biodiversity	Description
Levels of organization	Biodiversity is expressed in terms of levels of organization, related to species (taxon variety), genetic (gene variation between individuals, population and taxon) and ecosystem (taxon variety and the environment where they lived).
Biogeography	Biodiversity is expressed with emphasis on the time and space dimensions, including the organism's distribution in a period of time or geography.
Evolution	Biodiversity is expressed with emphasis on the time dimension and the variation of one or more groups of organisms during a period of time, establishing relations with an ancestor.
Conservation	Biodiversity is expressed with emphasis on the implications about the species conservation and the environment threats.
Human	Biodiversity is expressed with consideration of the human dimension. This approach can be presented in two forms: the human being as a species like any other biological species; or as a central species, considering cultural, social and economical aspects. In the latter case, there is no relation with conservation aspects.

scientific knowledge of plant and animal species. They make use of lighting effects, painted backgrounds, and taxidermied plants and animals. They present a type of motionless theater, which places us in make-believe habitats that function by creating a degree of realism (Almeida 2012). Dioramas can be understood as objects produced with the intent of teaching and learning in museums; indeed, their institutional longevity seems to attest to their efficacy as educational devices (Van Präet 1989).

The biological knowledge embedded in dioramas is usually connected to the observation, identification and recognition of species of plants, animals or fungi, the relationships of these organisms with each other and with the environment, and also the identification of geophysical phenomena such as rock formations, soil types, types of biome, and others. Therefore, dioramas can realistically illustrate both flora and fauna of different biomes in terms of the different adaptations of the animals and plants living in these environments. Moreover, dioramas can represent different ecological relationships, including the symbiotic relationships among living creatures. They are therefore particularly effective with regards to disseminating knowledge about different habitats and the interactions between organisms. Dioramas are potentially powerful tools for science education and should be developed as such (Tunnicliffe 2009).

In recent years, studies of dioramas have focused on how they represent different habitats (Insley 2008), meaning that the dioramas have historically been, and still are, used to represent realistic scenarios consisting of natural specimens and at the same time also to showcase the skills of taxidermists. They thus offer visitors new, image-mediated learning experiences which, according to Hooper-Greenhill (1990), are the most concrete medium for learning. Paddon (2009) adds that dioramas can provide valuable opportunities for education in museums, because in addition to

their visual qualities and learning, dioramas may also offer opportunities to interpret historical collections, mappings and, for example, 'the story of taxidermy'.

A number of studies have explored the potentials of dioramas to elicit educational activities in science museums (Ash 2004; Tunnicliffe 2009; Bueno and Marandino 2017). These studies emphasize the potential of dioramas to promote the understanding of ecology, biodiversity, and conservation issues by allowing visitors to observe environments they have never before experienced. Thus, in our view, dioramas are educational objects, meaning that they are created by combining scientific, artistic, education and communication knowledge into one product. Dioramas are objects that demonstrate the contents and actions intended by their designers and producers; thus, it is possible to study how dioramas address biodiversity as a means to characterize their potential to disseminate this theme in the museum.

13.4 Teaching Biodiversity with Dioramas in Museums

Dioramas, like other educational objects, are the results of human efforts. They result from processes that include simplifications and reductions but also enrichment and reconstruction; these processes are governed by the intended learning objectives of their designers. To understand how dioramas represent knowledge in museums, we draw on research into the representation of biodiversity in a variety of exhibitions in museums, science centers and aquariums (Bueno 2015; Marandino et al. 2014; Salgado 2011; Marandino and Diaz Rocha 2011; Oliveira 2010).

Oliveira (2010), for example, studied the transformation process of biodiversity idea that occurs in dioramas production – museographic transposition – in two Brazilian museums, considering not only conceptual dimensions of biodiversity but also value dimensions. This work showed how aspects related to the *species* and *ecosystems* levels of biodiversity are strongly present in dioramas. Oliveira also found that aspects related to *values* of biodiversity are less present in dioramas, but that they emerge when a diorama explicitly explores conservation themes.

More recently, a number of studies of *praxeologies* in museums have emerged. The focus of these studies has been the learning environment of museum exhibitions; specifically, these studies have sought to understand the relationship between design and learning. This understanding, in turn, has been used to generate theoretically grounded yet operational principles for optimizing the alignment between the design of exhibitions and the educational outcomes (Mortensen 2010; Achiam and Marandino 2014). Using the potential of this approach to describe diorama contents, Bueno (2015) analyzed the Amazon Forest diorama, an element of the thematic area "Neotropical Fauna and Marine Environment" of the exhibition "Zoology Research: Biodiversity under the view of the zoologist" of the Museum of Zoology, University of São Paulo. This analysis included the diorama and its supporting elements (e.g. the display case and the panel containing text, image and layout with subtitles; see Fig. 24.1), and aimed to give a detailed description of what and how a diorama represents biodiversity concepts.

Fig. 24.1 Front view of the "Amazon Forest" cluster of ZMUSP

To systematically describe the diorama, a focal question was chosen. This focal question served to orient the investigation of what and how biodiversity was represented. The question "How can the visitor perceive the ideas and concepts of biodiversity represented by the diorama of the Amazon Forest and its exhibition set?" helped to describe in details each element, using the theoretical framework of praxeology.

The diorama of the Amazon Forest has an "L" shape, and is about 3 m high, 4.5 m long, 2.4 m wide at the wider part of the "L" and 1 m at the narrower part. The display is open and has guardrails. Light sources are located at the front and directed towards the rear. The diorama includes taxidermied animals, models of flowering plants, and trees. One of the supporting elements of the diorama, the display case, is 50 cm from the floor and consists of three glass covered, backlit boxes. Two of the boxes include invertebrates and the third has a legend to identify some of the vertebrates in the diorama. Another supporting element of the "Amazon Forest" cluster was a panel, including a text, an image, and a sketch with a legend, which together displayed the characteristics of the Amazon Forest. In order to describe the diorama according to the notion of praxeology, a thorough documentation was carried out to reveal the ideas and concepts expressed in the whole cluster. An example of the description is given in the following:

> In the 2nd quadrant, in the center, there is a cut tree trunk with ferns, vines, a pink orchid in tree trunks. At the bottom, on a branch of the cut trunk, there is an iguana *(Iguana iguana)* with its tail extending to quadrant 1. The soil is sparsely covered by shrub vegetation – 20 to 30 cm high – with some elevation representing rocks or exposed plant roots (Description of a part of the Amazon Forest diorama/ZMUSP).

The description represents a translation of the elements presented in the Amazon Forest diorama into text, and outlines the ideas and the elements that define and operationalize the design of the exhibition in order to communicate the contents of biodiversity to the visitors. Considering the focal question "How can the visitor perceive the ideas and concepts of biodiversity represented by the diorama of the Amazon Forest and its exhibition set?" we observe that the visitor has the opportunity to recognize the diversity of species and ecosystems of the Amazon Forest. This idea is expressed in a specific way, because the diorama represents an ecosystem composed of different environments, with great plant and animal diversity. Also, with the help of the panel, the cluster represents the geographical distribution, and the threats this ecosystem is currently subjected to.

Each element of the rich object that is the diorama potentially supports a multitude of ideas and concepts. From the visitor's perspective, the diorama presents them with a variety of tasks. For example, the diorama affords the visitor a view of a complete scenario; in other words, the visitor may perceive the *tasks* of observing the entire scenario, identifying the environment and the organisms distributed within it, at the same time recognizing and discerning aspects as ecological relationships of the Amazon Forest, the plant and animal richness of this forest or the species that compose the animal diversity of the Amazon Forest. Regarding this last aspect, the visitor may identify this diversity by discerning an iguana and a pink orchid, or by looking into the glass covered boxes with specimens of the insect, arachnid and crustacean diversity, as illustrated in Fig. 24.1 of the Amazon Forest cluster.

Bueno (2015) found that most of the tasks identified in her analysis were related to the action of identifying organisms in the scene, as in the task "distinguish organisms that contribute to Amazon Forest diversity". It was interesting to note that the diorama is conceived as an *object to show objects*; in the present case, the displayed objects are those organisms that can be found in the Amazon Forest, and the diorama seemed to be well-suited to accomplish this goal. Further, Bueno concludes, the diorama is a suitable medium to help visitors to perceive ecological relations between species and the environment. Because the species in question are static, the diorama offers the visitor the opportunity to stop, look, observe, visualize, find, identify, recognize, discriminate, suppose, and search for their questions in a different way than in a zoo, for example, where animals are alive and exhibit behaviors that may make observation difficult.

However, Bueno's study also observed that very few diorama tasks gave rise to complex mental operations. To the extent that the visitor was able to see and identify biodiversity elements by observing the diorama, they typically named and pointed out the organisms and their relations. In these cases, tasks and techniques related to technologies such as inferring and supposing were less frequent in the praxeology analysis. Such technologies were rarely prompted by the tasks and techniques

embedded in the cluster of the Amazon Forest. This, of course, has implications for visitors, for whom opportunities are lost to compare morphological and functional characteristics of species in the different habitats. Such comparisons could potentially reveal the complexity of species' behavior and of the idea of biodiversity itself.

Another important aspect of the Amazon Forest cluster is that it presents contents related to biogeography, such as data about clime, rainfall rate, deforestation (and, conversely, the preservation of forest), and also the location of the biome on the world map. However, whether the visitor grasps these contents depends on the type of interaction established with the exhibition, because the visitor would need to look at the panel and read the information on it.

Clearly, the praxeology framework helps to detail the concepts shown in the cluster of the Amazon Forest diorama and reveals the potential of the diorama to disseminate ideas of biodiversity in an objective way. Further, the analysis helps identify which aspects of biodiversity are privileged and which are absent or deliberately removed from the diorama when it was produced. This information was available from observations, the documents, and the interviews with the designers of the exhibition, and provides the basis for an evaluation of the dissemination potential of the diorama in a museum.

Recently, the notion of praxeology was adapted to be used by museum educators or schoolteachers to improve the learning process in museum settings (Oliveira et al. 2015). The approach used praxeology as a framework to describe the scientific concepts and ideas present in an exhibit in a museum (such as a diorama), and to identify the techniques used to represent those concepts and ideas. The description made by the museum educator, the teacher or even the students helps to identify the theory, technology, techniques, and tasks presented in the object. With these elements in hand, it is possible for educators and teachers to design a teaching sequence that can be carried out during visits in museum exhibitions.

13.5 Comprehension of Biodiversity from Dioramas in Museums

In order to understand the role of museums in disseminating aspects of biodiversity to adult audiences, we carried out a study of what adult visitors observe and talk about when interacting with dioramas. As mentioned previously, the collected data consisted of two parts: thinking aloud (when the visitor says what comes to their mind while looking at the diorama), and the subsequent interview. This data was analyzed using the categories of approaches of biodiversity (Marandino and Diaz Rocha 2011), related to levels of biodiversity organization, biogeography, evolution, conservationist and human.

The categories of approaches of biodiversity have been used previously to identify the biodiversity content presented by in museum exhibitions (Marandino et al.

2009; Monaco and Marandino 2010; Marandino and Diaz Rocha 2011). The data from those investigations, which analyzed five museums: three Brazilian, one French, and one Canadian, reflect similar patterns: The perspective of *levels of organization* is represented most frequently, especially in particular the species and the ecosystem levels, whereas the genetic level is often absent. Aspects of biogeography and evolution are present but infrequently, mostly cited in panels or labels. The conservationist approach appears in some cases in the exhibition narrative, represented by a threatened species for example whereas the *human* approach was very rare. Both of the latter approaches were more frequently present in the immersion exhibitions studied.

But what kinds of biodiversity knowledge does the audience acquire during their visits to dioramas? The literature reveals that a visitor, when observing a diorama, constructs a particular narrative that adapts what they see to their previous knowledge of the environment and the displayed organisms (Piqueras et al. 2008; Tunnicliffe 2009). In our research we analyzed the narratives of visitors, searching for evidence of the approaches of biodiversity presented in them. We noticed that some approaches of biodiversity are more common in visitors' perceptions than others. For instance, all the observed subjects spoke about the species they observed in the dioramas, making the approach of *levels of organization* the most strongly present in the verbalizations, both in Brazil and in Denmark. In particular, the *species* level is recurrent, as for example when the visitors identified and named the organisms in the scene during the thinking aloud data collection:

> How many plant species, here we observe many trees, there are also lianas, where some animals, we also see ferns, plants (ZMUSP).

> I've never seen pelicans in Denmark, so I did not know we had them here (ZMUC).

The *ecosystem* level is also expressed in the verbalizations of the adult visitors, but less frequently than the *species* level, as seen above. The *genetic* level was not found in the data; that is, the visitors did not make any comments related to the characteristic variations between individuals, populations or taxa.

> Well, it's ecosystem … peace, ah … power … dense forest, diversity in fauna and flora, a large trunk trees … a rainforest. Interaction of the environment, the animals are interacting, less the jaguar, the jaguar seems mad at someone who is coming, are the human? … Collectors animals in the case squirrels, … vines, … means it is a hawk feeding a monkey, predator, …, has a bio-indicator, also in … the vine trunk, oxygen bio-indicator, are the lichens, um … a den, a house, a monkey, here is a lizard, a chameleon in search of sun (ZMUSP).

As we know, the behavior of identifying and naming organisms during an exhibition visits is common (Allen 2002; Tunnicliffe and Scheersoi 2009). In such instances, the visitor emphasizes the *species* approach of biodiversity. It thus seems that dioramas are efficacious media for promoting this kind of interaction, especially when the diorama affords the perception of the species that belong to a specific ecosystem. Also, identifying relations between different species, and between species and the abiotic environment, characterizes the level of *ecosystem* organization approach, which arguably has been the role of dioramas since their

origin. The aspects related to the level of *organization* were verbalized spontaneously by the subjects during the thinking aloud method but also discussed during the subsequent interview.

The *conservationism* approach was also present in our data, suggesting that the diorama scenario can create a link between the audience and discussions about environmental threats. This may occur even if the scenario does not address a specific environmental problem, as we can see in the verbalization of the subject from the Zoology Museum of University of Copenhagen, when they speculated about the objective of displaying a present-day beech forest in a diorama. Also, the visitors offer their own knowledge or alternatively, information collected during the visit to speak about this theme, what is promoted by the object observed in the scenario. This occurred both during the thinking aloud and the interview:

> (…) It is something about how much forest we have in Denmark, when we had it and how much we have, how many trees were planted and learn a little (ZMUC).

> The jaguar is an endangered animal, so it has a certain appeal, and being endangered, we already think, reflects on the degradation of the environment (ZMUSP).

The *biogeography* and *evolution* approaches of biodiversity were also mentioned, but in relatively few instances, compared with the other approaches. Generally, these topics were mentioned during the interviews, when we asked visitors about what they thought was the learning objective of the dioramas. However, it is important to highlight that aspects of the *evolution* approach were present only at ZMUC; this occurrence is almost certainly related to the overarching theme of the exhibition which was "The Danish Fauna throughout 20,000 years: From Mammoth Steppe to Cultural Steppe".

> I would say I should learn something about when I find it. I must learn about what happened seven thousand years ago, because of this,… that I'm exactly in this area of the museum, you can see from the beginning and when the period comes close today. I would say that's why I stopped and looked in those scenarios, where the animals were living at that time (ZMUC).

> Yes, looking at this diorama now there are animals that we have now and there are others we do not, you do not find those animals anymore. Then I would expect that represents an environment that exists before (ZMUC).

The *human* approach was present neither in the thinking aloud, nor the interviews. In the example shown below, a visitor comments that in a preserved environment, humans cannot be present.

> And it's the preserved environment, right. Preserved, … man is not present (ZMUSP).

We consider that in this case, the focus is on the *conservationism* approach and not the *human* approach, as the visitor is not discussing the role of the human being in preservation or considering cultural, social and economical aspects of the biodiversity.

Our data allow us to discuss aspects about what approach of biodiversity the dioramas focus on. We are able to affirm that the *level of organization* of biodiversity is frequently perceived when adults observe naturalistic dioramas in the studied

museums. The *species* level is strongly present in the verbalizations of the audience; the *ecosystem* level is also present but less frequent. The *genetic* level was absent: it was not identified when adult visitors observed the dioramas.

In relation to the other approaches of biodiversity, the *biogeography* and *evolutionary* approaches were identified in a smaller number of verbalizations, just as the *conservationism* approach. The *human* approach was not identified.

These results indicate that the studied naturalistic dioramas are very efficacious devices for audiences to learn about the *species* and the *ecosystem* levels of biodiversity organization; further, they may be suitable for visitors to learn aspects of *conservation*, *biogeography* and *evolution* concepts of biodiversity, considering the previous knowledge of the visitor and the information given by panels and labels. However, dioramas do not seem to be effective prompts for discussions of the complexity of biodiversity, a complexity that includes the role of the human in preservation and human biodiversity itself.

13.6 Discussion and Conclusion

Dioramas are effective devices for the dissemination and acquisition of knowledge in museums. Moreover, they are well suited for teaching and learning some aspects of biodiversity. Like other educational objects, they are created through a process of simplification and reduction in order to organize and select information according to educational and communication goals. Our analysis elucidates the final product of this process and its potential to disseminate important biodiversity content. But is also true that there are limits to the complexity of biodiversity content that can be expressed through dioramas, at least with the present genres of naturalistic and classical dioramas still featured in many museums.

The use of praxeology as a theoretical and a methodological tool was an effective means to identify the biodiversity concepts in dioramas. The praxeological characterization of the diorama helps to identify the elements that define the design of the exhibit as well as the operationalisation of these features in the communication of biodiversity content to the visitors of the cluster of Amazon Forest diorama. In terms of dissemination potential, this cluster is composed of many different types of tasks, expressed in a variety of modalities: a scenario with taxidermied animals, models of plants, display cases, panels and labels with text and images, and interpretative schemes to be observed and read. Many concepts, related to different aspects of biodiversity, require interpretation by the visitor. The praxeological analysis revealed several tasks that could allow the visitor to perceive the characteristics of the environment and species, their behavior, and the distribution of organisms in the space.

It was noted, however, that there was a prevalence of tasks that prompted the visitor to simply identify animals in the scene. Even though the Amazon Forest cluster shows elements that go beyond the field of biological concepts, including contents from other areas of knowledge such as biogeography, it does so with the help of panels with text and images. As stated previously, those contents will be appre-

hended by the visitor strictly depending on the type of interaction that is established with that information. Nevertheless, dioramas still have a powerful role to play in helping visitors understand biodiversity and the ecological relationships between organisms and with the environment, because they have the potential to reach a wide audience, thereby expanding access to biological knowledge. Many cognitive tasks are posed to the visitor during their observation, namely identifying, recognizing and distinguishing elements that belong to the ecosystem in question. The educational intention of the diorama is therefore substantial; even though it seems a totally static object, the diorama embodies an interactive quality, further strengthening its educational role. This trait resides in the potential of the diorama to 'lead' the visitor to the natural environment to which it represents, and to reveal behaviors, dynamics and relationships that occur in those environments.

Thus, the results related to the praxeological analysis reveal the potential and the limitations of dioramas for disseminating biodiversity in museums. Of course, not every concept and idea can be shown in an educational object; choices must be made to select what and how to disseminate using a particular medium. This selection process explains the absence of some ecological relationships, some animal classes, and some plant species. Also, it is noted that certain cognitive tasks are not frequently present in the praxeological analysis of the Amazon Forest, related, for example, to the ability of compare morphological and functional characteristics of the species and habitats (Bueno 2015).

In our studies of the adult audience visiting dioramas, the same characteristic was noticed. Visitors frequently discussed species and ecosystem characteristics (*levels of organization* of the biodiversity), *conservation*, *biogeography* and *evolution* aspects (when they are mentioned in panels and labels), and very rarely discussed the *human* approach of biodiversity. They did not consider the complexity of biodiversity, which includes the role of the *human* in the preservation and the human diversity itself. This finding is corroborated by Campos (2013), who found that most adult pairs observing and talking in front of the same Amazon Forest diorama used cognitive operations such as naming and pointing; affective comments and characterization of the elements were also frequent whereas the mental operations of supposing and explaining were very rarely present.

It is clear that dioramas are suitable objects for disseminating certain aspects of biodiversity, but not all of them. However, the dissemination potential of dioramas could be improved depending on the communication devices and the mediation strategies supported by the museographic elements. The process of teaching and learning in museums involves the personal context, the sociocultural context and the physical context (Falk and Dierking 2000). Regarding this last aspect, topics such as the orientation to the physical space, the architecture, the environment, the design of exhibits influences individually and collectively and significantly contribute to the quality of a museum experience (Falk and Storksdieck 2005). Taking this statement together with our data, we observe that to improve the visitors' comprehension of the complexity of biodiversity using dioramas, it is necessary to implement strategies that suggest tasks and techniques beyond those already present; only then will visitors be prompted to move beyond simply identifying and naming species and ecosystems.

References

Achiam, M. F. (2013). A content-oriented model for science exhibit engineering. *International Journal of Science Education, Part B, 3*(3), 214–232.

Achiam, M., & Marandino, M. (2014). A framework for understanding the conditions of science representation and dissemination in museums. *Museum Management and Curatorship, 29*(1), 66–82.

Allen, S. (2002). Looking for learning in visitor talk: A methodological exploration. In G. Leinhardt, K. Crowley, & K. Knutson (Eds.), *Learning conversations in museums* (pp. 259–303). Mahwah: Lawrence Erlbaum Associates.

Almeida, A. P. (2012). Realismo e Fotografia: Dioramas de Hiroshi Sugimoto do Museu de História natural de Nova Iorque. *Museologia & Interdisciplinaridade, 1*(2), 114–133.

Ash, D. (2004). How families use questions at dioramas: Ideas for exhibit design. *Curator: the museum journal, 47*(1), 84–100.

Brandão, C. R. (2010). A pesquisa em biodiversidade. In M. Marandino, L. Mônaco, & A. D. Oliveira (Eds.), *Olhares sobre os diferentes contextos da biodiversidade: pesquisa, divulgação e educação* (pp. 8–12). São Paulo: GEENF/FEUSP/INCTTOX.

Brown, E. H. (1997). Toward a natural history museum for the 21st century – Change catalogue. *Museum News*, Nov–Dec, pp. 39–40.

Bueno, J. P. P. (2015). *Objetos que ensinam em museus: análise do diorama do Museu de Zoologia da USP na perspectiva da praxeologia*. Dissertation, Universidade de São Paulo.

Bueno, J. P. P., & Marandino, M. (2017). The notion of praxeology as a tool to analyze educational process in science museums. In K. Hahl, K. Juuti, J. Lampiselkä, A. Uitto, & J. Lavonen (Eds.), *Cognitive and affective aspects in science education research*, *Contributions from science education research* (Vol. 3, pp. 339–355). Cham: Springer International Publishing.

Campos, N. F. (2013). *Percepção e Aprendizagem no Museu de Zoologia: uma análise das conversas dos visitantes*. Dissertation, Universidade de São Paulo.

Davis, P. (1999). *Conserving biodiversity – The role of smaller museums*, *Les Musées et Collections de Sciences Naturelles – Cahiers d'étude* (Vol. 7, pp. 26–27). Paris: ICOM/NatHist.

Dean, D. (1994). *Museum exhibition – Theory and practice*. London: Routledge.

Dufresné-Tasse, Sauvé, M., Weltzl-Fairchild, A., Banna, N., Lepage, Y., & Dassa, C. (1998). Pour des expositions muséales plus éducatives, accénder a l'experiénce du visiteur adulte. Développment d'une approache. *Canadian Journal of Education/Revue canadienne de l'éducation, 23*(3), 302–315.

Émond, A. M. (2002). *The effects of historical arts and contemporary arts on cognitive dissonance and consonance as verbalized by adult visitors in a fine arts museum*. Thesis, Concordia University.

Ericsson, K. A., & Simon, H. A. (1993). *Protocol analysis: Verbal reports as data* (2nd ed.). Boston: MIT Press.

Falk, J. H., & Dierking, L. D. (2000). *Learning from museums: Visitor experiences and the making of meaning*. Walnut Creek: Altamira Press.

Falk, J., & Storksdieck, M. (2005). Using the contextual model of learning to understand visitor learning from a science center exhibition. *Science Education, 89*, 744–778. https://doi.org/10.1002/sce.20078.

Fortin-Debart, C. (2003). Le Musee de Sciences Naturelles, un partenaire de l'école pour une education relative a l'environnement: du message scientifique au débat de société. *VertigO, 4*(2). https://doi.org/10.4000/vertigo.4494.

Gayford, C. (2000). Biodiversity education: A teachers perspective. *Environmental Education Research, 6*(4), 347–361.

Hooper-Greenhill, E. (1990). *The educational role of the museum* (2nd ed.). London: Routledge.

Insley, J. (2008). Little landscapes: Dioramas in museum displays. *Endeavour, 32*(1), 27–31.

Krishtalka, L., & Humphrey, P. S. (2000). Can natural history museums capture the future? *BioScience, 50*(7), 611–617.

Lévêque, C. (1999). *A Biodiversidade*. Bauru: Edusc.

Marandino, M. (2005). Museus de Ciências como espaços de educação. In B. G. Figueiredo & D. Vidal (Eds.), *Museus dos Gabinetes de Curiosidades ao Museu Moderno* (pp. 165–176). Belo Horizonte: Argvmentvm.

Marandino, M., & Diaz Rocha, P. E. (2011). La biodiversidade en exposiciones inmersivas de museos de ciencias: Implicaciones para educación en museos. *Enseñar Ciencia, 29*(2), 221–236.

Marandino, M., Oliveira, A. D., & Mortensen, M. (2009). Discussing biodiversity in dioramas: A powerful tool to museum education. *ICOM/NatHist, 29*, 30–36.

Marandino, M., Achiam, M., & Oliveira, A. D. (2014). The diorama as a means for biodiversity education. In S. D. Tunnicliffe & A. Scheersoi (Eds.), *Natural history dioramas history, construction and educational role* (pp. 251–266). Dorthrecht: Springer.

Mehrhoff, L. J. (1997). Museums, research collections, and the biodiversity challenge. In M. L. Reaka-Kudla, D. E. Wilson, & E. O. Wilson (Eds.), *Biodiversity II: Understanding and protecting our biological resources* (pp. 447–464). Washington, DC: Joseph Henri Press.

Monaco, L. M., & Marandino, M. (2010). Biodiversidade nos museus: discussões sobre a (in)existencia de um discurso relativo à conservação em ações educativas dos museus de ciências. In M. Marandino, L. M. Monaco, & A. D. Oliveira (Eds.), *Olhares sobre os diferentes contextos da biodiversidade: pesquisa, divulgação e educação* (pp. 13–29). São Paulo: GEENF/FEUSP/INCTTOX.

Morris, P. (2009). A window on the world- wildlife dioramas. *ICOM/NatHist, 29*, 27–30.

Mortensen, M. F. (2010). Museographic transposition: The development of a museum exhibit on animal adaptations to darkness. *Education & Didactique, 4*(1), 115–138.

Mortensen, M. F. (2011). Analysis of the educational potential of a science museum learning environment: Visitors' experience with and understanding of an immersion exhibit. *International Journal of Science Education, 33*(4), 517–545.

Oliveira, A. D. (2010). *Biodiversidade e museus de ciências: um estudo sobre transposição museográfica nos dioramas*. Dissertation, Universidade de São Paulo.

Oliveira, A. D., Bueno, J. P. P., & Vidal, F. (2015). Identificando o potencial de objetos expositivos para ações educativas em museus de ciências. In M. Marandino & D. Contier (Eds.), *Educação Não Formal e Divulgação em Ciência: da produção do conhecimento a ações de formação* (pp. 37–44). São Paulo: Faculdade de Educação, Universidade de São Paulo.

Paddon, H. (2009). Curatorial responses to natural history dioramas. In S. D. Tunnicliffe & A. Scheersoi (Eds.), The important role of natural history dioramas in biological learning. *ICOM/NatHist, 29*, 11.

Piqueras, J., Hamza, K. M., & Edvall, S. (2008). The practical epistemologies in the museum: a study of students learning in encounters with dioramas. *Journal of Museum Education, 33*(2), 153–164.

Salgado, M. O. (2011). *A Transposição Museográfica da Biodiversidade no Aquário de Ubatuba: estudo atr.avés de mapas conceituais*. Dissertation, Universidade de São Paulo.

Tunnicliffe, S. D. (2009). Inquiry at natural history dioramas – useful resource in science education. *ICOM/NatHist, 29*, 16–20.

Tunnicliffe, S. D., & Scheersoi, A. (2009). The important role of Natural History dioramas in biological learning. *ICOM/NatHist, 29*, 1–40.

Union for Ethical BioTrade UEBT. (2015). *UEBT Biodiversity Barometer 2009–2015*. http://ethicalbiotrade.org/dl/UEBT%20-%20EN%20Barometer%202015.pdf. Accessed 10 Feb 2016.

Van-Präet, M. (1989). Contradictions des musées d'histoire naturelle et evolution de leurs expositions. In B. Schiele (Ed.), *Faire Voir, Faire Savoir: la muséologie scientifique au present* (pp. 25–33). Montreal: Musée de la civilization.

Van-Präet, M., & Poucet, B. (1992). Les Musées, lieux de contre-éducation et de partenariat avec l'école. *Education et Pédagogie, 16*, 1–7.

Vilches, A., & Gil-Peres, D. (2003). *Construyamos un futuro sostenible. Diálogos de supervivencia*. Madrid: Cambridge University Press.

Weelie, D. V., & Wals, A. E. J. (2002). Making biodiversity meaningful through environmental education. *International Journal of Science Education, 24*(11), 1143–1156.

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