Universidade de Aveiro
2022

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VIEIRA DE SOUSA

# Perceções dos portugueses sobre o Antropocénico: um caso de estudo na Galeria da Biodiversidade – Centro Ciência Viva | MHNC-UP

# Portuguese population perceptions on the Anthropocene: a case study at the Hall of Biodiversity – Ciência Viva Center | MHNC-UP

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Dissertação apresentada à Universidade de Aveiro para cumprimento dos requisitos necessários à obtenção do grau de Mestre em Biologia Aplicada, realizada sob a orientação científica do Doutor Ulisses Miranda Azeiteiro, Professor Associado com Agregação do Departamento de Biologia da Universidade de Aveiro e da Doutora Maria João Fonseca, Diretora de Comunicação do Museu de História Natural e da Ciência da Universidade do Porto e Diretora Executiva da Galeria da Biodiversidade – Centro Ciência Viva | MHNC-UP.

*“In a world of inhumane reality, it is the only humane sanctuary left. That is a dream.”*

Paprika (2006), dir. Satoshi Kon

**o júri**

| | |
|---|---|
| presidente | Professora Doutora Maria Adelaide de Pinho Almeida<br>Professora Catedrática, Departamento de Biologia, Universidade de Aveiro |
| vogal – arguente | Doutor Nelson José Cabaços Abrantes<br>Investigador Auxiliar em Regime Laboral, CESAM & Departamento de Biologia, Universidade de Aveiro |
| vogal – coorientadora | Doutora Maria João Guimarães Fonseca<br>Dirigente Intermédio de 2º Grau, Museu de História Natural e da Ciência, Universidade do Porto |

**agradecimentos**

Em primeiro lugar, gostaria de agradecer ao meu orientador Professor Doutor Ulisses Azeiteiro, por ter acreditado em mim desde o meu primeiro ano de licenciatura até hoje. Obrigada por tudo o que me ensinou, pelos debates, por ter instigado em mim um enorme gosto pela Biologia e por ter alimentado a curiosidade pela sua vertente social. À minha co-orientadora Doutora Maria João Fonseca, por me ter proposto este desafio e por ter estado presente em todas as fases deste processo, garantindo-me segurança e confiança na execução do projeto. Pelo contínuo apoio e ajuda, pela motivação e pelo entusiasmo, o meu muito obrigada. Quero também agradecer à Doutora Sara Carvalho e ao Doutor António García-Vinuesa pela ajuda no processo. Agradeço também às turmas que voluntariamente participaram no projeto, bem como aos visitantes que despenderam um pouco do seu tempo para serem entrevistados. À equipa da Galeria da Biodiversidade que me ajudou no processo: Rosário, Luísa, Teresa, Carla, Pedro e Miguel, obrigada. À minha mãe, que faz tudo por mim e me apoia incondicionalmente. Ao meu pai que me relembra constantemente que devo acreditar em mim. À minha irmã, por demonstrar que a vida não nos encaminha para um beco sem saída, mas sim para uma multiplicidade de caminhos que se interligam. Ao Ricardo, por me apoiar e alegrar. Ao Miguel, ao Francisco, à Tia Sara, por estarem sempre aqui para mim. À Tia Bela, por insistir comigo para respirar, para apanhar sol e pelo contínuo apoio. Aos meus avós Tona, Nando, Tina e Tono, pelo carinho e apoio. Ao Tio Mico, Tio João, Tia Rita, Margarida, Isabel, Tio Nando, Cláudia, Eduardo, Fernando e Davi que, de uma forma ou de outra, contribuíram para o meu desenvolvimento. À Lunna e à Ju, por me relembrarem o que é verdadeiramente importante. E aos meus gatinhos, pelos miminhos e arranhadelas. Obrigada a todos.

**palavras-chave**

Antropocénico, Biodiversidade, Comunicação de Ciência, Galeria da Biodiversidade, Mobilização de Público em Ciência, Museus de Ciência, Perceções

**resumo**

O conceito *Antropocénico* levanta questões sociais relevantes, representando um tema emergente num mundo em constante mudança. Desta forma, aumentar o nível de conscientização é fundamental para promover ações coletivas sustentáveis. Os museus de ciência são instituições de educação informal essenciais que proporcionam experiências únicas aos visitantes, enquanto promovem a literacia e cultura científica. Como resultado, os museus de ciência podem moldar valores, opiniões e crenças e contribuir para desmitificar conceções erradas. A Galeria da Biodiversidade - Centro Ciência Viva | MHNC-UP representa o primeiro centro Ciência Viva focado na diversidade biológica, instigando a reflexão sobre a importância da sua preservação. O presente trabalho visa caracterizar as perceções da população portuguesa sobre o Antropocénico, com foco nas implicações na biodiversidade, e avaliar o impacto da exposição permanente da Galeria da Biodiversidade nas perceções dos visitantes. Os dados quantitativos e qualitativos foram recolhidos através da aplicação de questionários (abordagem pré-/pós-teste) a alunos do 11.º ano e através de entrevistas a visitantes de diversas origens. Realizou-se análise estatística e de conteúdo. Os resultados mostram que, embora haja uma baixa compreensão do significado de *Antropocénico*, os participantes reconhecem o papel do ser humano na transformação da biodiversidade e do mundo natural e como é vital protegê-los. A visita à Galeria da Biodiversidade revelou-se uma experiência enriquecedora, que influenciou positivamente os valores dos visitantes quanto à preservação da biodiversidade, enquanto contribuiu para o seu desenvolvimento pessoal. No entanto, uma vez que este estudo representa uma análise num curto espaço de tempo, é necessário efetuar estudos longitudinais.

**keywords**

Anthropocene, Biodiversity, Hall of Biodiversity, Perceptions, Science Communication, Science Engagement, Science Museums

**abstract**

The concept *Anthropocene* raises relevant societal questions, representing an emerging theme in an ever-changing world. Hence, raising awareness is crucial to promote collective sustainable action. Science museums are essential informal education institutions that provide unique experiences to visitors, whilst promoting scientific literacy and culture. As a result, science museums can shape values, opinions, and beliefs, and contribute to debunking misconceptions. The Hall of Biodiversity – Ciência Viva Center | MHNC-UP represents the first Ciência Viva center focused on biological diversity, instigating reflection on the importance of its preservation. The present work aims to characterize the Portuguese population's perceptions on the Anthropocene, with a focus on the implications on biodiversity, and assess the impact of the permanent exhibition of the Hall of Biodiversity on the visitors' perceptions. Quantitative and qualitative data were collected through the application of questionnaires (pre-/post-test approach) to 11th grade students, and by interviewing visitors from various backgrounds. Statistical and content analysis were conducted. Results show that although there is a low understanding of the meaning of *Anthropocene*, participants acknowledge the human's role in shaping biodiversity and the natural world, and how it is vital to protect it. Visiting the Hall of Biodiversity proved to be an enriching experience, that positively influenced the visitors' values regarding the preservation of biodiversity, while contributing to their personal growth. However, since this study represents a short-term analysis, further longitudinal research is needed.

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| | |
|---|---|
| **A** | Aveiro |
| **ASTC** | Association of Science-Technology Centers |
| **AWG** | Anthropocene Working Group |
| **B** | Braga |
| **Cont.** | Control |
| **D** | District |
| **DRCN** | Direção Regional de Cultura do Norte |
| ***df*** | Degrees of freedom |
| **E** | Excerpt |
| **EU** | European Union |
| **f** | Female |
| **G** | Gender |
| **GSSA** | Global Standard Stratigraphic Age |
| **GSSP** | Global Boundary Stratigraphic Sections and Point |
| **HKW** | Haus der Kulturen der Welt |
| **I** | Interviewee |
| **IBM** | International Business Machines Corporation |
| **ICS** | International Commission on Stratigraphy |
| **IPBES** | Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services |
| **IPCC** | Intergovernmental Panel on Climate Change |
| **IUCN** | International Union for Conservation of Nature |
| **m** | Male |
| ***M*** | Mean |
| ***Mdn*** | Median |
| **MAAT** | Museum of Art, Architecture and Technology, Lisbon |
| **MHNC-UP** | Natural History and Science Museum of the University of Porto |
| ***n*** | Number of observations |
| **N.A.** | Non applicable |
| **NGC** | National Gallery of Canada |
| ***SD*** | Standard deviation |
| **SPECO** | Portuguese Ecological Society |
| **SPSS** | Statistical Package for the Social Sciences |
| **SQS** | Subcommission on Quaternary Stratigraphy |

| | |
|---|---|
| ***p*** | p-value |
| **PhD** | Doctor of Philosophy |
| **Q** | Question |
| ***t*** | t-value |
| ***U*** | Mann-Whitney U value |
| ***z*** | z-value |

# 1. INTRODUCTION

## 1.1. The Anthropocene

### 1.1.1. Inception and perception

We live in a time that presents us with unprecedented challenges. The world is being pushed to its limits more and more, with humans serving as a considerable transformative agent. As a result, the concept *Anthropocene* has become increasingly popular. It is used to designate the most recent geological epoch in Earth's history, marked by human activity's significant impact on the natural world, ecosystems, and climate. Several scholars have developed this idea since the 19th century, but it was only in 2000 that this term was popularized by chemist Paul Crutzen and limnologist Eugene Stoermer. They proposed that human action manifests in such a pronounced way that it would justify the designation of a new geological epoch. Crutzen & Stoermer (2000) and Crutzen (2002) acknowledge the existence of the Anthropocene given the impact that the near exponential human expansion has in the world, allowing massive exploitation of resources and exacerbated changes at a global level, such as increasing livestock production and urbanization, extensive fossil fuels usage, biogeochemical changes in soils and atmospheric composition with an increase in greenhouse gases (e.g., $CO_2$ and $CH_4$) and chlorofluorocarbons, changes in primary ocean production and destruction of ecosystems.

Perhaps the most prominent anthropogenic pressure reflects on climate. The human hand shares a large percentage of responsibility concerning the increase in greenhouse gases concentration since the second half of the 18th century, with 2019 standing out as the year with the highest concentrations of atmospheric $CO_2$ in 2 million years. This reflects on the global surface temperature's increase, noting that the last four decades have been the hottest since 1850 (IPCC, 2021). This leads to glacier melt and oceanic thermal expansion, translating into a global mean sea level rise. Additionally, the increase in atmospheric $CO_2$ concentration leads to a greater carbon uptake by the ocean, influencing its rising acidification and decreasing oxygenation. Conversely, the ocean's ability to capture carbon decreases as emissions rise. In future scenarios of low and high carbon emissions, an increase in the global surface temperature is expected, until the mid-21st century, surpassing the 1.5°C above pre-industrial levels threshold, if there is no drastic reduction in greenhouse gases emissions (IPCC, 2021). Moreover, the frequency and intensity of extreme events (e.g., droughts, floods, heatwaves) have been growing globally;

the rise in global surface temperature is expected to largely influence this component. It is essential to point out that some of these effects are irremediable in hundreds and even thousands of years (IPCC, 2021). Finally, climate change profoundly impacts the biosphere, from the individual to the biome. It can affect fundamental processes and characteristics such as species phenology, behaviour, distribution, and trophic relationships, leading to numerous extinctions, massively impacting our planet's biodiversity (Bellard et al., 2012; Bowler et al., 2017; Schleuning et al., 2020).

Despite its strong connection to various components, it is not just climate change that could jeopardize the diversity of life that this world presents. Human population growth accelerated the frequency and intensity of activities in the primary (e.g., agriculture), secondary (e.g., industry), and tertiary (e.g., transport) sectors. These activities enhance drivers such as land and sea usage, organism exploitation (whether through excessive production and consumption or poaching), pollution (e.g., plastic pollution), and invasive species, which increased in the last half a century (IPBES, 2019). This seriously influences the degradation, fragmentation, and loss of habitats, essential for the survival of several species, therefore taking a considerable toll on biodiversity. According to the Convention on Biological Diversity (United Nations, 1992), biodiversity encompasses diversity within species, diversity between species, and ecosystems diversity. The impacts on biodiversity can also reflect in our well-being and potential survival as we need and enjoy numerous ecosystem services, whether provisioning, regulatory or cultural (Millennium Ecosystem Assessment, 2005).

However, the big question that arises is: to what extent is biodiversity really at stake? The International Union for Conservation of Nature's Red List of Threatened Species is globally acclaimed as a reliable source of integrated information on our planet's biodiversity through the analysis of the extinction risk of various animal, fungi, and plant taxa as well as their conservation status. It was noticed that there is a current decline in biodiversity through the 142,500 species analyzed so far, of which around 28% are threatened (IUCN, 2022). Furthermore, it is crucial to keep in mind that there is an ongoing sixth mass extinction event, the consequences of which are still unknown and undervalued, and that has been accelerated by anthropic action (Ceballos et al., 2020).

### 1.1.2. An unofficial geological time unit

Zalasiewicz et al. (2015) summarize the three main proposals for the onset of the Anthropocene. The first concerns an *early Anthropocene* or *Palaeoanthropocene*, a term coined by Foley et al. (2013), which includes the Holocene and possibly part of the Pleistocene, comprised until the Industrial Revolution, recognizing the anthropogenic effects on landscapes and climate through processes such as agriculture. The second is in line with Crutzen & Stoermer's (2000) proposal, highlighting the increase in atmospheric carbon dioxide that followed the Industrial Revolution and James Watt's invention of the steam engine. Finally, the third hypothesis, the most consensual, defines the *Great Acceleration* as a starting point for this epoch, dating back to the mid-20th century. Since then, there has been an accentuated increase in human demography, use of natural resources, emissions of greenhouse gases, and biotic changes, in addition to rapid technological development and globalization. However, this designation is neither official nor consensual among the scientific community, as some argue that the stay of human beings on this planet is too short, considering it is 4.5 billion years old. As a result, the transformations caused by us are considered by some as transient and of low relevance. Additionally, the formal proposal of this geological unit of time must, like for the previous units, be accompanied by relevant stratigraphic data (lithostratigraphic, chemostratigraphic, and biostratigraphic) that contain indicators of environmental change caused by humans (Waters et al., 2014; Zalasiewicz et al., 2020). Furthermore, a specific numerical date (Global Standard Stratigraphic Age - GSSA) or a *golden spike* (Global Boundary Stratigraphic Sections and Point - GSSP) - a physical reference point in strata to determine the lower boundary of this geological unit - must be identified (Zalasiewicz et al., 2008). It is believed that this *golden spike* is associated with radioactivity from the mid-20$^{th}$ century (Subramanian, 2019). Thus, we are currently and formally still in the Holocene.

In 2009, the Subcommission on Quaternary Stratigraphy (SQS) of the International Commission on Stratigraphy (ICS), the largest scientific institution within the International Union of Geological Sciences, established the Anthropocene Working Group (AWG). This group aims to analyze data that support the hypothesis of the Anthropocene becoming an official geological time unit, hoping for to be formalized soon (SQS, 2019).

Nevertheless, the Anthropocene has become an essential tool in discourses that motivate sustainable human action despite not being formally integrated into the Geological

Time Scale. The emergence of the concept *Anthropocene* in the scientific press came after the publication of Crutzen (2002), expanding to other domains, from exact sciences to social sciences (Carruthers, 2019). Moreover, since AWG's creation, there has been an increase in literacy on the Anthropocene, reflecting the value of this theme in the scientific world (Waters & Zalasiewicz, 2019). Hence, applying this concept in several domains is fundamental for advancing science and preserving the natural world as we know it, combining knowledge and education in favor of the sustainable management of resources and ecosystems since the uncertainties and challenges ahead are still vast (Crutzen, 2002; Crutzen & Stoermer, 2000). To do so, interdisciplinary knowledge must be applied while communicating with various audiences, raising awareness, and encouraging collective action.

### 1.2. Museums, science engagement and science communication

The thirst for knowledge inherent to the human condition and the need to communicate it allowed engagement strategies to grow in the most diverse areas. The complexity of scientific concepts and their presence in different components of our society require effective communication between all parties involved (Shaby et al., 2019a; van Est, 2011). Therefore, science engagement is crucial to bring the scientific and academic communities closer to civilians, politicians, and other stakeholders, addressing scientific issues (Jensen & Holliman, 2016; Marino, 2017). Marino (2017, p. 55) further defines this type of engagement as "*the kind of publicity that science should do to explain to people the value and benefits that they can gain from science"*.

Science is present in everyone's daily life. In most cases, it is thought to be only learned in formal and traditional contexts, such as schools and universities. However, science can be perceived through various social and cultural sources, whether in a television program, book, museum, or even in a conversation between two friends. These latter are considered informal learning contexts (Dierking et al., 2003; Osborne & Dillon, 2007).

Visiting places and having informal learning experiences has been increasingly important, often representing the first time a person is exposed to scientific content (Bell et al., 2009). The engagement that one has in informal learning institutions involves cognitive, behavioral, and affective components, which are crucial for developing competencies and practices. While behavioral engagement refers to expressing participatory (e.g.,

responding) or non-participatory (e.g., ignoring) behaviours, affective or emotional engagement is related to the emotional responses generated in the learning process (e.g., frustration), which can influence the readiness to participate. Lastly, the willingness to get mentally involved and understand the content to be covered is part of cognitive engagement (Fredricks et al., 2004). The motivation to engage in an experience can be generated intrinsically or by extrinsic factors, standing, therefore, as something that will depend on the context (Mujtaba et al., 2018; Ryan & Deci, 2000). Thus, informal educational institutions not only serve to complement formal education but have their own value, disseminating content that may not be found in school curricula (Bell et al., 2009; Mujtaba et al., 2018; Stavrova & Urhahne, 2010).

According to the International Council of Museums (2022), "*a museum is a not-for-profit, permanent institution in the service of society that researches, collects, conserves, interprets and exhibits tangible and intangible heritage. Open to the public, accessible and inclusive, museums foster diversity and sustainability. They operate and communicate ethically, professionally and with the participation of communities, offering varied experiences for education, enjoyment, reflection and knowledge sharing"*. Museums emerge as essential informal education institutions and cultural resources, having a didactic and playful character and representing reliable sources of information. Additionally, museums have an exceptional ability to engage people and provide unique experiences to visitors, shaping values, opinions, and beliefs (Ballard et al., 2017; Gutwill & Allen, 2012; Mujtaba et al., 2018). Science communication in museums aims to increase scientific literacy and culture, strengthening knowledge and destroying misconceptions to raise awareness and comprehension of the processes and phenomena presented. Burns et al. (2003) clarify that this type of communication's ultimate objective is the production or increase of one of five components in an individual, namely, awareness, enjoyment, interest, opinion-forming, and understanding. Museums do this very well since the kind of engagement they produce has the power to radically transform a visitor, turning a particular topic in a personal matter, generating significant social and environmental repercussions (Ballard et al., 2017; DeWitt et al., 2016; Mujtaba et al., 2018).

Generally, science and Natural History museums present a large influx of people with different backgrounds every year (ASTC, 2017; Korn, 1995). The rich collections of high cultural value and the interactive and technological modules characteristic of many

science museums are crucial to the attractiveness of an exhibition, whose success is ultimately measured through the engagement it generates, that is, the visitor's attention and participation in the exhibition (Boisvert & Slez, 1995; Mujtaba et al., 2018; Serrell, 1997). Any science museum wishes to understand the impact its exhibitions have on the visitors in a process of continuous improvement of the learning experiences (Barriault & Pearson, 2010). Moreover, an exhibition's impact on an individual can linger for a long time after the visit (Falk & Dierking, 2013; Mujtaba et al., 2018; Stocklmayer & Gilbert, 2002).

Several studies have been carried out in science museum visitors, but despite the existence of longitudinal studies (Bamberger & Tal, 2008a), most only consider short-term effects (Mujtaba et al., 2018; Shaby et al., 2019a). Many of these studies allowed museums to understand information of great value, such as its positive influence on students' career choices (Salmi, 2003), or the exhibition's impact depending on the group's compositions (Block et al., 2015). However, our understanding of an exhibition's influence on the values and interests of visitors is still embryonic (Mujtaba et al., 2018).

But what makes a good exhibition? Interactivity is one of the core ingredients for its success, as the engagement it generates is highly effective (Meisner et al., 2007). When we interact with an exhibition, we receive something from it reciprocally, which can also trigger social interaction, and promote cooperation and sharing (Jakobsson & Davidsson, 2012; Meisner et al., 2007; Shaby et al., 2017). Furthermore, given their stimulating, sensory and multifaceted character, these interactions provoke an enjoyment seldom found in everyday life (J. D. Adams & Gupta, 2017; Shaby et al., 2019c). Some authors also highlight, as an engagement-enhancing agent, the use of a cohesive narrative throughout the exhibition, which profoundly addresses the themes (Shaby et al., 2019a; Tunnicliffe, 1996). Technology is a strong ally of science museums, particularly captivating in modules that have gaming as the interactive principle (Feinstein et al., 2013; Loveland et al., 2015). Outside the atmosphere of the exhibition, social networks are a growing communication tool for these cultural facilities, not in a pure marketing sense, but to instigate curiosity and increase engagement (Jarreau et al., 2019). Finally, the integration of art in science museum exhibitions can positively affect visitors' experience. The increase in science capital in these museums can be supported by art through its use for storytelling, as an educational tool, or as a promoter of debate and reflection, enabling a better understanding of the addressed concepts (Braund & Reiss, 2019; Ma et al., 2012; Rossi-Linnemann & de

Martini, 2019). Studies reveal that incorporating art-based programs and visits to art galleries in the education of medical students is highly valuable for their careers, enabling the development and maturation of fundamental skills in this area (C. C. Anderson, 2018; Kagan et al., 2021). Further, designing an exhibition taking into account its aesthetics and integrating art proves to be highly motivating for scaffolding knowledge development, increasing scientific engagement, and provoking emotional engagement (Duckett et al., 2021; Grant & Patterson, 2016; Neitzel et al., 2020). For instance, a recent study carried out by Greenslit et al. (2021) concluded that the visualization of artistic content before the scientific exhibition at the Museum of Science and Industry in Chicago increased interest in this exhibition, with a particular focus on its aesthetic component. These could be pertinent findings for developing more captivating exhibitions in science museums.

Science museums are trusted places for the civil community, and impartial cultural equipments wealthy in knowledge (Cameron, 2012). In the words of Gurian (2010, p.12), museums are "*safe spaces for unsafe ideas"*, in which the most challenging topics can be addressed. In this way, museums are critical in promoting debate on controversial issues such as global changes and the Anthropocene. By opening doors to ideas and conversations, museums will act as powerful tools against the polarization of these themes, promoting the synergy between traditional and scientific knowledge, and increasing confidence in scientific evidence and reports from various communities (Hamilton & Ronning, 2020).

### 1.3. The Anthropocene in museums

The relevance of the Anthropocene in the museological panorama has increased exponentially. Hundreds of exhibitions related to this theme have been developed worldwide (G. Oliveira et al., 2020). The fact that it is a concept still under construction makes it challenging to be approached, as it always has an associated uncertainty (Robin et al., 2014). However, it allows different interpretations, which can be beneficial since a museum can adapt this concept to its collections, transmitting a unique vision of the theme (G. Oliveira et al., 2020; Þórsson, 2020a). The multiplicity of narratives around which the exhibitions revolve and their power to motivate action makes this holistic theme exciting (G. Oliveira et al., 2020). Yet, in this type of discourse, it is easy to fall into a rigid and pessimistic vision, and often ignoring the enormous weight of capitalism, consumerism, and colonialism

(Hohti et al., 2021; G. Oliveira et al., 2020). Hence, according to G. Oliveira et al. (2020), the discourse that museums adopt within this theme must be carefully structured.

The Anthropocene is a highly engaging topic. It overcomes the environmental barriers that are naturally associated with it and spreads throughout culture, placing the human being at the center of the discussion, as a transforming agent of nature, but also clarifying that he is part of it (Robin et al., 2014). This concept provides the creation of interdisciplinary and intergenerational relationships between civil society, policymakers, and the scientific community. This way, it offers ordinary citizens a legitimate platform for discussion, inserting them into decision-making to solve problems (Kiefer, 2020; Robin et al., 2014). One way to do so is integrating them into the exhibition curation process (Hohti et al., 2021). Thus, approaching this topic could be a way for museums to assume a prominent position in the current museological paradigm, contributing to its academic and societal evolution (G. Oliveira et al., 2020).

The first major exhibition on this topic is *Welcome to the Anthropocene: The Earth in Our Hands* (December 2014 to September 2016), displayed at the Deutsches Museum, Munich, developed with the Rachel Carson Center for Environment and Society (Möllers, 2014). From the origins of the concept and technological advancement associated with societal components (e.g., urbanization and mobility) to the postulation of future hypotheses, the exhibition took crucial museological steps in identifying the human being as a driver of change for our planet (G. Oliveira et al., 2020; Robin et al., 2014). Interactivity was prominent in this exhibition, which encouraged opinion and debate; the final installation intended for visitors to reflect a possible future scenario and plant it in a field of paper flowers (Robin et al., 2014). According to Þórsson (2020b), this exhibition highlighted the complexity of approaching the Anthropocene in these cultural equipments, making room for a simultaneity of multiple approaches.

In turn, *We Are Nature: Living in the Anthropocene* at the Carnegie Museum of Natural History, Pittsburgh, which opened to the public in 2017, focuses on environmental and ecological phenomena influenced by human activities (e.g., extinction and habitat alteration) (G. Oliveira et al., 2020). The exhibition's narrative develops linearly, from contextualization to motivate taking action (G. Oliveira et al., 2020). This last section is rather interesting since it suggests community-based initiatives for the civil society to engage and demonstrates the museum's work towards sustainability (Kiefer, 2020).

Additionally, emotional engagement is very explored, particularly in the installation of a Post-It Wall, aiming to encourage the visitor to reflect on the Anthropocene and put it into words, to be later displayed on the wall (G. Oliveira et al., 2020); there were several emotions shared, including motivation, curiosity, and anger (Kiefer, 2020). The title *We Are Nature* intends to overturn the misconception that we humans are not part of nature, characteristic of a nature-culture division that has been represented in many traditional Natural History Museums (Kiefer, 2020; G. Oliveira et al., 2020).

In addition to the communication and exhibition components, Natural History museums play a fundamental role in research on global change and the Anthropocene through their collections (Meineke et al., 2018; Schmitt et al., 2018). These collections are essential for documenting changes throughout this geological epoch since they provide long-term data (Brooks et al., 2011; Funk, 2018; Schmitt et al., 2018). The plethora of representative specimens in the collections allows investigation in areas such as climate change, extinction, environmental contamination, and emerging infectious diseases, as well as understanding adaptive ecological responses to environmental changes (Hou et al., 2021; Lughadha et al., 2019; Meineke et al., 2018; Schmitt et al., 2018; Vellend et al., 2013). Nonetheless, using collections for research purposes ends up being devalued (Meineke et al., 2018). Further, new technologies and ways of integrating these collections in research must be carried out, such as disposing data in online repositories and databases. Plus, citizen science is an excellent way of supplementing museum collection documentation while integrating the general audience (Ballard et al., 2017; Schmitt et al., 2018). Thus, by studying Natural History and how biodiversity has responded to changes, it is possible to create and develop future predictive scenarios, contributing to scientific advancement (Hou et al., 2021; Krishtalka & Humphrey, 2000; Schmitt et al., 2018).

As stated earlier, this concept has grown far beyond the exact sciences. Art galleries and museums are also cast members of this great play of Anthropocene communication. Artists Edward Burtynsky, Jennifer Baichwal, and Nicholas de Pencier are responsible for *The Anthropocene Project*. This collaborative project includes two complementary *Anthropocene* exhibitions, first shown simultaneously in 2018 at the Art Gallery of Ontario, Toronto, and the National Gallery of Canada (NGC) in Ottawa, aiming to do a global tour until 2023 (The Anthropocene Project, 2018). Through art and to test its ability to change mentalities, this project's purpose is to raise awareness and encourage conscious human

action. Like *We Are Nature: Living in the Anthropocene*, the Ontario exhibition carried out an emotional survey of the visitors, highlighting the *worried* and *sad* emotions. The Art Gallery of Ontario exhibition was complemented by other innovative communication methods, namely, the *Into the Anthropocene* podcast (Hill, 2020).

Exhibitions can be displayed out of the museum's physical boundaries. One project that has unorthodoxly motivated action is *Anthropocene Posters*, developed by the Art Museum Haus der Kulturen der Welt (HKW) in collaboration with the Deutsches Museum. This project was displayed on the streets of Berlin, outside the museum walls, making it visible to everyone, even those who typically do not visit this type of institution, thus creating an inclusive atmosphere (Robin et al., 2014). In the words of Robin et al. (2014, p. 216), this exhibition represented a "*new hybridity between science, technology, and the arts"*, reinforcing the growing relevance of multidisciplinary approaches.

In Portugal, this theme has been gradually worked on. The *Eco-Visionaries: Art and Architecture after the Anthropocene* project (April to October 2018) has been exhibited at the Museum of Art, Architecture and Technology (MAAT), Lisbon, resulting from the collaboration of several European museums, artists, and architects (MAAT, n.d.). Museums and science centers also develop some environmental education actions within the Anthropocene concept (Gouveia et al., 2019; MHNC-UP, n.d.-a; Rodrigues et al., 2019). However, there seems to be a certain disconnection between this topic and civil society.

### 1.4. The Hall of Biodiversity

#### 1.4.1. Origins and legacy

The Hall of Biodiversity – Ciência Viva Center represents one of the poles that constitute the Natural History and Science Museum of the University of Porto (MHNC-UP). It was inaugurated on June 30th, 2017, by His Excellency the President of the Republic Marcelo Rebelo de Sousa, and emerged from a partnership between Ciência Viva (the National Agency for Scientific and Technological Culture) and the MHNC-UP (MHNC-UP, n.d.-b). According to Doctor Nuno Ferrand de Almeida, biologist and first director of the MHNC-UP, "*this is the first time a project to refurbish a university museum has been combined with a Ciência Viva Center"*. Doctor Ferrand also points that this is "*the first Ciência Viva Center dedicated to biological sciences, evolution and Biodiversity"* (Santos, 2016).

In addition to these two distinct backgrounds, the Hall of Biodiversity combines science, history, architecture, art, and literature, living up to the origins of the building where it is installed. Located in Casa Andresen, formerly home of the grandparents of the renowned author Sophia de Mello Breyner Andresen, the Hall of Biodiversity incorporates the author's legacy in its permanent exhibition. We can see one of the main examples of this connection in the Hall's atrium, where the skeleton of a juvenile blue whale that was stranded at Praia do Paraíso, Porto, in 1937, is displayed (Figure 1) (DRCN, 2020). In the tale *Saga,* Sophia de Mello Breyner Andresen (1984) describes that the skeleton of a whale, whose bones had laid for years in the basement of the Faculty of Sciences, could be risen in the atrium of the building**.** This represents the materialization of Sophia's [de Mello Breyner Andresen] literary fantasy, consisting in the Hall's main motto for structuring its narrative. As a matter of fact, it is this museographic metaphor that underpins the museum's entire discourse: a discourse on art and science (Ferrand, 2017). Given its symbolic value, this iconic specimen appears as the identity image of the *Arte e Ciência* editorial brand, which is a crucial part of the Museum's communication strategy (SPECO, 2019).

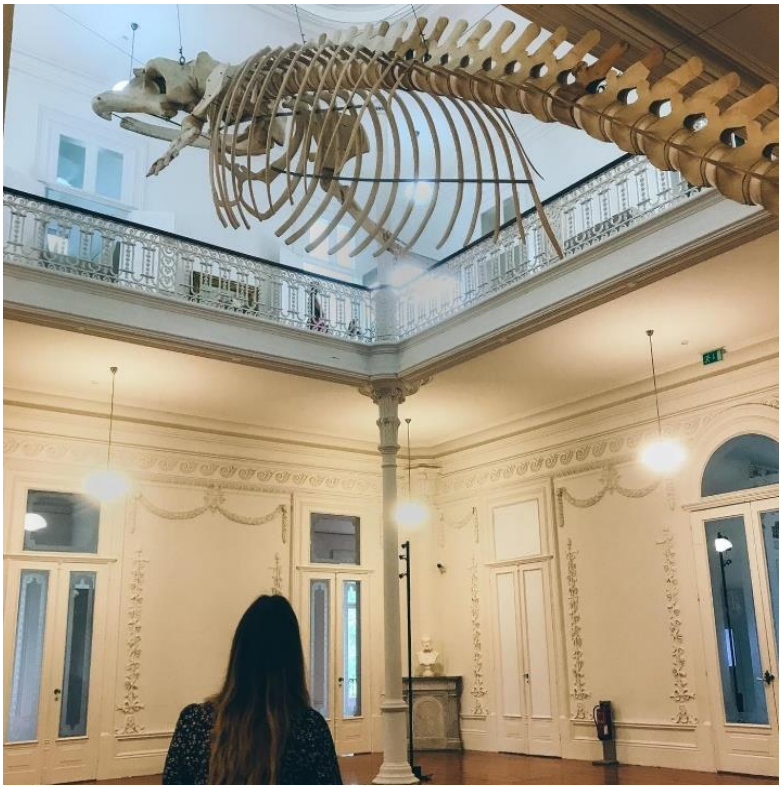

**Figure 1.** The blue whale skeleton, displayed at the Hall of Biodiversity's atrium, constitutes this cultural facility's narrative motto.

The Casa Andresen, also formerly Faculty of Sciences of the University of Porto, underwent a first rehabilitation to host the exhibition *Darwin's Evolution* (February to July, 2011), held on the 200th birthday of Charles Darwin and at the centenary celebrations of the University of Porto. To reinforce the University of Porto's commitment to scientific culture and knowledge dissemination, this exhibition allowed visitors to get in touch with the life and work of Charles Darwin, as well as his legacy and contribution to the development of contemporary biology. From Natural History before Darwin to the Modern Synthesis, this exhibition filled two floors of the Casa Andresen with collections from some of the most prestigious institutions, such as the American Museum of Natural History, National Museum of Natural Sciences of Spain, Calouste Gulbenkian Foundation, and the Natural History and Science Museum of the University of Porto (which the designation, at the time, was the Natural History Museum of Porto). In addition to being able to catch a glimpse of the scientific contribution of some of the most prominent personalities in Natural History, such as Carl Linnaeus, Jean-Baptiste de Lamark, Georges Cuvier, and James Hutton, the visitor could learn more about the famous Voyage of the Beagle, which took on board a young and

inexperienced Charles Darwin to see the world and explore South America in more detail, including the Galapagos, where he made some of his most important discoveries. This was followed by a section regarding the birth of the hypothesis of Evolution by Natural Selection, when, on his return to London, Darwin drew the first evolutionary tree, with the famous inscription "*I think"* at the top of the page. Of course, an allusion to the publication of his life's work *On the Origin of Species* (1859) could not be missing, as well as to the entire process of research and investigation that this publication entailed. The emergence of Genetics and its subsequent combination with Natural Selection had considerable weight in this exhibition, as well as the legacy left by Charles Darwin, which is reflected, for example, in the case of the evolution of the human species, that still leaves scientists looking for answers. The connection between Darwin and Portugal was also shown, from its influence on the works of Eça de Queiroz, to the case of rabbits of Porto Santo, and the first Portuguese translation of *On the Origin of Species* by Livraria Lello. Finally, visitors were able to observe live animals in a reconstitution of desert and tropical biomes, carried out in the greenhouses of Porto's Botanical Garden (Ferrand & Feijó, 2011). After the exhibition and with the aim of creating the Hall of Biodiversity, the building's rehabilitation process restarted, in a second phase, developed under the coordination of architect Nuno Valentim, and completed in 2015 (Fonseca & Santos, 2018).

Along with the history of the building itself, this cultural equipment is located at the heart of Porto's Botanical Garden and develops its activity in conjunction with it. With historical roots dating back to the 19th century and currently located in the former Quinta do Campo Alegre, Porto's Botanical Garden of Porto followed some of the most troubling moments in Portuguese politics, since the transition from monarchy to republic (First Republic), to the Estado Novo, and the Carnation Revolution. At the end of the 20th century, it closed its doors due to its degradation state, having started to be re-qualified in 2001, opening, again, to the public on May 12$^{th}$, 2007. This 4-hectare garden has great aesthetic, economic, social, and scientific value, enabling scientific research to be carried out, demonstrating the importance of conservation, including environmental education actions, and being a place of leisure and contemplation (T. Andresen, 2018). Additionally, it is divided into three tiers, each with its own set of characteristics. The formal gardens, separated by towering hedges of camellias, make up the first tier. The bosquets, the Shale Garden, the Fish Garden, *J's* Garden (named after the initials of João and Joana Andresen, former owners of Quinta do Campo Alegre), and the Rose Garden are among the formal gardens' sections. The outdoor

Cactus Garden and greenhouses are located on the second tier. Lastly, the arboretum, fernery, reservoir, and huge pond are located on the third level (MHNC-UP, n.d.-c). The Botanical Garden is also inseparable from art and literature, having been a place that highly influenced the life and work of the authors Sophia de Mello Breyner Andresen and Ruben A., who frequented this place in their youth (Pereira, 2018).

The MHNC-UP also includes a core pole, located in downtown Porto, undergoing deep rehabilitation and contemplating a wide range of collections from the most diverse areas such as zoology, archeology, paleontology, geology, ethnography, and botany (MHNC-UP, n.d.-d). This pole is currently hosting the *Ferreira da Silva Laboratory*, the first place to open to the public following the ongoing restructuring process. It opened in 2021, the year of the University of Porto's 110th anniversary, presenting us with a reconstruction of this emblematic place in the area of chemistry in the 30s and 40s of the 20th century (MHNC-UP, 2021a).

### 1.4.2. Organizational structure and services

The Hall of Biodiversity is part of the MHNC-UP. Therefore is under the tutelage of the University of Porto, benefiting from its central administrative, financial, and legal services. Additionally, it has the support of Sonae in a patronage agreement since 2018 (DRCN, 2020).

This cultural equipment is headed by its executive director Doctor Maria João Fonseca, and includes a communication team and an educational service team. This multidisciplinary organizational body also includes a maintenance technician for infrastructure and exhibition modules, a team of guides, and benefits from the services of the MHNC-UP curator team. On the middle floor, we find the ticket office, shop, and information services, and a cafeteria on the ground floor. Lastly, this cultural equipment also includes security and cleaning teams (DRCN, 2020; Ferrand, 2017).

Regarding the educational service, the Hall of Biodiversity presents a wide range of activities performed in collaboration with other institutions such as museums, research centers, and universities. These services include guided visits, customized according to the group's interests, workshops, seasonal and thematic activities, training courses, seminars, citizen science projects, and also the distance learning project *Museu em Linha com a Escola*, created in response to the limitations caused by the COVID-19 pandemic (DRCN,

2020; MHNC-UP, 2021b). This place was also designed to host temporary exhibitions, such as National Geographic's *Photo Ark*, open to the public between October 18, 2017, and July 29, 2018. *Photo Ark* is based on the work of photographer Joel Sartore, whose objective is to document species before their extinction, calling for attention to the importance of preserving and conserving the natural world (MHNC-UP, 2017; Sartore, n.d.). From the same producer, *Sharks* was also on display at the Hall of Biodiversity from May 24th to December 31st, 2019. This exhibition was based on a project by Brian Skerry, photographer and photojournalist, who strives to increase awareness of these marine animals (Reis, 2019).

### 1.4.3. Museological language and permanent exhibition

One of the many ways to successfully combine art and science is through multidisciplinary work (Wagensberg, 2005). In this regard, the Hall of Biodiversity is the result of the multidisciplinary conception, carried out by the director of the MHNC-UP Nuno Ferrand de Almeida, Luís Mendonça, designer, professor, and researcher at the Faculty of Fine Arts of the University of Porto, and by the catalan physicist and museologist Jorge Wagensberg (DRCN, 2020). The latter created the museological concept by which the Hall is guided, called *total museology*, allowing the visitor to experience the union of beauty and intelligibility, that is to enjoy the benefits of both art and science, therefore increasing this equipment's social and cultural value. According to this concept, a modern science museum must be a generator of personal and social change, stimulating visitors in favor of scientific knowledge, method, and opinion. These stimuli can be developed at the sensory (*hands-on*), cognitive (*minds-on*) and affective (*heart-on*) levels, which develop interactivity and reflection. That said, nothing stimulates more than reality, and, for that reason, it can be said that we will find ourselves in a space of *concentrated reality*. It should also be noted that museum metaphors can be used to represent the object or phenomenon in question if the reality to be experienced is inaccessible (either because it is microscopic, or too slow, or because of its opaque nature). Moreover, this museological concept assumes the universality of its audience, making no distinctions between social class, age, education, or any other characteristic. This is possible, as the prior knowledge that the visitor may have is not a requirement to interpret the exhibitions shown in museums. Thus, it defines that all visitors are museologically adults. Within this concept, it is considered that a museum's success is not necessarily linked to its number of visitors, but to the amount of conversation

generated before, during and after the visit. It is just as important to see visitors leave the museum with more questions than they had initially, as figuring out if this is their second time entering the museum's doors (Wagensberg, 2000, 2005, 2015). The Hall of Biodiversity was recognized in 2018 with the *Work of Museography* award by the Portuguese Association of Museology for including this innovative approach in its permanent exhibition (Fonseca & Santos, 2018).

A visit to the Hall of Biodiversity allows us to explore the permanent exhibition, which occupies the entire first floor and part of the middle floor. The permanent exhibition is based on the conservation of biological diversity, instigating reflection on the importance of its preservation. Thus, it is divided into fifteen fundamental themes, covering forty-nine modules and expositive content. This content is accompanied by brief information on the subject, written in a more literary way than what is common in a traditional Natural History museum or science center, keeping the necessary scientific accuracy (DRCN, 2020). The aesthetic sense also guided this exhibition's creation, which can be easily observed by the visitor and proven by the tremendous photographic interest that has existed, enhancing visual contemplation and, later, reflection and understanding on the subjects in question (Ferrand, 2017). To achieve this end, and here also combining aesthetics and knowledge, it includes a large panoply of unique museographic resources, such as multimedia and audiovisual platforms, live animals and taxidermies, fossils, representative structures, scientific illustrations, paintings, photographs, poems, among others (DRCN, 2020).

Going up the white helix-shaped stairs, it is possible to observe some aphorisms on the wall that reinforce the reflective nature of this exhibition, such as "*Enjoy my home/Your world"* and "*Feel while thinking/imagine while knowing"*. On the first floor, turning to the right, two red curtains reveal a dark and mysterious room presenting curiosities about Natural History – the *Biodiversity in the Portuguese Language* room. At the center of the room, there is an enormous illuminated and interactive globe that includes the travel routes of naturalists such as Rodrigues Ferreira and Charles Darwin, as well as navigators such as Bartolomeu Dias, Vasco da Gama, and Fernão de Magalhães. It is also possible to get to know some animals' migratory routes, such as the leatherback sea turtle (*Dermochelys coriacea*) and the monarch butterfly (*Danaus plexippus*), domestication processes (e.g., domestication of dogs and wheat), continental drift, and human mobility (world's colonization and the main world air connections). Additionally, the room is adorned by a collection including

cartographies, scientific illustrations, paintings, fossils, scientific instruments, preserved animals, minerals, among others, to highlight the importance of explorers for the development of Natural History.

The *Speciation* room presents a full-scale reconstitution of its main contributor, Charles Darwin (Figure 2). This hyper-realistic mannequin was created by the artist Élisabeth Daynès and is seated on a chair, with a second one beside it, so that the visitor can interact with it, whether taking a picture or having a casual conversation. This representation is accompanied by the exploration of the concept of speciation through the case of the Porto Santo rabbit, studied by this naturalist, whose mannequin holds two taxidermies in its hands (one is the mainland rabbit and the other is the island rabbit). Furthermore, this module displays the similarity and differences in lagomorphs, showing the morphological homogeneity of 15 specimens of the genus *Lepus* and 18 of the genus *Sylvilagus*. Comparatively, the tremendous morphological variability of the European rabbit (*Oryctolagus cuniculus*) can be observed through its 11 specimens arranged on the wall. The reality at first sight inaccessible, addressed in Jorge Wagensberg's concept of total museology, is also represented here, through audiovisual resources, which display images captured by x-ray (opaque), microscopes (small), drones (large), in slow motion (fast), among other technological innovations, representing phenomena that are invisible to the naked eye.

**Figure 2.** Charles Darwin’s mannequin, by Élisabeth Daynès.

Within this exploratory line, *Natural Selection* is presented through one of its classic examples: the moth *Biston betularia*. In this theme, a digital scientific illustration panel includes representations of this species' dark and light varieties, with a background that has two images of birch trees that change (one image with darkened tree barks and a second with light bark). In this way, this evolutionary process is illustrated by identifying moths that stand out depending on the background and which, in turn, are more visible to predators. This case is contextualized in the Industrial Revolution, which caused the darkening of these trees' bark with the increment of pollution, favoring the dark variety's survival.

*To eat and not be eaten* refers to three survival strategies used in the natural environment. It includes three terrariums with live animals, each one illustrating a strategy. One of the strategies discussed is camouflage, represented by stick insects, in an environment in which they go unnoticed. The existence of characteristics that pose a danger to predators (such as a vibrant coloration) is called aposematism, and it is evidenced by a

salamander that stands out in the terrarium where it is located. Finally, mimicry is shown through the false coral snake, whose scale pattern resembles that of the coral snake. Accompanying these terrariums are representations of these strategies using other resources, such as toy soldiers and an interactive module related to camouflage.

One of the themes aims to demonstrate the *Diversity of Shapes* that exist in nature, relating them to functions performed by living beings in the natural world. This is a rather interactive module, which, in addition to contextualizing in the nature, includes everyday objects and panels with demonstrations. Additionally, it conveys the fundamental message through eight aphorisms, each for the geometric shape to be illustrated. The eight aphorisms used are "*the sphere protects", "the hexagon paves", "the catenary supports", "the spiral packs", "the helix grips", "the fractal colonises space", "the wave moves", "the point penetrates"*.

*Artificial selection* is also a prominent theme in the permanent exhibition and is addressed through maize (Figure 3). In this room, the visitor will find a glass showcase, with corn cobs perfectly aligned and divided into four groups:

- wild maize, or teosinte, originating from Mexico;
- domesticated maize, which has a wide variety of shapes, colors, and patterns;
- maize resulting from hybridization;
- genetically modified maize, constituting the most homogeneous group.

This module encourages the debate on production *vs.* diversity, since genetically modified maize is less diverse than the domesticated maize group despite having greater economic value and a larger production yield.

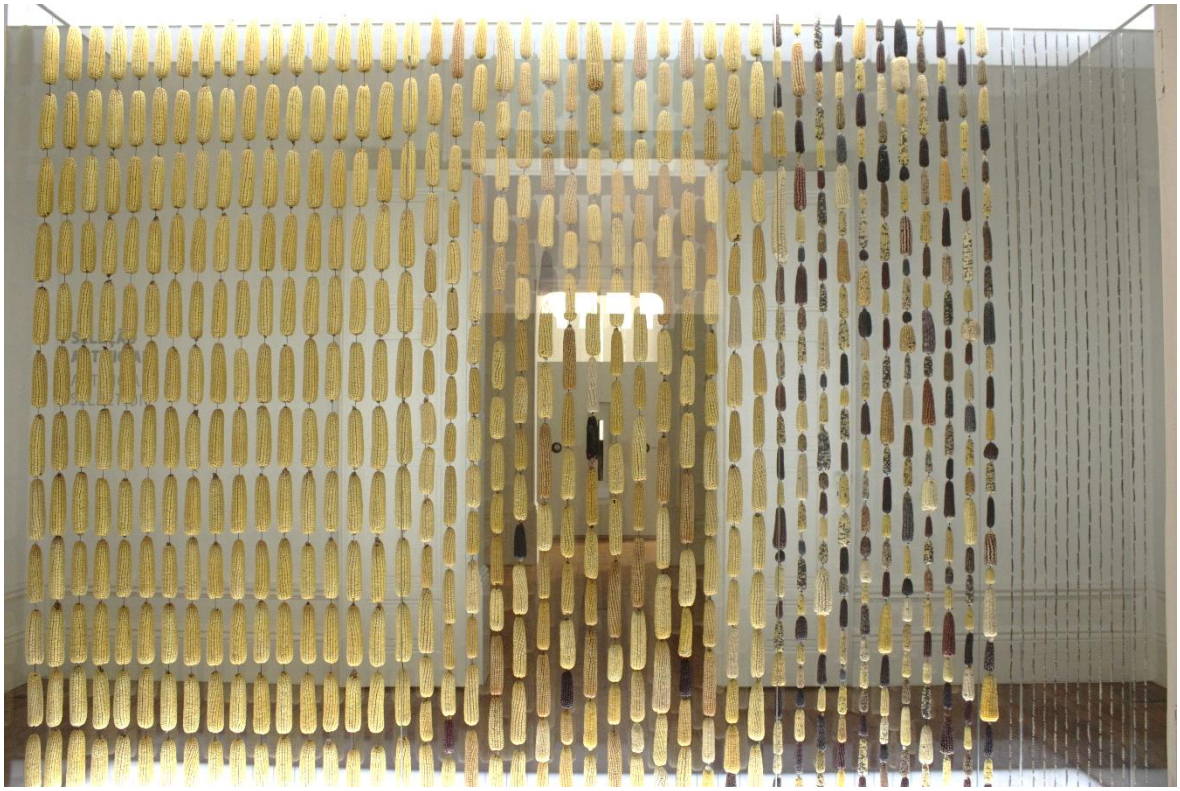

**Figure 3.** The *Artificial Selection* room demonstrates the domestication of maize, from its origins to its homogenization.

The evolutionary processes of *Analogy and Homology* are analyzed in the next room. Using simple associations, it is argued that while the process of evolutionary convergence (analogy) is guided by a specific end or destiny, evolutionary divergence (homology) means that the living beings in question have a common ancestry. The showcase referring to analogy includes representations of two groups, one of animals originating in South America, namely, agouti (*Dasyprocta* sp.), giant armadillo (*Priodontes maximus*), capybara (*Hydrochoerus hydrochaeris*), and the second from Africa, namely, royal antelope (*Neotragus pygmaeus*), giant pangolin (*Manis gigantea*) and pygmy hippopotamus (*Hexaprotodon liberiensis*). The representations are vertically arranged by group, from the smallest to the largest animal, enabling a morphological comparison between the animals from the two continents and observe their resemblance, given the shared similarity at an environmental level. On the homology side, there are representations of predators and prey, with a particular focus on vision, through lighting oriented towards each figure's eye. The objective is to demonstrate that, despite their common ancestry (responsible for the

similarity of the ocular structure), their divergence of functions in nature allowed lateralization of the eyes in prey and frontal placement in predators.

The following theme is also developed in the line of vision and is called *Theatre of Senses*. The idea is to show different visual perceptions of eight animals. Here, interactivity is reinforced by using technological resources that simulate the vision of the chosen animals (bee, owl, hawk, cow, earthworm, snake, spider, wolf).

The discussion on genetic diversity is raised, considering environmental uncertainty (*Genetic diversity vs. Uncertainty*). Thus, this room includes a window displaying 2418 grove snail (*Cepaea nemoralis*) specimens, demonstrating the enormous heterogeneity that characterizes this species. The message that is conveyed is that if there is greater intraspecific diversity, there are more solutions for possible environmental challenges, increasing the probability of the species' survival. Allied to this discussion, the visitor can create a multiplicity of himself, taking a photograph that is transformed into a set of images in distinct chromatic tones, in line with Pop Art.

It is not just the animal kingdom that is full of beauty and splendor. The *Diversity of Colours* is transmitted through the exhibition of leaves of 256 species from Porto's Botanical Garden collected on. The windows display varnished leaves in gold or silver, with a background in the leaf's natural color.

The variety of ways of locomotion is another topic addressed in this exhibition (*By land, sea and air).* In this room, animal sculptures are organized by colored axes, each corresponding to a mode of locomotion: swimming, walking, flying. It is reinforced that, although some animals belong to the same taxonomic class, they do not all move in the same way, having structures that are more similar to those of animals from other classes. It is the case of the penguin that, despite being a bird, swims underwater, like the dolphin (mammal) or the gilthead seabream (fish).

In addition to natural and artificial selection, the Hall of Biodiversity mentions the theory of *Sexual Selection* in one of the rooms that most resembles a more classic Natural History museum. There are modern animal taxidermies such as the red deer (*Cervus elaphus*) and the peacock (*Pavo cristatus*), both males and females. Here, selection behaviours and characteristics linked to sexual selection that may be more important than some linked to survival are evidenced, explaining the frequency of genes that could be counterintuitive to

natural selection. This room has a more intimate lighting scheme, with small light spots in the display areas aimed at the specimens, as excess light can gradually degrade the taxidermies.

There are four showcases in the first-floor atrium, each visually enunciating a principle that seeks to answer a core question: *Why should Biodiversity be preserved?* The first principle is the *Aesthetic Principle*: biodiversity must be preserved because it is beautiful. This module displays eggs of the most varied shapes, colours, and sizes arranged according to these three gradients (e.g., from the smallest to the largest; Figure 4). These eggs, mostly from birds, constitute a metaphor representing all animals, as they all come from an egg. Additionally, the eggs represent different environments, with a predominance of ovoid eggs compared to spherical ones. This question is elucidated in an interactive module with representations of two ovoid and two spherical eggs in a mobile medium, demonstrating that the spherical egg rolls more quickly from a nest and has a lower probability of survival. The second principle is the *Ethical Principle*, which clarifies that a species must be preserved simply because it exists. Here is presented the classic example of the oldest animal domestication: the dog. This showcase includes several figures of different breeds of dogs and, at the bottom and center, a wolf, their ancestor. Next to this module, a table shows artistic representations of dogs and wolves (e.g., paintings, sculptures) from Mesopotamia to the 21$^{st}$ century. This module implies that wolves have always been represented as evil and ferocious, while dogs are portrayed as loyal and docile. This way encourages reflection on this type of anthropocentric classification of species and the implications for their conservation and preservation. The following principles may be considered more utilitarian than the first ones. The third principle is the *Economic Principle*, which clarifies that biodiversity must be preserved, as we manage to extract something from them for our benefit, whether food, construction material, textiles, among others. Thus, it has an earth globe, with seeds from various plants linked to a particular region of the planet. This principle also includes an interactive module, this time of aromatic nature. Visitors can experience different aromas, reinforcing the idea that living beings are valuable because there is something about them that we like and need. Finally, the fourth principle is the *Scientific Principle* and displays a variety of medicines. The idea is to make people understand that nature is our *great pillbox* and that preserving biodiversity is essential. In it, we will be able to discover the cure for a particular disease; with the extinction of a species, we may never find that cure.

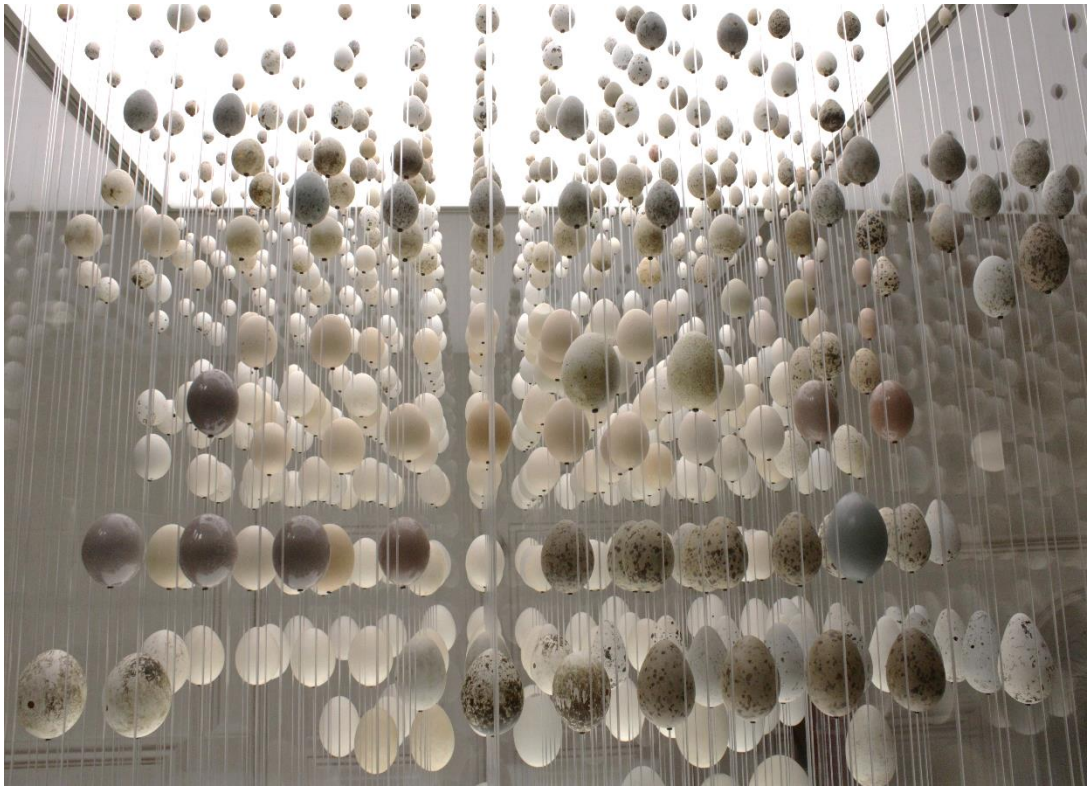

**Figure 4.** The Aesthetic Principle's showcase of eggs.

In this atrium, there is a chair, which allows the observation of the two extremes of mammals in terms of size: the blue whale (*Balaenoptera musculus*) and the white-toothed pygmy shrew (*Suncus etruscus*). This section of the exhibition is called *Diversity of Sizes.* This chair has three buttons, each revealing three distinct heart rhythms: a familiar rhythm, with 70 bpm, corresponding to that of a human being, also a mammal, used as a comparison term for the other two animals exposed. The blue whale's heart rate is slower, corresponding to about 6 bpm. Conversely, the heart of the pygmy shrew beats 900 times a minute. These heart rates vary with size because of heat dissipation, as a more petite body dissipates more energy and therefore has to increase its metabolism to maintain it. The species' longevity is also associated with this explanation, recognizing that a blue whale lives longer than the white-toothed pygmy shrew.

Human beings usually talk about biodiversity as if it were not part of it. Thus, going down to the middle floor, it is possible to observe *Human Diversity* through the artistic creation of Angélica Dass. This creation exhibits photographs of various human beings, each with the

predominant pantone in their nose as a background. This creation also includes white squares, in recognition by the author that it is an unfinished project and that many pantones remain to be represented. Here, a multimedia module modifies the visitor's appearance to fit more European, Asian, or African features.

On this floor, the *Diversity of Language* is also represented in a room that displays photographs of people who share a connection to the Portuguese language in their cultural heritage. The impact that Sophia de Mello Breyner Andresen had on Portuguese culture and language could not be missing within this theme. Thus, the visitor can read and listen to some of her work's most emblematic poems.

Returning to the middle floor atrium, the visitor is again faced with the skeleton of the blue whale that is centrally located in a building whose requalification intended to maintain some of the house's original features in the time of João Henrique Andresen, such as his emblem on the glass doors. However, the walls, formerly pink, were painted white to take advantage of the sunlight that passes through the large windows, in line with the Hall's vision of sustainability.

### 1.5. Objectives

The fact that the Anthropocene is increasingly relevant in the continuous evolution of society, the importance of museums in disseminating knowledge, and the Hall of Biodiversity's great potential to stand out in the national and international museological panorama motivated this project. Thus, this work aims to characterize the Portuguese population's perceptions (beliefs, values, concerns, conceptions, and opinions) on the Anthropocene, with a focus on the implications on biodiversity, and assess the impact of the permanent exhibition of the Hall of Biodiversity – Ciência Viva Center | MHNC-UP in the scope of this theme.

## 2. MATERIALS AND METHODS

Since this is a study that aims to analyze environmental perceptions and that intrinsic and extrinsic factors influence these, Albuquerque et al. (2014) suggest the application of a diversified methodology, as different types of data may lead to different and complementary interpretations. Therefore, the present work consists in a case study at the Hall of Biodiversity, where quantitative and qualitative data were collected through questionnaires

(based on a pre-/post-test approach) applied to high school students and interviews to the general public.

There was an initial period of attending some guided visits to the permanent exhibition (October - December 2021) to prepare the materials for this project.

## 2.1. Questionnaires

Aiming to assess whether or not the permanent exhibition of the Hall of Biodiversity impacts visitors' knowledge and attitudes towards the Anthropocene, a questionnaire was purposely designed.

### 2.1.1. Preparation of the questionnaires

The pre-test and post-test questionnaires included multiple-choice and open-ended questions regarding knowledge and attitudes of the visitors (see Appendix A and Appendix B). Plus, the pre-test questionnaire included sociodemographic questions, namely, age, gender, district, education level, field of study. Visitors were also asked if that was their first time visiting the Hall of Biodiversity. And if not, how long had it been since their last visit, and how many times have they visited.

To allow making a comparative analysis of the outcomes of the pre- and post-test questionnaires, the multiple-choice questions in both of them were the same, except for one question in the attitudinal section of the post-test questionnaire, which enquires if the visit to the Hall of Biodiversity contributed to the visitors' personal growth (question A1m). Open-ended items are also the same, except for item A2, in which the pre-test question refers to each students' expectations about the visit, and the post-test question asks the students to highlight any aspect of the visit that surprised them.

A few knowledge items were built with reference to the Special Eurobarometer Nº 481: *Attitudes of Europeans towards Biodiversity*, carried out in 2019, by the European Commission (European Commission, 2019). The remaining questions were formulated based on the contents covered in the modules of the permanent exhibition related to the human-nature interaction and revolving around biodiversity. The structuring of the questionnaires followed the orientation of Oppenheim (1992).

Table 1 summarizes the questions in the questionnaires and the scores given to each answer. Questions marked with a *C* refer to knowledge questions; the questions marked

with an *A* refer to the attitudinal questions. A five-point Likert scale was used to analyze the attitudinal questions (Likert, 1932).

**Table 1.** Questionnaires applied to the experimental group (pre-test and post-test) and to the control group, to assess visitors' perceptions on the Anthropocene. Response scores are in brackets and in bold.

| Question | | | Answer (Score) |
|---|---|---|---|
| **C1** | | Select the option that best suits you: | a) I have heard of the term *Biodiversity,* and I know what it means **(3)** |
| | | | b) I have heard of the term *Biodiversity*, but I don't know what it means **(2)** |
| | | | c) I have never heard of the term *Biodiversity* **(1)** |
| **C2** | | If you selected options a) or b), tell us what *Biodiversity* means to you. | Check scoring rubric (see Appendix C) |
| **C3** | | Select the option that best suits you: | a) I have heard of the term *Anthropocene,* and I know what it means **(3)** |
| | | | b) I have heard of the term *Anthropocene,* but I don't know what it means **(2)** |
| | | | c) I have never heard of the term *Anthropocene* **(1)** |
| **C4** | | If you selected options a) or b), tell us what *Anthropocene* means to you. | Check scoring rubric (see Appendix C) |
| **C5** | **a)** | While the genetic manipulation of food may increase and speed up its production, it may reduce its genetic diversity[a] | Agree **(correct - 1)**, Disagree **(incorrect - 0)**, I don't know **(missing value)** |
| | **b)** | Decreased genetic diversity can lead to species extinction. | |
| | **c)** | Human activities, such as industry, can influence the evolution of a species. | |
| | **d)** | Human activities, such as industry, can lead to the extinction of a species. | |
| | **e)** | Human beings are part of the Earth's biodiversity. | |
| **A1** | **a)** | It is important to preserve biodiversity. | |

| | | | |
|---|---|---|---|
| | **b)** | Biodiversity must be preserved because it is beautiful. | Strongly agree **(5)**, Agree **(4)**, Neutral **(3)**, Disagree **(2)**, Strongly disagree **(1)**, I don't know **(missing value)** |
| | **c)** | Biodiversity must be preserved because it exists. | |
| | **d)** | Biodiversity must be preserved because it provides human beings with resources (e.g., food). | |
| | **e)** | Biodiversity must be preserved because it allows for scientific advancement (e.g., medicines). | |
| | **f)**[b] | There are species that are not worth preserving. | |
| | **g)** | The human being is a transforming agent of nature. | |
| | **h)** | The negative impact that humans have on nature must be minimized. | |
| | **i)** | Human beings perform actions that compromise biodiversity. | |
| | **j)** | Human beings have a responsibility to preserve biodiversity. | |
| | **k)** | Preserving biodiversity implies preserving the human species. | |
| | **l)** | In the past, the human-centered view led to undue biodiversity exploitation. | |
| | **m)**[c] | The visit to the Hall of Biodiversity contributed to my personal growth. | |
| **A2** | **Pre-test/Control** | What do you expect to find in the Hall of Biodiversity's permanent exhibition? | N.A. |
| | **Post-test** | What did you learn during your visit to the permanent exhibition of the Hall of Biodiversity (a new notion, something that may have surprised you…) ? | N.A. |

[a] *All living beings have genes which are largely responsible for the various features. Genetic diversity defines all the variation at the level of the set of genes present in a group (species, race, or population).* [b] Question A1f score: Strongly agree (1), Agree (2), Neutral (3), Agree (4), Strongly disagree (5). [c] Question A1m is only featured in the post-test questionnaire. N.A. Non applicable.

### 2.1.2. Questionnaire implementation

The participants selected for the purpose of this study were students attending the 11th-grade in public schools of the districts of Braga and Aveiro. The experimental group comprised 116 students aged between 16 and 19 years, with 69 students attending a school

in Braga and 47 attending a school in Aveiro. Additionally, 112 participants attended the Science and Technology Course, and 4 attended the Scientific-humanistic Course on Languages and Humanities. All participants were attending Biology and Geology as an optional subject.

The team from the Hall of Biodiversity assisted in establishing communication with the schools. The schools, which already had the visit scheduled, were contacted by phone and, later, by email. They were given the study's description and consent forms prepared according to the EU General Data Protection Regulation (2016) (see Appendix D).

The guided visits took place on April 6, 2022, for the Braga school, and on April 29, 2022, for the Aveiro school. Two questionnaires were applied: one (including sociodemographic questions) before the visit, and another one immediately after the visit. The data were anonymized: each student's post-test questionnaire was matched to the corresponding pre-test using numerical codes. The duration of the visits ranged from 45 minutes to 1 hour.

#### 2.1.3. Control group

On May 9, 2022, a questionnaire was applied to a control group that did not visit the Hall of the Biodiversity's permanent exhibition.

The 11th grade class from a public school in Porto comprised 19 students aged between 15 and 17. All students attended the Science and Technology Course and Biology and Geology as an optional subject.

The control questionnaire included the same multiple-choice questions as the pre-test. Question A2 surveys the student's expectations for a visit to the Hall of Biodiversity (see Appendix E).

The control group's students were given the study's description and consent forms prepared according to the EU General Data Protection Regulation (2016) (see Appendix F).

Comparisons between pre-test vs. control group, and post-test vs. control group were conducted. The comparisons between pre-test vs. control group were made in order to see if there were differences before the visit, meaning that the variations would not be due to the visit. The pre-/post-test vs. control group design controls internal validity.

### 2.1.4. Data analysis

The questions were analyzed using IBM® SPSS® Statistics, Version 28.0 (IBM, 2021).

Given that data normality was not analyzed, the limited sample size, and that the sample was not randomly selected, parametric tests were conducted, as well as their non-parametric equivalent.

A confidence level of 95% was considered for all performed statistical tests. And effect sizes were classified as small ($0,2 \leq d < 0,5$), medium ($0,5 \leq d < 0,8$), or large ($d \leq 0,8$) (Cohen, 1988).

For items C1, C3, and A1 of the experimental group (pre-test vs. post-test), a paired-samples *t*-test was performed, and Cohen's *d* was calculated (Effect size). Additionally, the non-parametric Wilcoxon signed-rank test was performed to complement the parametric tests. Moreover, an independent-samples *t*-test was performed to compare C1, C3, and A1's results between experimental and control groups, and Cohen's *d* was determined. In addition, the non-parametric Mann-Whitney U test was performed.

Question C5 results were analyzed using a McNemar test to compare the pre-test vs. post-test outcomes, and a Fisher's exact test was used to compare control/pre-test and control/post-test results.

The open-ended items C2 and C4 were analyzed using two methodologies:

- Scoring each answer according to dedicated rubric (see Appendix C)

The scoring rubric was designed after reviewing the students' answers and determining the evaluation criteria for what represents a good response, considering the students' education level. Thus, for question C2, the highest level in the scoring rubric, that represents a high-quality response includes species, genetic and ecosystems diversity, as well as the ecological and evolutionary processes that sustain life. The assessment of the results for these questions underwent the same statistical analyses as the results for questions C1, C3, and A1.

- Analysis of notions mentioned by the participants

A preliminary analysis of the responses and an inventory of the notions were conducted. The topics covered in the pre-test questionnaire and in the post-test questionnaire were then subjected to a McNemar test to see if there were any differences in how frequently each group addressed a particular concept. An analysis

was also conducted to compare the control group vs. pre-test and the control group vs. post-test, using a Fisher's exact test, since the sample size is limited.

The students' answers to questions A2 and *Other comments* were categorized. The responses to item A2 of the pre-test and control questionnaires were categorized following the students' general notions. The answers to question A2 of the post-test questionnaire were categorized, taking into account the messages conveyed in the different rooms and modules of the permanent exhibition, and having in mind general ideas highlighted by the students. This means that if a student provided information about the *Analogy and Homology* room, the response would be listed under that category. Additionally, for item A2, a McNemar test and a Fisher's exact test were used to analyze the students' notions in pre-/post-test, and pre-test/control and post-test/control, respectively.

Finally, comparisons of the pre-test, post-test, and control results were performed for the variables gender, district, and frequency of visit for questions C1, C2 (score), C3, C4 (score), C5, and A1. Since only the control group belongs to the district of Porto, the comparisons between districts were not conducted. The *frequency of visit'*s analysis was only conducted on the experimental group. These analyses were carried out using the independent-samples *t*-test and the Mann-Whitney U test.

Figures 5 and 6 summarize the analyses applied to the questionnaires.

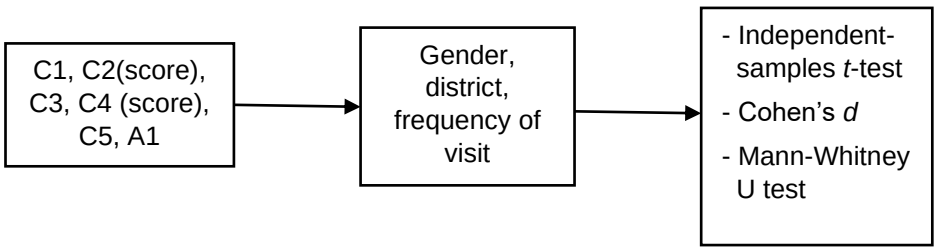


**Figure 5.** Analysis applied to compare gender, district, and frequency of visit results. The analysis included pre-, post-test, and control group, except in the variable *district*, since only the control group belongs to the district of Porto, and in the variable *frequency of visit* (only applied to the experimental group).

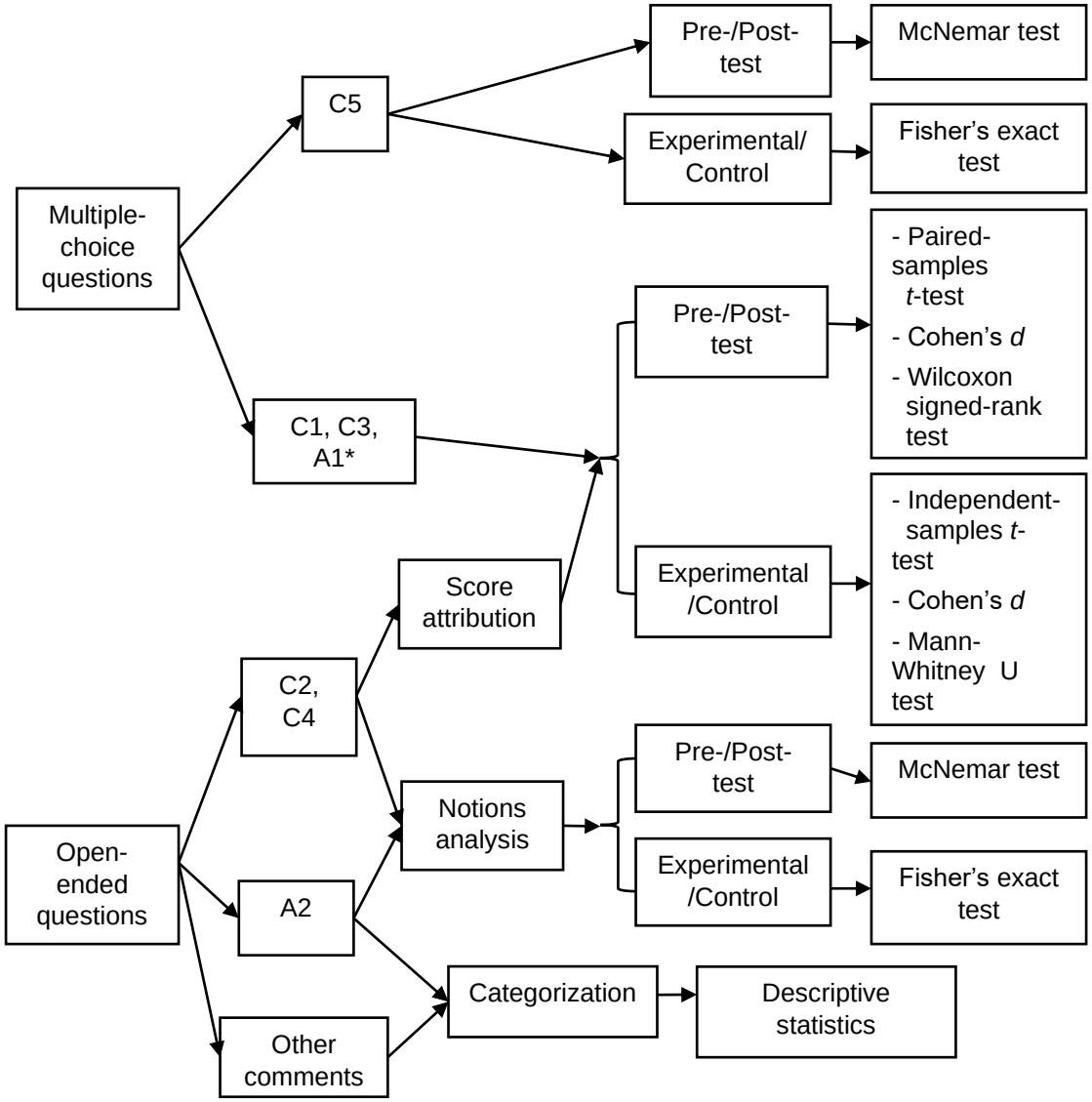


**Figure 6.** Analysis applied to the questionnaires' results. The experimental/control group includes pre-test/control and post-test/control comparisons. *Note: question A1m results did not underwent through the tests presented in this figure; only descriptive statistics of this question's results were performed.

## 2.2. Interviews

This part of the study aimed to understand the visitor's perceptions on the Anthropocene and the importance of visiting the permanent exhibition of the Hall of Biodiversity.

### 2.2.1. Preparation of the interviews

The interview script followed the same logic as the questionnaires: it included sociodemographic questions and questions comparable to those in the questionnaires (Table 2; see Appendix G). The interviews were semi-structured: the interviewer had set a prior orientation and structuring, while allowing the interviewee to speak freely without straying from the topic (Albuquerque et al., 2014). The guidelines made available by Albuquerque et al. (2014) and Oppenheim (1992) were followed for the preparation of the interview script and how to proceed during the interview.

### 2.2.2. Interview implementation

During April and May 2022, 20 people were interviewed. The participants were approached after visiting the permanent exhibition and guided to a separate room to be individually interviewed. A cell phone was used to record the audio of the interviews. The average duration of the interviews was 07:03 minutes. All interviewees filled out a consent form prepared according to the EU General Data Protection Regulation (2016) (see Appendix H).

### 2.2.3. Data analysis

After the interviews were applied, the audios were eliminated after anonymous transcription. A non-naturalistic transcription was carried out, that is, a cleaner transcription focused on the interviewee's verbal speech and following the guidelines of Azevedo et al. (2017).

Afterward, the interviews' analysis was carried out by categorizing the answers in different category trees, following the methodology described in Bardin (1977). This process involves coding the raw data, identifying thematic categories, developing a thematic framework for each topic and capturing excerpts illustrating said categories.

The categorization was carried out after the interviews were applied, as the interviewee's freedom of response did not allow the prior definition of categories, as it was a semi-structured interview (Albuquerque et al., 2014).

Questions 4, 5, and 8 were grouped in a category tree, as these questions represented different ways of asking the respondent about the human impact on biodiversity. Likewise, questions 6 and 7 originated the category tree referring to biodiversity loss effects.

**Table 2.** Questions applied in the interviews to assess the participants' perceptions on the Anthropocene.

| | Question |
|---|---|
| **1** | Are you familiar with the notion *Biodiversity*? |
| **2** | Do you think that the visit to the permanent exhibition helped you to better understand the notion *Biodiversity*? Why? |
| **3** | Are you familiar with the notion A*nthropocene*? |
| **3.1/3.2[a]** | Did you identify any examples of human interaction with the environment in the exhibition? |
| **4** | Do you think that human activity can have a negative impact on biodiversity? If so, can you give an example? |
| **5** | Do you believe that humans are responsible for the decline in species diversity that has been observed in recent years? If so, can you give an example? |
| **6** | Do you foresee any negative future scenario with the decline of species diversity? |
| **7** | Do you think that human beings will be harmed by their impact on biodiversity? If so, can you give an example? |
| **8** | Do you believe that the human-centered viewpoint has led to an undue exploitation of biodiversity? |
| **9** | Do you think it is important to preserve biodiversity? Why? |
| **10** | Do you have any idea of what we can do to preserve biodiversity? If so, can you give an example? |
| **11** | Do you think visiting the Hall Biodiversity has contributed to your personal growth? |

[a] 3.2 includes a description of *Anthropocene*, if the answer to question 3 is *No - The Anthropocene refers, unofficially, to the most recent geological epoch in Earth's history, marked by the significant impact of human activity on the natural world, ecosystems, and climate.*

# 3. RESULTS

## 3.1. Questionnaires

### 3.1.1. Participants' profile

The demographic profiles of the 116 participants from the experimental group and of the 19 participants from the control group are shown in table 3.

**Table 3.** Questionnaire participants (*n*=135) demographic information

| | Group | Subcategories | *N* |
|---|---|---|---|
| **Age** | Experimental | 16 | 64 |
| | | 17 | 50 |
| | | 19 | 2 |
| | Control | 15 | 1 |
| | | 16 | 13 |
| | | 17 | 5 |
| **Gender** | Experimental | Female | 67 |
| | | Male | 47 |
| | | Other | 1 |
| | | Prefered not to answer | 1 |
| | Control | Female | 9 |
| | | Male | 10 |
| **District** | Experimental | Aveiro | 47 |
| | | Braga | 69 |
| | Control | Porto | 19 |
| **Field of education** | Experimental | Science and Technology | 112 |
| | | Languages and Humanities | 4 |
| | Control | Science and Technology | 19 |

| | | | |
|---|---|---|---|
| **Visiting for the first time?** | Experimental | Yes | 109 |
| | | No | 7 |
| **How long was your last visit?** | Experimental | Less than 6 months | 1 |
| | | 6 months to a year | 0 |
| | | Over a year | 6 |
| **How many times have you visited?** | Experimental | Once | 4 |
| | | Twice | 2 |
| | | Three or more times | 1 |

As mentioned previously, the experimental group comprises two school groups, one from Braga (n=69) and another from Aveiro (n=47), whose participants are aged between 16 and 19 years. In turn, the control group is based in Porto, with students aged between 15 and 17.

Within the experimental group there were 67 female participants, 47 male participants, one participant that identified with a gender outside the binary classification, and another student who preferred not to respond. The control group was made up of 9 female participants and 10 male participants.

Only 7 of the 116 participants in the experimental group had previously visited the Hall of Biodiversity.

### 3.1.2. Response rate

Table 4 presents the response rate in pre-test, post-test and control groups.

**Table 4.** Number of respondents in pre-test, post-test and control groups for each question, and response variation between pre-test and post-test.

| Question | Pre-test | Post-test | Response variation between pre- and post-test | Control |
|---|---|---|---|---|
| **C1** | 116 | 116 | 0% | 19 |
| **C2** | 113 | 115 | 1,8% | 19 |
| **C3** | 115 | 116 | 0,9% | 19 |
| **C4** | 32 | 48 | 50,0% | 10 |
| **C5a** | 107 | 115 | 7,5% | 16 |
| **C5b** | 115 | 115 | 0% | 18 |
| **C5c** | 112 | 112 | 0% | 19 |
| **C5d** | 114 | 115 | 0,9% | 19 |
| **C5e** | 114 | 116 | 1,8% | 17 |
| **A1a** | 116 | 116 | 0% | 19 |
| **A1b** | 115 | 115 | 0% | 19 |
| **A1c** | 112 | 115 | 2,7% | 17 |
| **A1d** | 115 | 116 | 0,9% | 19 |
| **A1e** | 116 | 116 | 0% | 19 |
| **A1f** | 108 | 115 | 6,5% | 18 |
| **A1g** | 116 | 115 | -0,9% | 18 |
| **A1h** | 116 | 116 | 0% | 18 |
| **A1i** | 116 | 116 | 0% | 19 |
| **A1j** | 116 | 116 | 0% | 19 |
| **A1k** | 110 | 112 | 1,8% | 15 |
| **A1l** | 105 | 110 | 4,8% | 16 |
| **A1m** | N.A. | 116 | N.A. | N.A. |

N.A. Question A1m was only present in the post-test questionnaire.

All participants in the control group answered questions C1, C2, C3, C5c), C5d), A1a), A1b), A1d), A1e), A1i, and A1j.

Every student of the experimental group responded to the pre- and post-test questionnaires' items C1, A1a), A1e), A1h), A1i), and A1j).

There was a 50% growth in the response rate to question C4, which asked to describe what *Anthropocene* means.

Moreover, questions C2, C3, C4, C5a), C5d), C5e), A1c), A1d), A1f), A1k), and A1l) showed an increase in the response rate, unlike question A1g).

### 3.1.3. C1 and C2- Understanding of the meaning of *Biodiversity*

#### a) Experimental group – Pre- vs. Post-test

The results of the analyses performed for questions C1 and C2 between pre- and post-test are presented in Table 5. The full version of the results is present in Appendix I.

**Table 5.** Pre-/Post-test results for questions C1 and C2.

| Question | Pre/Post | Descriptive statistics | | | Paired-samples *t*-Test | Effect size | Wilcoxon signed-rank test |
|---|---|---|---|---|---|---|---|
| | | ***n*** | ***M*** | ***SD*** | ***p*** | **Cohen's *d*** | ***p*** |
| **C1** | Pre | 116 | 2,84 | 0,429 | **0,049*** | 0,185 | 0,068 |
| | Post | 116 | 2,92 | 0,299 | | | |
| **C2** | Pre | 112 | 5,98 | 1,811 | 0,205 | 0,120 | 0,233 |
| | Post | 112 | 6,16 | 1,901 | | | |

*n* - number of observations. *M* - Mean. *SD* - Standard deviation. *p* - p-value (2-tailed).

*Results were considered statistically significant for $p < 0,05$.

The results of the paired-samples *t*-test performed for question C1 between the pre-test and post-test indicate that, after the visit, there was a tendency to choose option a) *I have heard of the term Biodiversity, and I know what it means*. However, since the paired-samples *t*-test's *p-value* is very close to the considered significance level and that the Wilcoxon signed-rank test's *p-value* is $p=0,068$, this variation is not statistically significant.

Concerning question C2, which required the participants to describe what *Biodiversity* meant to them, the paired-samples *t*-test performed between the scores from the pre-test and post-test shows that there is a tendency to score higher after the visit, even though it is not statistically significant. This result is consistent with the Wilcoxon signed-rank test. The post-test questionnaire revealed that only one student had received the highest score possible according to the grading criteria. In the pre-test questionnaire, no student achieved the highest score.

Regarding question C2 notions analysis, there was an increase in the total number of notions mentioned from the pre-test (number of notions = 34) to the post-test (number of notions = 41). The most highlighted notions were *Diversity*, which was mentioned equally in both the pre- and the post-test (*n*=90), *Living beings,* mentioned 73 times before the visit and 68 times after the visit, and *Species* mentioned 39 times in the pre-test and 45 times in the post-test. After the visit new concepts were mentioned, such as *Adaptation, Body Size, Colour, Evolution, Genetic variability, Morphological variability, Niche* (ecology), *Phylogeny, Shape,* and *Traces* (see Appendix J).

It is important to point out that both the paired-samples *t*-test and the McNemar test only consider the answers given by the respondents who provided answers in both instances (pre- and post-test). Even though there were 113 respondents in the pre-test, and 115 respondents in the post-test, *n*=112 was considered in the pre- vs. post-test analysis by applying a test-by-test exclusion. Therefore, the responses from students who responded only before or only after the visit were not taken into account.

There are no significant differences in the frequencies of the notions between pre- and post-tests (see Appendix J).

b) Control group vs. Experimental group

Table 6 presents the analyses conducted for questions C1 and C2 between the control and experimental groups. The full version of the results is present in Appendix I.

**Table 6.** Experimental and control groups' results for questions C1 and C2.

| Question | Pre/Post/ Control | Descriptive statistics | | | Independent-samples *t*-test | Effect size | Mann-Whitney U test |
|---|---|---|---|---|---|---|---|
| | | ***n*** | ***M*** | ***SD*** | ***p*** | **Cohen's *d*** | ***p*** |
| **C1** | Pre | 116 | 2,84 | 0,429 | 0,602 | 0,129 | 0,381 |
| | Control | 19 | 2,79 | 0,419 | | | |
| | Post | 116 | 2,92 | 0,299 | 0,198 | 0,418 | **0,048*** |
| | Control | 19 | 2,79 | 0,419 | | | |
| **C2** | Pre | 113 | 5,98 | 1,803 | 0,602 | 0,130 | 0,450 |
| | Control | 19 | 6,21 | 1,475 | | | |
| | Post | 115 | 6,19 | 1,891 | 0,966 | 0,010 | 0,702 |
| | Control | 19 | 6,21 | 1,475 | | | |

*n* - number of observations. *M* - Mean. *SD* - Standard deviation. *p* - p-value (2-tailed).

*Results were considered statistically significant for $p < 0,05$.

The results of the independent-samples *t*-test performed for question C1 answers for the experimental group - post-test and the control group show that there was a higher tendency for the first ones to choose option a) *I have heard of the term Biodiversity, and I know what it means*. Nonetheless, differences are not statistically significant, regardless of the Mann-Whitney U test's *p-value*.

Regarding C2 score analysis, no statistically significant differences were found between the results of the experimental and control groups. The top score wasn't reached by any student.

Lastly, considering C2 notions analysis, 21 notions emerged from the control group's answers. There are no significant differences in the frequency with which the notions were addressed in both groups. The most mentioned notions by the control group were *Living beings* (*n*=16) and *Diversity* (*n*=15). Moreover, *Balance* (*n*=1) and *Behaviour* (*n*=1) were

two concepts presented in this group that were not mentioned in the experimental group (see Appendix J).

### 3.1.4. C3 and C4- Understanding of the meaning of *Anthropocene*

#### a) Experimental group – Pre- vs. Post-test

The results of the analyses performed for questions C3 and C4 between pre- and post-test are presented in Table 7. The full version of the results is present in Appendix I.

**Table 7.** Pre-/Post-test results for questions C3 and C4.

| Question | Pre/Post | Descriptive statistics | | | Paired-samples *t*-Test | Effect size | Wilcoxon signed-rank test |
|---|---|---|---|---|---|---|---|
| | | ***n*** | ***M*** | ***SD*** | ***p*** | **Cohen's *d*** | ***p*** |
| **C3** | Pre | 115 | 1,46 | 0,741 | **<0,001*** | 0,481 | **<0,001*** |
| | Post | 115 | 1,78 | 0,896 | | | |
| **C4** | Pre | 29 | 4,79 | 2,833 | 0,062 | 0,362 | **0,042*** |
| | Post | 29 | 5,34 | 2,781 | | | |

*n* - number of observations. *M* - Mean. *SD* - Standard deviation. *p* - p-value (2-tailed).

*Results were considered statistically significant for *p* <0,05.

The results of the paired-samples *t*-test performed for question C3 between the pre-test and the post-test show some improvement in the students' answers when asked about whether they knew and understood the meaning of *Anthropocene*. And this was a statistically significant difference ($p$<0,001). This result is consistent with the Wilcoxon signed-rank test ($p$<0,001). Regarding the effect size, the value of Cohen's *d* is 0,481, representing a small/medium effect.

Considering the score analysis to question C4, about describing what *Anthropocene* means to the students, the outcomes of the paired-samples *t*-test performed for the scores of the pre- and post-test indicate that there is a propensity to score higher after the visit, but the differences are not statistically significant. And the outcome of the Wilcoxon signed-rank test's somewhat confirms this result. No student received the highest score.

In terms of the notions analysis for C4, it appears that there is a slight increase in the total number of concepts used from pre- (number of notions= 20) to post-test (number of notions = 26).

The most highlighted notion was *Period* (time) mentioned equally in both the pre- and post-tests (*n*=23). Secondly, *Human* is mentioned 17 times before the visit, and 16 times after the visit. The notions *Earth* (pre-test – *n*=16; post-test – *n*=13) and *History* (pre-test – *n*=16; post-test – *n*=11) were also highlighted. There were no statistically significant differences between pre- and post-test frequencies for any notion (see Appendix K).

Again, it is crucial to remember that the McNemar test and paired-samples *t*-test only take into account responses from students who answered on both occasions (pre- and post-test). It should be noted that although in the pre-test, 32 participants answered, and in the post-test, there were 48 respondents, *n*=29 was considered in the pre- vs. post-test analysis by applying a test-by-test exclusion. With that said, the answers given by students that responded only before or only after the visit were not considered. It should be noted that for the post-test, the notions *Environment* (*n*=1), *Epoch* (*n*=1) and *Living Beings* (*n*=1) were also mentioned.

b) Control group vs. Experimental group

The results of the independent-samples *t*-test and the Mann-Whitney U test conducted for questions C3 and C4 scores for the control and experimental groups show that the differences are not statistically significant (see Appendix I). Regarding C4 analysis, the highest score was not obtained by any student.

Concerning the analysis of notions mentioned by the participants in C4, there are statistically significant differences between the frequency of *Human action* (*p*=0,041; in pre-test – *n*=11 vs. control – *n*=0), *Emergence* (*p*=0,032; in post-test – *n*=2 vs. control – *n*=3) and *Hominids* (*p*=0,027; in post-test – *n*=0 vs. control – *n*=2); the latter was only mentioned in the control group. The most frequently mentioned notions in the control group were *Period* (*n*=6), *Human* (*n*=6), and *Earth* (*n*=4).

It is important to stress that both in the experimental group (pre-test – *n*=32; post-test – *n*=48) and in the control group (*n*=10), the geological time unit most associated to the Anthropocene was *Period* (pre-test – *n*=23; post-test – *n*=31; control – *n*=6), followed by

*Era* (pre-test – *n*=3; post-test – *n*=12; control – *n*=3). *Epoch* was only mentioned once by a student from the post-test (see Appendix K).

3.1.5. C5 - Knowledge: multiple choice questions

a) Experimental group – Pre- vs. Post-test

For questions C5a), b), c) and e) there is a slight increase in the number of correct answers after the visit, but these differences are not statistically significant. For question C5d), every participant who answered selected *Agree* (see Appendix L).

b) Control group vs. Experimental group

The results of the Fisher's exact test for question C5a) for the experimental group in the post-test (*n*=115; *M*=0,93; *SD*=0,256) and the control group (*n*=16; *M*=0,75; *SD*=0,442) reveal that the visiting group tends to provide more correct answers when compared to the control group. These differences are statistically significant (*p*=0,041). For the remaining questions (C5b) to e)), there are no statistically significant differences between these groups (see Appendix L).

### 3.1.6. A1 – Attitudes: multiple choice questions

#### a) Experimental group – Pre- vs. Post-test

There are statistically significant pre- to post-test differences for questions A1b), A1c) e A1g) (Table 8). Only statistically significant differences are presented. The full version of the results is present in Appendix I.

**Table 8.** Pre-/Post-test results for question A1.

| Question | Pre/Post | Descriptive statistics | | | Paired-samples *t*-Test | Effect size | Wilcoxon signed-rank test |
|---|---|---|---|---|---|---|---|
| | | ***n*** | ***M*** | ***SD*** | ***p*** | **Cohen's *d*** | ***p*** |
| **A1b)** | Pre | 114 | 3,71 | 0,948 | **0,007*** | 0,255 | **0,010*** |
| | Post | 114 | 3,93 | 0,859 | | | |
| **A1c)** | Pre | 111 | 3,86 | 1,022 | **<0,001*** | 0,371 | **<0,001*** |
| | Post | 111 | 4,20 | 0,893 | | | |
| **A1g)** | Pre | 115 | 4,60 | 0,686 | **0,032*** | 0,203 | **0,037*** |
| | Post | 115 | 4,75 | 0,475 | | | |

*n* - number of observations. *M* - Mean. *SD* - Standard deviation. *p* - p-value (2-tailed).

*Results were considered statistically significant for *p* <0,05.

The results for the paired-samples *t*-test performed in question A1b) indicate that there is a tendency for demonstrating more favourable attitudes towards preserving biodiversity considering its beauty after visiting the permanent exhibition (*p*=0,007, *d*=0,255). These results are verified by the Wilcoxon signed-rank test (*p*=0,010).

Regarding question A1c), on whether biodiversity should be preserved simply because it exists, the participants tend to express more positive attitudes in the post-test than in the pre-test. And this outcome is statistically significant, as shown by the paired-samples *t*-test (*p*<0,001), and by the Wilcoxon signed-rank test (*p*<0,001). The effect size in this case is small (*d*=0,371).

Concerning question A1g), on whether human beings are transforming agents of nature, the paired-samples *t*-test results indicate a propensity to agree even further with this

statement after the visit (*p*=0,032). This is consistent with the Wilcoxon signed-rank test (*p*=0,037). For this case, the effect size is small (*d*=0,203).

There are no statistically significant differences for questions A1a), A1d), A1e), A1f), Aih), A1i), A1j), A1k), A1l). Overall, the results for all questions in A1 demonstrate a tendency for the participants to agree with the statements in both pre- and post-test, except for question A1f *(There are species that are not worth preserving)*.

The principles for the preservation of biodiversity are represented in A1b) (aesthetic), A1c) (ethic), A1d) (economic), and A1e) (scientific). The reason that received the most concordant responses was the scientific principle, followed by the economic principle, the ethical principle, and the aesthetic principle. This was observed both in the pre- and post-test.

The question with the lowest mean values is A1b) and the highest is question A1a).

Regarding this question, the answers of students (three in the pre-test, and one in the post-test) who referred that they had not heard about the term *Biodiversity* were still considered.

b) Control group vs. Experimental group

The results show that there are statistically significant differences between the experimental and control groups for questions A1a), A1c), A1d), A1e) and A1l) (Table 9). Only statistically significant differences are presented. The full version of the results is present in Appendix I.

**Table 9.** Experimental and control groups' results for question A1.

| Question | Pre/Post/Control | Descriptive statistics | | | Independent-samples *t*-test | Effect size | Mann-Whitney U test |
|---|---|---|---|---|---|---|---|
| | | ***n*** | ***M*** | ***SD*** | ***p*** | **Cohen's *d*** | ***p*** |
| **A1a)** | Pre | 116 | 4,99 | 0,093 | 0,234 | 0,731 | **0,008*** |
| | Control | 19 | 4,79 | 0,713 | | | |
| **A1c)** | Pre | 112 | 3,87 | 1,018 | 0,110 | 0,419 | **0,047*** |
| | Control | 17 | 4,29 | 1,047 | | | |
| **A1d)** | Pre | 115 | 4,39 | 0,734 | **0,012*** | 0,942 | **0,001*** |
| | Control | 19 | 3,63 | 1,165 | | | |
| | Post | 116 | 4,47 | 0,691 | **0,007*** | 1,080 | **<0,001*** |
| | Control | 19 | 3,63 | 1,165 | | | |
| **A1e)** | Post | 116 | 4,53 | 0,751 | **0,033*** | 0,532 | 0,055 |
| | Control | 19 | 4,11 | 1,100 | | | |
| **A1l)** | Pre | 105 | 4,42 | 0,782 | **0,004*** | 0,528 | **0,033*** |
| | Control | 16 | 4,81 | 0,403 | | | |
| | Post | 110 | 4,48 | 0,751 | **0,012*** | 0,461 | 0,062 |
| | Control | 16 | 4,81 | 0,403 | | | |

*n* - number of observations. *M* - Mean. *SD* - Standard deviation. *p* - p-value (2-tailed).

*Results were considered statistically significant for *p* <0,05.

- For question A1a) regarding the importance of preserving biodiversity, the results of the independent-samples *t*-test for the experimental group's pre-test and the control group show that there are no significant differences (*p*=0,234). However, the Mann-Whitney U test's *p-value* is *p*=0,008 contradicting the results of the parametric test.
- Concerning question A1c), the results of the independent-samples *t*-test for the experimental group in the pre-test and the control group do not show a statistically significant difference (*p*=0,110). The Mann-Whitney U test results

show a *p-value* of *p*=0,047, which is very close to the significance level considered.

- For question A1d) (*Biodiversity must be preserved because it provides human beings with resources*) there are significant differences between the control group and the experimental group both in the pre-test and in the post-test.
    - The independent-samples *t*-test results for the experimental group in the pre-test vs. the control group indicate a *p*=0,012, which is consistent with the Mann-Whitney U test (*p*=0,001).
    - The independent-samples *t*-test results for experimental group in the post-test vs. the control group indicate a *p*=0,007, which is consistent with the Mann-Whitney U test (*p*<0,001).
- Regarding question A1e), the independent-samples *t*-test results show a statistically significant difference between the experimental group in the post-test and control group (*p*=0,033). However, these results are not consistent with Mann-Whitney U test (*p*=0,55).
- The results of the independent-samples *t*-test for question A1l) show a statistically significant difference for the control group and the experimental group in both the pre-test and the post-test.
    - The independent-samples *t*-test results for the experimental group in the pre-test and the control group indicate a *p*=0,004, which is consistent with the Mann-Whitney U test (*p*=0,033).
    - The independent-samples *t*-test results for the experimental group in the post-test and the control group indicate a *p*=0,012, which is not consistent with the Mann-Whitney U test (*p*=0,062).

The significant differences registered occurred between the experimental group in the pre-test and the control group (except for question A1e)), which suggests that they are not associated with the visit. However, for question A1d (*Biodiversity must be preserved because it provides human beings with resources*) after the visit, there is an intensification of these differences, with an increment of the tendency for the participants to agree with this perspective.

There are no statistically significant differences for questions A1b) and A1f) to A1k). For the control group, there is a tendency for the participants to agree with all of the questions, except for question A1f).

The question with lowest mean values is A1b) and the highest is A1h).

### 3.1.7. A2 - Expectations on the permanent exhibition and feedback about the visit

#### a) Analysis of notions reported

In total, there were 41 notions mentioned by the experimental group participants in the pre-test, 87 in the post-test, and 24 notions by participants in the control group (see Appendix M).

Considering the pre-/post-test comparison by the McNemar test, in the pre-test, the most frequently mentioned notions in the pre-test were *Diversity* (*n*=53), *Species* (*n*=46), *Biodiversity* (*n*=38), *Living beings* (*n*=31), and *Knowledge* (*n*=27), and the most frequently mentioned notions in the post-test were *Diversity* (*n*=42), *Eyesight* (*n*=40), *Animals* (*n*=37) and *Species* (*n*=25).

In the control group, the most frequently highlighted notions were *Biodiversity* (*n*=8), *Living beings* (*n*=7), and *Diversity* (*n*=6).

##### i) Pre- vs. Post-test

Regarding the analysis of notions mentioned within the experimental group for question A2, there are statistically significant differences worth noting in Table 10. *n*=105 was considered in each group by applying a test-by-test exclusion. The full version of the results is present in Appendix M.

**Table 10.** Pre-/Post-test analysis of notions mentioned for question A2.

| Notion | Pre/Post | *n* | Absolute frequency | McNemar test |
|---|---|---|---|---|
| | | | | ***p*** |
| Animals | Pre | 106 | 9 | **<0,001*** |
| | Post | 110 | 37 | |
| Biodiversity | Pre | 106 | 38 | **<0,001*** |
| | Post | 110 | 9 | |
| Body size | Pre | 106 | 0 | **0,002*** |
| | Post | 110 | 10 | |
| Eggs | Pre | 106 | 0 | **<0,001*** |
| | Post | 110 | 18 | |
| Evidences | Pre | 106 | 13 | **0,002*** |
| | Post | 110 | 1 | |
| Eyesight | Pre | 106 | 0 | **<0,001*** |
| | Post | 110 | 40 | |
| Fossil | Pre | 106 | 7 | **0,016*** |
| | Post | 110 | 0 | |
| Heartbeat | Pre | 106 | 0 | **<0,001*** |
| | Post | 110 | 16 | |
| Knowledge | Pre | 106 | 27 | **0,002*** |
| | Post | 110 | 9 | |
| Living beings | Pre | 106 | 31 | **0,043*** |
| | Post | 110 | 18 | |
| Mammals | Pre | 106 | 0 | **0,008*** |
| | Post | 110 | 8 | |
| Species | Pre | 106 | 46 | **0,002*** |
| | Post | 110 | 25 | |

*n* - number of observations. *p* - p-value (2-tailed). *Results were considered statistically significant for *p* <0,05. Note: *n*=105 was considered in each group by applying a test-by-test exclusion.

More general notions such as *Biodiversity, Diversity, Evidences, Fossil, Living beings, Knowledge, Species* are more frequently mentioned in the pre-test.

On the other hand, concepts like *Body size, Eggs, Eyesight, Heartbeat* are more specific and refer to curiosities addressed in the exhibition sections. Additionally, general notions such as *Animals* and *Mammals* are highlighted more often in the post-test.

ii) Pre-test vs. Control group

There are only significant differences in regard to *Research* (*p*=0,011) mentioned once in the pre-test group and three times in the control group (see Appendix M).

iii) Post-test vs. Control group

Table 11 presents the notions for which there are statistically significant differences for question A2 between the experimental group in the post-test and the control group. Only statistically significant differences are presented. The full version of the results is present in Appendix M.

**Table 11.** Post-test/Control analysis of notions mentioned by the participants in question A2.

| Notion | Post/Control | *n* | Absolute frequency | McNemar test |
|---|---|---|---|---|
| | | | | *p* |
| Biodiversity | Post | 110 | 11 | **0,001*** |
| | Control | 19 | 8 | |
| Extinction | Post | 110 | 0 | **0,003*** |
| | Control | 19 | 3 | |
| Eyesight | Post | 110 | 42 | **<0,001*** |
| | Control | 19 | 0 | |
| Photographs | Post | 110 | 0 | **0,021*** |
| | Control | 19 | 2 | |
| Preservation | Post | 110 | 6 | **0,040*** |
| | Control | 19 | 4 | |
| Research | Post | 110 | 0 | **0,003*** |
| | Control | 19 | 3 | |

*n* - number of observations. *M* - Mean. *SD* - Standard deviation. *p* - p-value (2-tailed). *Results were considered statistically significant for *p* <0,05.

Again, when the control group participants were asked what their expectations for the visit were, there was a tendency for them to mention general notions, such as the ones presented on the table above.

It should be noted how often *Preservation* was mentioned in the control group and how weak its relevance was within the experimental group in the post-test, despite the section *Why should Biodiversity be preserved?* in the permanent exhibition of the Hall of Biodiversity.

Moreover, the control group appeared to be interested in knowing more about research on *Biodiversity.*

a) Categorical analysis

i) Experimental group - Pre-test and Control group

Figure 7 presents the results of the categorization of responses to question A2, on expectations about the visit to the permanent exhibition.

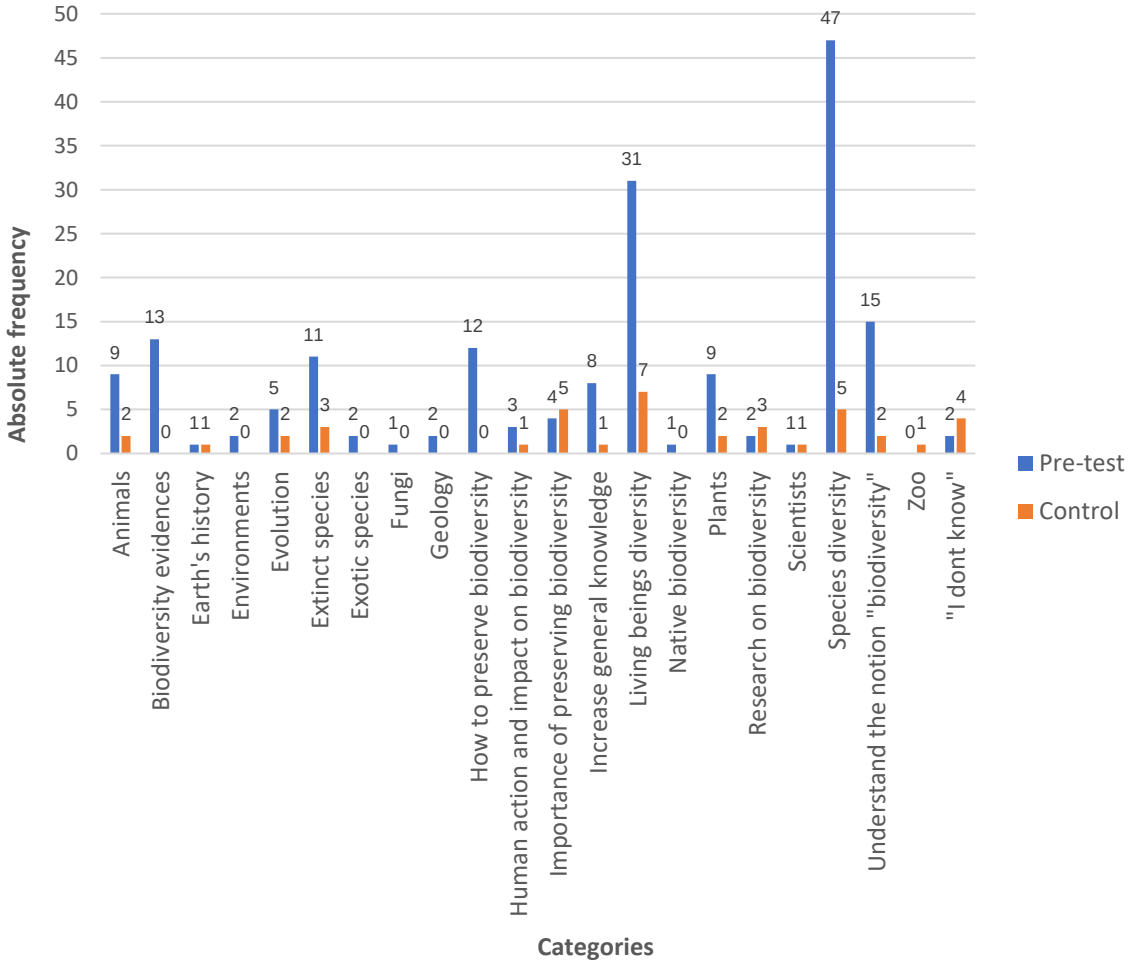


**Figure 7.** Pre-test/Control categorical analysis of the answers to question A2. Note: Experimental group - pre-test (*n*=106) and Control group (*n*=19).

The answers were grouped into 22 categories. The most prominent category within the experimental group in the pre-test is *Species diversity,* with 47 mentions, followed by *Living beings' diversity*, mentioned 31 times.

The participants also showed considerable interest from in better understanding the meaning of *Biodiversity* (*n*=15), observe some *Biodiversity evidences* (*n*=13), get to *Know how to preserve biodiversity* (*n*=12), and know more about *Extinct species* (*n*=11).

In turn, in the control group, the most frequently highlighted category was *Living beings' diversity*, mentioned 7 times, followed by *Species diversity,* with 5 mentions, and, with an equal number of mentions, *Importance of preserving biodiversity.* The latter was only mentioned 4 times by the experimental group students in the pre-test.

ii) Experimental group - Post-test

The results of the categorization of the answers to question A2 provided by the experimental group participants in the post-test are presented in Figure 8.

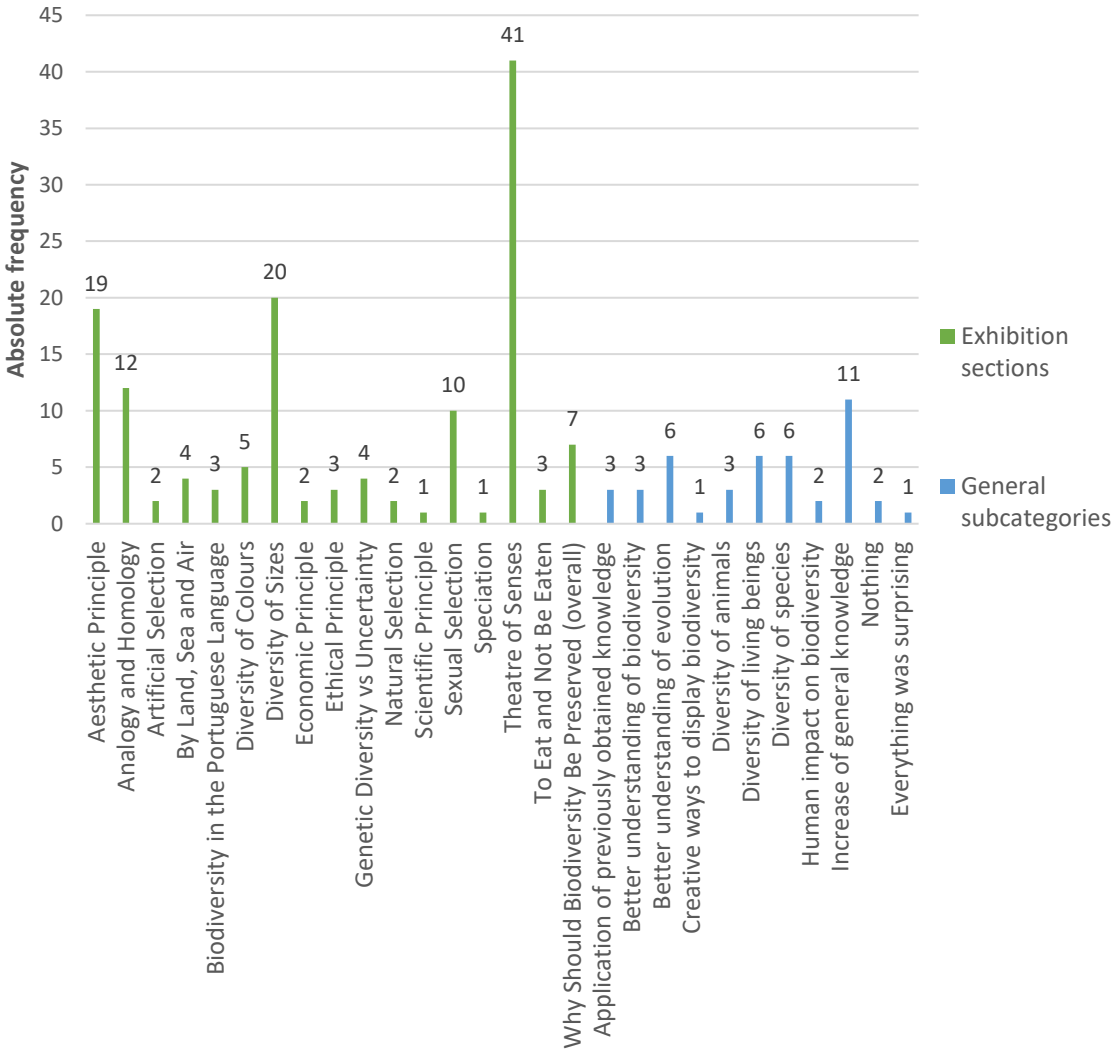


**Figure 8.** Post-test categorical analysis of the answers to question A2. Note: Post-test (n=110).

There are two main categories: *Exhibition sections*, which includes 17 subcategories, and *General categories*, which comprises 11 subcategories.

The three most frequently highlighted subcategories belong to the category *Exhibition sections*. These are *Theatre of Senses,* mentioned 41 times, *Diversity of Sizes,* with 20 mentions, and *Aesthetic Principle,* referred 19 times.

Within the *General subcategories,* the most common feedback was that the visit allowed for an *Increase of general knowledge* (*n*=11).

### 3.1.8. A1m) – Visit's contribution to personal growth

The results obtained for question A1m) within the experimental group in the post-test are shown in Figure 9.

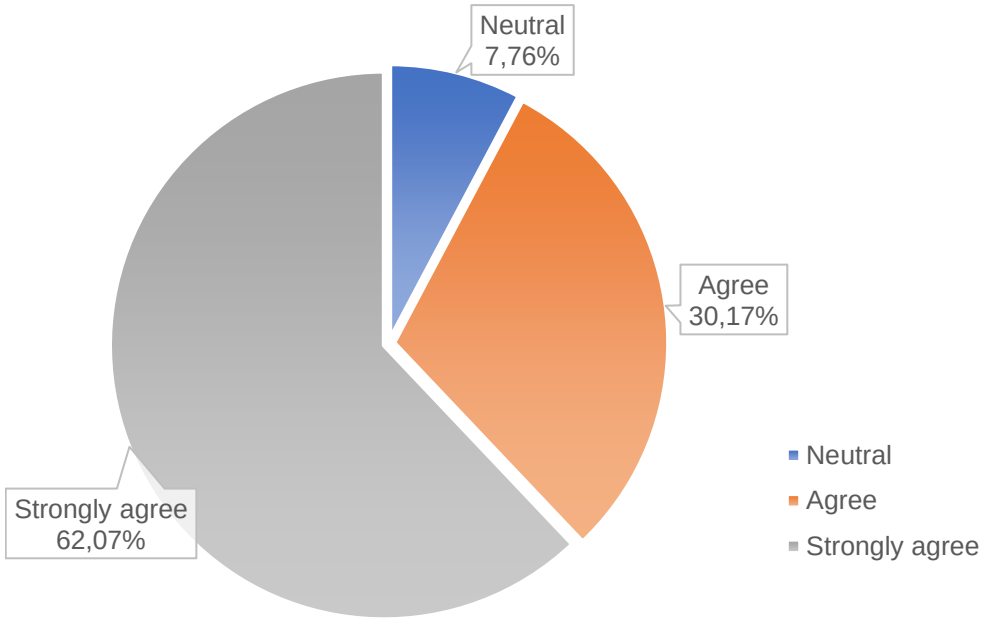


**Figure 9.** Answers to question A1m) *Did the visit contribute to your personal growth?* provided by the experimental group participants in post-test. Note: *n*=116

Most participants (*n*=72; 62,07%) strongly agreed with question A1m), 30,17% (*n*=35) agreed with the statement, and only 7,76% (*n*=9) were neutral as to whether or not the visit contributed to their personal growth.

### 3.1.9. Gender, district, and frequency of visit comparisons

a) Gender comparisons

Table 12 refers to the comparisons by gender of the results obtained for the experimental group in the pre-test and in the post-test, and for the control group. Only statistically significant differences are represented. All results for this comparison can be found in Appendix N.

Only male and female genders were considered here to facilitate statistical analysis. This is mainly because there is no actual representation of other genders in this study (only one participant identified with another gender outside the binary classification, and another one who preferred not to respond to this question).

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**Table 12.** Gender comparisons of the answers to questions C1, C2, C3, C4, C5 and A1.

| Question | Pre/ Post/ Control | Gender | Descriptive statistics | | | Independent-samples *t*-test | Effect size | Mann-Whitney U test |
|---|---|---|---|---|---|---|---|---|
| | | | *n* | *M* | *SD* | *p* | Cohen's *d* | *p* |
| **C4** | Pre | Female | 21 | 3,62 | 3,170 | **0,026*** | 0,770 | 0,055 |
| | | Male | 11 | 5,82 | 2,089 | | | |
| | Post | Female | 28 | 3,79 | 2,833 | **0,035*** | 0,635 | **0,021*** |
| | | Male | 20 | 5,40 | 2,062 | | | |
| **A1b)** | Pre | Female | 67 | 3,85 | 0,857 | **0,035*** | 0,424 | **0,038*** |
| | | Male | 46 | 3,46 | 1,026 | | | |
| | Control | Female | 9 | 4,11 | 1,167 | **0,035*** | 1,054 | **0,041*** |
| | | Male | 10 | 3,00 | 0,943 | | | |
| **A1g)** | Post | Female | 67 | 4,82 | 0,424 | 0,074 | 0,361 | **0,048*** |
| | | Male | 46 | 4,65 | 0,526 | | | |
| **A1j)** | Pre | Female | 67 | 4,82 | 0,386 | **0,014*** | 0,536 | **0,011*** |
| | | Male | 47 | 4,51 | 0,777 | | | |

*n* - number of observations. *M* - Mean. *SD* - Standard deviation. *p* - p-value (2-tailed).

*Results were considered statistically significant for *p* <0,05.

The questions for which statistically significant differences were found are C4, A1b), A1g) and A1j), that is, a question of knowledge and three attitudinal questions.

For the scores of answers to question C4 (describing the meaning of *Anthropocene*), the independent-samples *t*-test shows that there are statistically significant differences before the visit ($p$=0,026), although these are not confirmed by the Mann-Whitney U test, $p$=0,055. For this question, the effect size was medium, $d$=*0,*770. There are also significant differences after the visit, as demonstrated by the independent-samples *t*-test ($p$=0,035) and by the Mann-Whitney U test ($p$=0,021), with a medium effect size, $d$=0,635. In both cases, there is a tendency for male participants to have a higher quality of response than female participants.

Regarding question A1b), on preserving biodiversity due to its beauty, there are statistically significant differences in the pre-test (independent-samples *t*-test - $p$=0,035; Mann-Whitney U test - $p$=0,038) and control group (independent-samples *t*-test - $p$=0,035; Mann-Whitney U test - $p$=0,041). In the pre-test, there was a small effect size ($d$=424), while in the control group there was a large effect size ($d$=1,054). In both cases, there is a greater propensity for female participants to agree more with this statement than male participants. In turn, in the post-test, the trend was reversed as male participants ($n$=47; $M$=3,94; $SD$=0,942) were the ones who agreed the most with the statement in comparison to the female participants ($n$=66; $M$=3,88; $SD$=0,832). However, these differences are not significant.

For question A1g) (*The human being is a transforming agent of nature*), in the post-test, there was a propensity for female participants to agree more with this statement. This is the opposite situation to that encountered in the pre-test (male participants tended to agree the most). Significant differences were only detected in the post-test by the Mann-Whitney U test ($p$=0,048), although this value is quite close to the significance level.

Lastly, concerning question A1j), on human responsibility for preserving biodiversity, statistically significant differences were found only in the pre-test (independent-samples *t*-test - $p$=0,014; Mann-Whitney U test - $p$=0,011), with a medium effect size ($d$=0,536). In this case, there was a tendency for female participants to agree more with this statement than male participants. Nevertheless, after the visit, this question tended to be almost balanced between these two groups (independent-samples *t*-test - $p$=0,536; Mann-Whitney U test - $p$=0,434), since there was an increase in the tendency for male participants to strongly

agree with this (male – *n*=47; *M*=4,70; *SD*=0,507) and a slight decrease in the female participants tendency to do so (female – *n*=67; *M*=4,76; *SD*=0,495).

b) District comparisons

The results of the comparisons between districts of the results obtained for the experimental group are shown in Table 13. In this table, only the results in which statistically significant differences were obtained are found. All results are available in Appendix O.

**Table 13.** District comparisons of the answers to questions C1, C2, C3, C4, C5 and A1.

| Question | Pre/Post | District | Descriptive statistics | | | Independent-samples *t*-test | Effect size | Mann-Whitney U test |
|---|---|---|---|---|---|---|---|---|
| | | | *n* | *M* | *SD* | *p* | Cohen's *d* | *p* |
| **C1** | Pre | Aveiro | 47 | 2,68 | 0,594 | **0,003*** | 0,674 | **0,001*** |
| | | Braga | 69 | 2,96 | 0,205 | | | |
| | Post | Aveiro | 47 | 2,83 | 0,433 | **0,020*** | 0,536 | **0,005*** |
| | | Braga | 69 | 2,99 | 0,120 | | | |
| **C2** | Pre | Aveiro | 44 | 6,82 | 1,944 | **<0,001*** | 0,814 | **<0,001*** |
| | | Braga | 69 | 5,45 | 1,491 | | | |
| | Post | Aveiro | 46 | 7,04 | 1,920 | **<0,001*** | 0,805 | **<0,001*** |
| | | Braga | 69 | 5,62 | 1,655 | | | |
| **C3** | Pre | Aveiro | 46 | 1,83 | 0,851 | **<0,001*** | 0,894 | **<0,001*** |
| | | Braga | 69 | 1,22 | 0,539 | | | |
| | Post | Aveiro | 47 | 2,32 | 0,837 | **<0,001*** | 1,119 | **<0,001*** |
| | | Braga | 69 | 1,43 | 0,757 | | | |
| **C4** | Pre | Aveiro | 23 | 5,22 | 2,844 | **0,009*** | 1,102 | **0,008*** |
| | | Braga | 9 | 2,22 | 2,333 | | | |
| | Post | Aveiro | 33 | 5,15 | 2,729 | **0,006*** | 0,904 | **0,015*** |
| | | Braga | 15 | 2,93 | 1,668 | | | |
| **A1b)** | Post | Aveiro | 47 | 3,66 | 1,027 | **0,015*** | 0,503 | **0,023*** |
| | | Braga | 68 | 4,09 | 0,707 | | | |
| **A1c)** | Pre | Aveiro | 45 | 4,27 | 0,915 | **<0,001*** | 0,692 | **<0,001*** |
| | | Braga | 67 | 3,60 | 1,001 | | | |
| | Post | Aveiro | 46 | 4,41 | 0,909 | **0,023*** | 0,437 | **0,004*** |
| | | Braga | 69 | 4,03 | 0,857 | | | |

*n* - number of observations. *M* - Mean. *SD* - Standard deviation. *p* - p-value (2-tailed).

*Results were considered statistically significant for $p < 0,05$.

Differences were registered already before the visit between these groups, in knowledge questions C1, C2 (score), C3 and C4 (score). After the visit, the results show that the groups from Aveiro and Braga continue to have significant differences between them.

In questions C2 and C4, there was a tendency towards better quality of response in the school group from Aveiro, both before and after the visit.

Regarding the attitude questions, significant differences were detected for questions A1b) and A1c).

For question A1b), concerning the beauty of nature, significant differences were only detected after the visit (independent-samples *t*-test - $p$=0,015; Mann-Whitney U test - $p$=0,023). This was due to a considerable increase in the tendency of the Braga group to agree with this statement after the visit (pre-test – $n$=69; $M$=3,71; $SD$=0,893; post-test – $n$=*68;* $M$=4,09; $SD$=0,707), with a slight decrease in the Aveiro group (pre-test – $n$=46; $M$=3,70; $SD$=1,030; post-test – $n$=47*;* $M$=3,66; $SD$=1,027).

Concerning question A1c) (*Biodiversity must be preserved because it exists*) significant differences were detected before (independent-samples *t*-test - $p$<0,001; Mann-Whitney U test - $p$<0,001) and after the visit (independent-samples *t*-test - $p$=0,023; Mann-Whitney U test - $p$=0,004). There is a propensity for the group from Aveiro to be more in agreement with this statement than the group from Braga, despite its considerable increase in the tendency to agree with it after the visit.

c) Frequency of visit comparisons

Comparisons between participants who visited the Hall of Biodiversity for the first time ($n$=109) and visitors who had visited it before ($n$=7) were also conducted.

Significant differences were found in item C5a) in the pre-test (independent-samples *t*-test - $p$<0,001) that was not verified by the Mann-Whitney U test), and in the post-test (Mann-Whitney U test – $p$=0,021). Furthermore, question A1b) results also showed a significant variation in pre-test (independent-samples *t*-test – $p$=0,036; Mann-Whitney U test – $p$=0,025), as well as item A1g) in the post-test (independent-samples *t*-test – $p$<0,001; this result was not verified by the Mann-Whitney U Test), and in A1i) in the post-test (independent-samples *t*-test – $p$<0,001), that was not verified by the Mann-Whitney U test. The totality of the results is represented in Appendix P.

Nevertheless, since the number of students who had already visited is too small, the results of this comparison are considered negligible.

3.1.10. Other comments

The questionnaire included a box for additional comments. The feedback obtained was organized in 11 categories, and the results are shown in Figure 10.

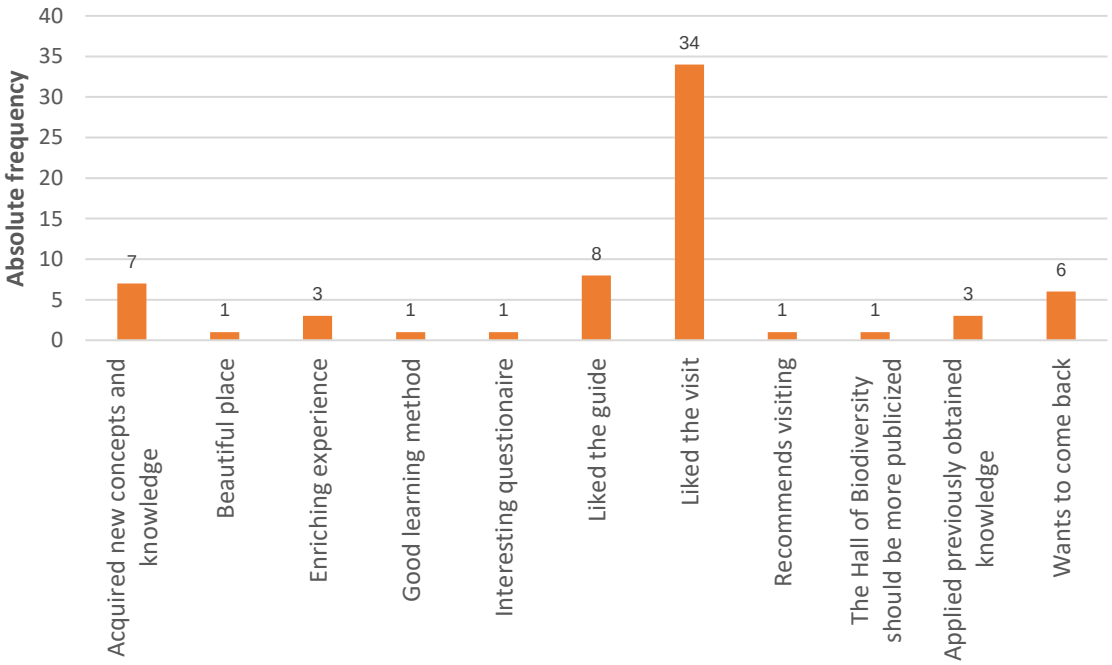


**Figure 10.** Other comments (*n*=44).

The most frequently mentioned comment was *Liked the visit* (*n*=34). Specifically in this regard, it was mentioned that the visit was interesting, dynamic, and well-structured. *Liked the guide* (*n*=*8*), *Acquired new concepts and knowledge* (*n*=7) and *Wants to come back* (*n*=6) were also highlighted.

Additionally, there were mentions to the beauty of the place (*n*=1*)*, the fact that it was an enriching experience (*n*=3) and the fact that it is a *Good learning method* (*n*=1), in which previous knowledge was applied (*n*=3).

There was also a suggestion to disseminate this cultural equipment more widely through the media (*n*=1).

Finally, there was a participant recommending the visit (*n*=1). And the questionnaire was considered interesting (*n*=1).

## 3.2. Interviews

### 3.2.1. Interviewees' profile

The demographic profile of the twenty participants is shown in Table 14.

**Table 14.** Interview participants (*n*=20) demographic information.

| | **Subcategories** | ***n*** |
|---|---|---|
| **Age** | 18-24 | 6 |
| | 25-34 | 3 |
| | 35-44 | 8 |
| | 55-64 | 2 |
| | Over 64 | 1 |
| **Gender** | Female | 7 |
| | Male | 12 |
| | Other | 1 |
| **District** | Aveiro | 1 |
| | Braga | 3 |
| | Faro | 1 |
| | Lisboa | 2 |
| | Porto | 10 |
| | Santarém | 1 |
| | Viseu | 1 |
| | *France | 1 |
| **Professional/study field** | Biology | 3 |
| | Commerce, Economics, Management, Secretariat | 8 |
| | Education | 1 |
| | Electrical engineering; IT | 3 |

| | | |
|---|---|---|
| | Fine Arts | 2 |
| | Languages and literature; Law | 2 |
| | Unemployed | 1 |
| **Education level** | High school | 11 |
| | Undergraduate degree | 5 |
| | Master's degree | 3 |
| | PhD | 1 |
| **First time visiting** | Yes | 18 |
| | No | 2 |

* Note: The interviewee is Portuguese, but currently lives in France.

Five age groups are represented, with the 35–44 age group (*n*=8; 40%) being the most frequent. No participants are in the 45–54 age group. Male is the most common gender among those surveyed (*n*=12; 60%).

Additionally, it was possible to interview participants from six Portuguese districts and one participant who currently resides in France despite having Portuguese nationality. Of these, the Porto district is the most frequent (*n*=10; 50%).

Eight professional/academic fields are represented, including one unemployed interviewee; the most common area is Commerce, Economics, Management, and Secretariat (*n*=8; 40%). On the other hand, high school (*n*=11; 55%) is the complete level of education that is most frequent.

Finally, 18 participants (90%) said this was their first time visiting the Hall of Biodiversity. The two participants who had previously visited had done so over a year ago with a group of friends.

### 3.2.2. Categorical analysis

Regarding the qualitative analysis of the interviews, the data were grouped into seven category trees (Figures 11 to 17) and a table (Table 15). For all the category trees, the numbers refer to the number of participants who mentioned each category. Additionally, the following notation is used: I – interviewee, E – excerpt, followed by the interviewees number,

or the excerpt number, respectively. For example, I11, E3 refers to the third excerpt mentioned by interviewee 11.

a) Understanding of the meaning of *Biodiversity* and *Anthropocene*

The results related to the understanding of the terms *Biodiversity* and *Anthropocene* are described in Table 15.

**Table 15.** Results of the interview questions 1 and 3, regarding the understanding of the meaning of *Biodiversity* and *Anthropocene*.

| | **Has heard of it and knows what it means (*n*)** | **Has heard of it but doesn't know what it means *(n)*** | **Has not heard of it *(n)*** |
|---|---|---|---|
| **Biodiversity** | 18 | 2 | 0 |
| **Anthropocene** | 5 | 1 | 14 |

The data show that 90% (*n*=18) of those surveyed have heard of and understand what *Biodiversity* is, whereas just 10% (*n*=2) do not exactly understand it despite having heard of it.

Only five people (25%) are familiar with the term *Anthropocene* and know what it means. When asked about it, the participant that has heard of it, but did not know its meaning (*n*=1), said it has to do with very primitive origins of species. The vast majority of those surveyed (*n*=14; 70%) had never heard the term *Anthropocene* and were therefore unaware of its meaning.

The concept *Anthropocene* appeared to be transversal to all five age groups, as each was represented by a participant who knew its meaning. All the considered levels of education were also represented: one participant completed high school education, two participants had an undergraduate degree, one participant had a master's degree, and one participant had a PhD. Plus, two of these interviewees were female, and three were male. Of these participants, only one had already visited the Hall of Biodiversity.

b) Did the visit to the Hall of Biodiversity lead to a better understanding of *Biodiversity?*

The first category tree corresponds to question 2. It describes how visiting the Hall of Biodiversity improved the understanding of *Biodiversity* (Figure 11).

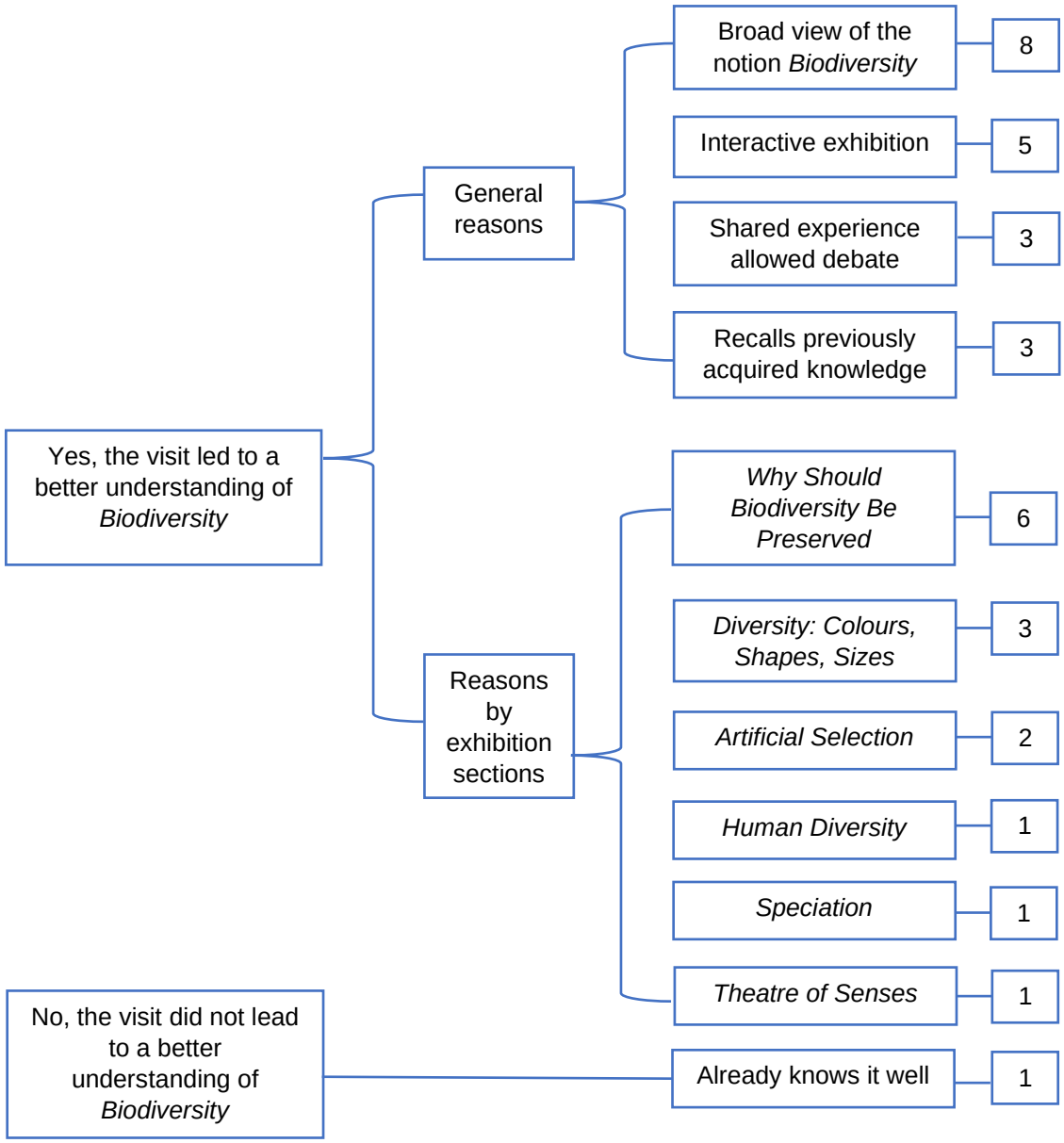


**Figure 11.** Categorization of the reasons why the visit led, or not, to a better understanding of *Biodiversity.*

Most of the interviewees (*n*=19) referred that the visit to the permanent exhibition enhanced their understanding of *Biodiversity.* The participant who stated that it did not lead to a better understanding of the notion has a master's degree in Biology, and so claimed to already have a vast understanding of *Biodiversity.*

Furthermore, one of the interviewees who responded *Yes* did not substantiate the answer, starting to digress about the interest in the subject and the taste in watching documentaries about it.

Two subcategories were highlighted among the reasons why this exhibition leads to a better understanding of this notion: *General reasons* and *Exhibition sections*.

Within the *General Reasons* subcategory, the reason with greater relevance is that this exhibition allowed a *Broad view of the notion Biodiversity* (*n*=8) (I17, E1). Furthermore, the interviewees mentioned that the exhibition presents a large sample of biodiversity, cements this knowledge, and mentions topics rarely discussed. Half of the participants (*n*=4) who mentioned this subcategory were male. Half of these participants (*n*=4) resided in Porto. All the participants were first time visitors.

> *"Biodiversity is often defined as something shorter in scope. This visit allowed me to have a broader view of the breadth of biodiversity."* (I17, E1).

Five participants highlighted that it is an interactive exhibition that includes practical and efficient applications of knowledge, thus incrementing the understanding of the notions presented. This sub-subcategory was transversal to all age groups (I14, E1).

> *"The idea of the visitor's immersion within the notions and the idea of when you have an experience, when we use our senses, the notions… It is easier to get to know the notions."* (I14, E1).

According to some interviewees (*n*=3), not only does the exhibition by itself allows this amplification of knowledge, but a shared experience — be it with a friend or the exhibition's guide — also has this power (I20, E1). All of the interviewees lived in Porto and were first time visitors.

> *"I feel that it was more the attitude of the people than the exhibition itself* (…) *mainly the way your colleague* (guide) *spoke to us and the conversations I had with my friend."* (I20, E1).

Furthermore, it was also mentioned that it is possible to recall some previously acquired knowledge while exploring the exhibition (*n*=3).

Regarding the exhibition's sections, the one that received the most attention was *Why Should Biodiversity Be Preserved* of which the Ethical (*n*=3), Aesthetic (*n*=1), and Scientific (n=1) principles were mentioned. The section as a whole (*n*=1) was also mentioned. The following excerpt addresses the Aesthetic Principle (I17, E2). Two of these participants had already visited the Hall of Biodiversity.

> *"For example, we can see the thousands of possibilities of eggs that are there (…) you can see, with this exhibition, that nature follows many different paths from a unique point."* (I17, E2).

The sub-subcategory *Diversity* (*n*=3) includes the sections *Diversity of Colour* (*n*=1), *Diversity of Shapes* (*n*=1) and *Diversity of Sizes* (*n*=1). The next excerpt (I14, E2) refers to the section *Diversity of Sizes:*

> *"But, sitting there in that chair listening, for the first time, to the heartbeat of a whale, a mouse, and my own, I think it is something that I will never forget."* (I14, E2).

Lastly, *Artificial Selection* (*n*=2), *Human Diversity* (*n*=1), *Speciation* (*n*=1) and *Theatre of Senses* (*n*=1) were also pointed out by the participants.

c) Human-environment interactions addressed in the exhibition.

The following categorization encompasses the answers to questions 3.1 and 3.2, which asked the participants if they identified any examples of human interaction with the environment in the permanent exhibition (Figure 12).

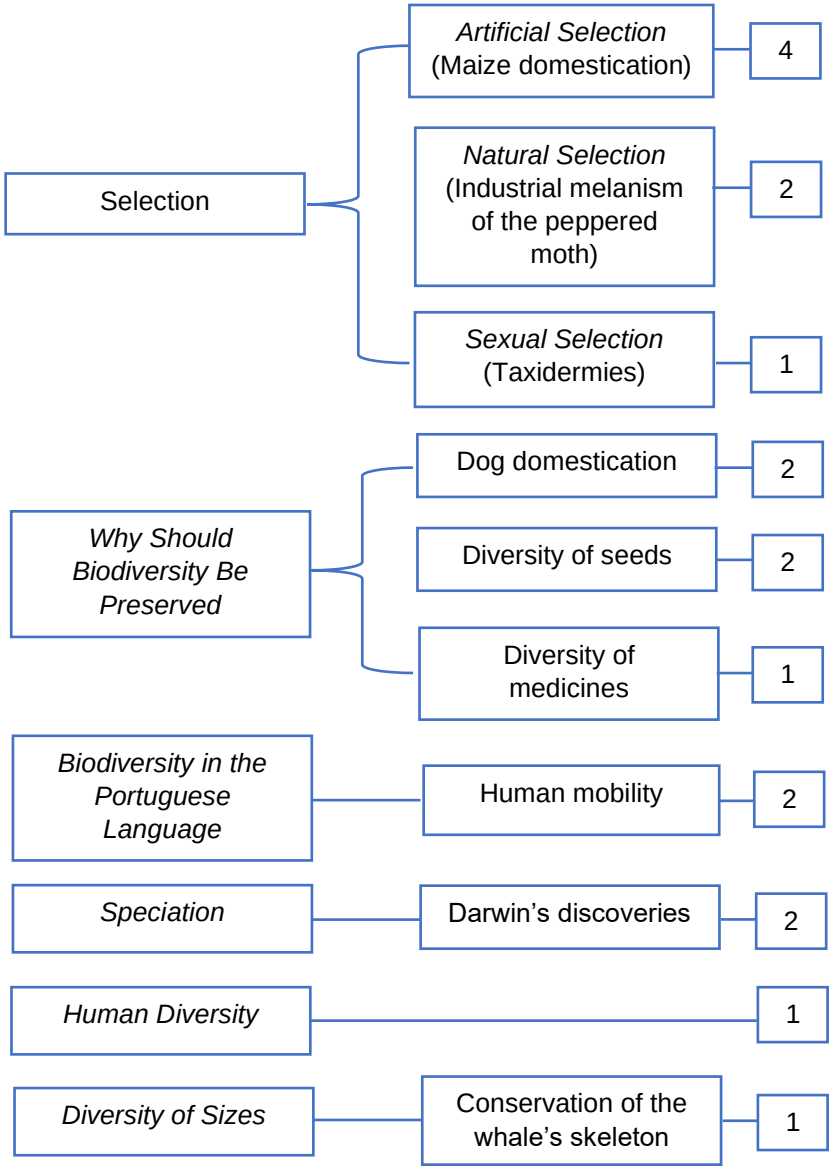


**Figure 12.** Categorization of the examples of human-environment interactions present in the exhibition.

In this figure, the main categories refer to a section of the exhibition or a group of sections that have a common point (as is the case of the *Selection* category).

Two out of twenty interviewees did not recall any examples.

The most predominant category amongst those who did was the *Selection* category (*n*=7), which encompasses the most mentioned subcategory, *Artificial Selection* (*n*=4). In this section, the example given was the domestication of maize and subsequent genetic manipulation to produce hyper-uniform maize for consumption. Six out of seven (86%) participants who mentioned this category were male.

The ethical principle was brought up by two participants who described how humans played a role in domesticating dogs (I14, E3).

> *"That dog thing is astounding. All that variability generated by man-made crossbreeding."* (I14, E3).

Another example that two visitors brought up had less to do with the exhibition's content and more with how the collections were treated. This is the case of taxidermies present in the section *Sexual Selection* (*n*=1) (I20, E2) and the conservation and restoration of the blue whale skeleton (*n*=1), present in the atrium of the Hall of Biodiversity and included in the section *Diversity of Sizes.* Both examples were executed by human hands.

> *"(…) this was a living being, and it was a human who took over its body to display it for other humans. (…) How do we know that the peacock did not want to be absorbed by the ground?"* (I20, E2).

The industrial melanism of the peppered moth (*Biston betularia),* present in the section *Natural Selection* (*n*=2)*,* was recognized as an example of this interaction, as well as *Darwin's discoveries,* addressed in the *Speciation* (*n*=2) section (I3, E1).

> *"A good example is Darwin discovering all that biodiversity in the islands through his voyages."* (I3, E1).

Within the *Why Should Biodiversity Be Preserved* category*,* the *Economic Principle* (*n*=1), demonstrated by the diversity of seeds, and the section *Scientific Principle,* which displays a variety of medicines (*n*=1), were highlighted.

Lastly, human colonization and mobility across the Earth's territories *(Biodiversity in the Portuguese Language*) *(n*=2) and *Human Diversity* (*n*=1) (I18, E1), were also addressed.

> *"The exhibition has a specific part for human diversity, and the human being is a part of biodiversity."* (I18, E1).

d) Human impacts on biodiversity

Questions 4, 5 and 8 survey perceptions about human impact on biodiversity. Thus, in response to question 4, all interviewees referred that human beings can have negative impacts on biodiversity, something that was pointed out as obvious by some. However, it was also clarified by one interviewee that this interaction could lead to harmony (I11, E1).

> *"Human activity can and does have a negative impact, but it can also create harmonies with nature."* (I11, E1).

Concerning question 5, which refers to the responsibility humans may have in reducing the diversity of species observed over the last few years, all interviewees assumed that humans have a responsibility in this regard.

Regarding question 8, about whether there is undue exploitation of biodiversity by humans, all respondents agreed that, in general, there is.

The examples presented by the participants were raised in these three questions, all of which have the human impact on biodiversity as their common theme (Figure 13).

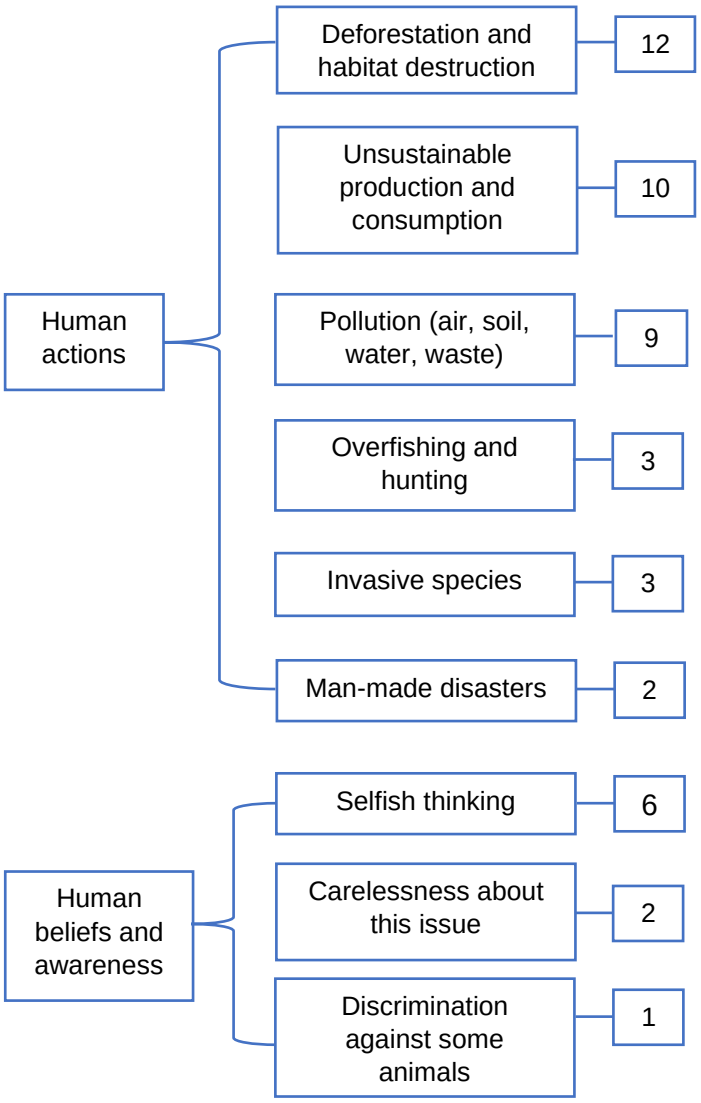


**Figure 13.** Categorization of human impacts on biodiversity.

All participants answered the three questions and then substantiated their response with examples.

The examples were divided into two categories: *Human actions*, which includes six subcategories, and *Human beliefs and awareness*, which includes three subcategories.

The top three most frequently mentioned subcategories belong to the *Human actions* category; these are *Deforestation and habitat destruction* (*n*=12) (I10, E1), followed by *Unsustainable production and consumption* (*n*=10), which consisted of examples such

as infrastructures and construction (*n*=7) (I4, E1), excessive meat consumption (*n*=2), and species selection for greater food productivity (*n*=1), and by *Pollution* (*n*=9) (I19, E1) which comprises air, soil, water and waste pollution (especially plastic). Considering the subcategory *Pollution,* eight out of nine interviewees who mentioned this category completed education until high school. Participants of all ages mentioned examples that belong to *Unsustainable production and consumption.*

> *"(…) the easiest things to identify are related to how forests are indiscriminately felled, and this has a direct impact not only on trees, in terms of vegetation, but also on animals, that depend a lot on those ecosystems to survive."* (I10, E1).
>
> *"There are many roads, and most infrastructures are made for cars and people, and you do not see much nature."* (I4, E1).
>
> *"Air, soil, and marine pollution shorten the lifetime of a species that lives in an impacted habitat."* (I19, E1).

*Human actions* such as *Overfishing and hunting* (*n*=3), *Invasive species* (*n*=3) and *Man-made disasters* (*n*=2) were also mentioned.

Regarding *Human beliefs and awareness*, six participants highlighted the human being's *Selfish thinking* (*n*=6) (I18, E2) that can lead to a reduction in biodiversity.

> *"Yes, the human being's philosophy is that the world is his, and with that, he enjoys the world as he pleases."* (I18, E2).

*Carelessness about the topic* (*n*=2*)* and *Discrimination against some animals* (*n*=1)*,* such as sharks, also represented human attitudes that may impact biodiversity.

Seven individuals provided answers under the category *Human beliefs and awareness* (two of them gave two examples).

e) Biodiversity loss effects

The consequences of biodiversity loss are the focus of questions 6 and 7. While question 6 encourages the interviewee to think about what this biodiversity loss would bring, question 7 focuses on the potential effects that could directly affect people.

Although every participant gave an affirmative response to both questions, only seventeen of the twenty participants provided examples, since "*the problem is that there isn't anything that specific.*" (I13, E1).

The answers to these questions were grouped in the category tree present in Figure 14.

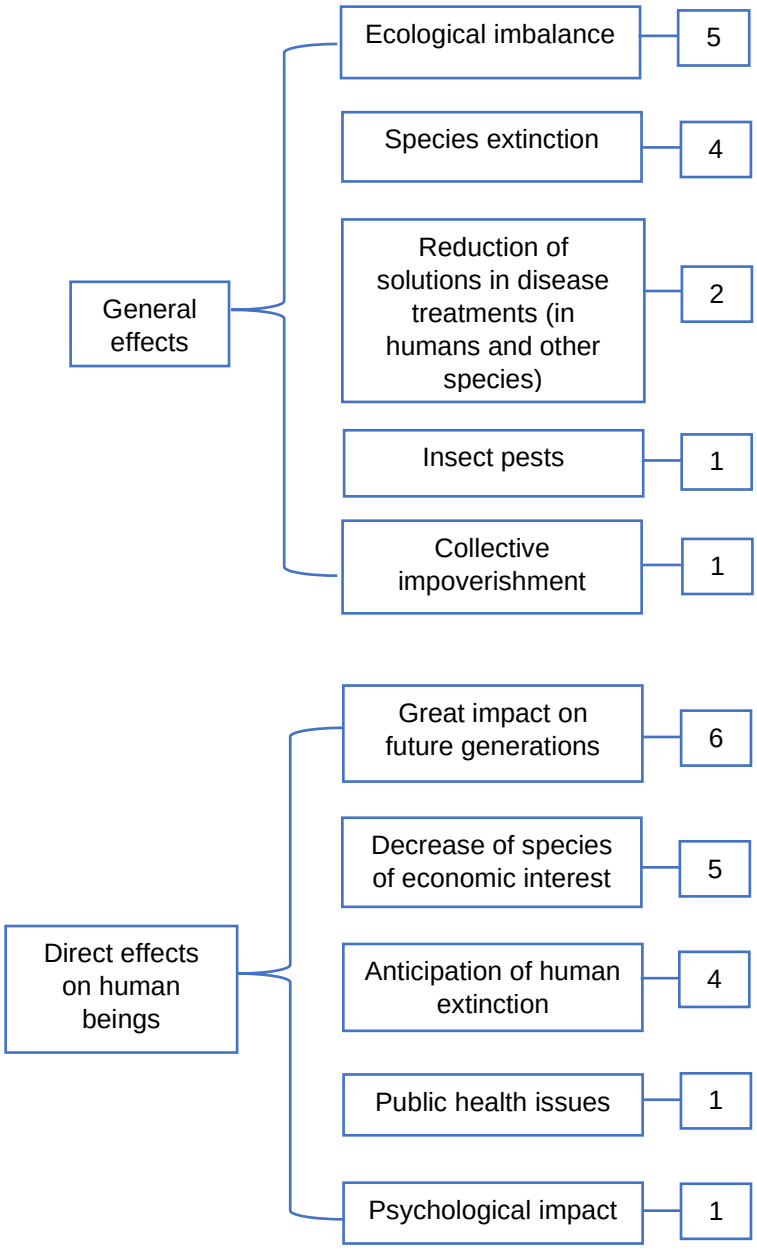


**Figure 14.** Categorization of biodiversity loss effects.

The answers to this topic fell into two broad categories: *General effects* and *Effects directly on the human being.*

The most frequently highlighted subcategories are present in the category *Direct effects on human beings* and concern the *Impact on future generations* (*n*=6) (I6, E1) and the *Decrease of species of economic interest* (*n*=5) (I3, E2). The first category was mostly mentioned by participants who were in the 35-44 age group (four out of six; 67%); the latter subcategory was mentioned by interviewees in the two youngest age groups, 18-24 (*n*=3*),* 25-34 (*n*=1*),* and by the interviewee that belongs to the Over 64 age group.

> *"If we keep acting this way, some species of animals or plants will become extinct, the climate will worsen, and future generations will suffer."* (I6, E1).

> *"So, if we kill the beginning of the (food) chain, we will consequently kill animals of economic interest."* (I3, E2).

Another concern shared by several participants (*n*=4) is the *Anticipation of human extinction* (I10, E2). All participants who mentioned this subcategory were male.

> *"As much as men studies and analyzes, I think this is like a locomotive without brakes. I believe that we are rapidly anticipating the end of our species."* (I10, E2).

Within the *General effects*, the *Ecological imbalance* subcategory stands out (*n*=5; I1, E1).

> *"Things work in dialogue with each other, even if we may not be familiar with it, or permanently aware of it. The disappearance of one of the interlocutors unbalances the entire structure."* (I1, E1).

Secondly, still within this category, the *Extinction of species* (*n*=4) is pointed out as a repercussion of the decrease in biodiversity (I4, E2).

> *"I'm seeing more species going extinct and at a very fast rate and it's unsettling."* (I4, E2).

Another aspect worthy of attention is that the subcategory *Reduction of solutions in disease treatments* (*n*=2) is not only oriented towards humans, but also to other species. The following example given by one of the participants refers to the plague of the grape phylloxera (*Daktulosphaira vitifoliae*) in European grapevine (*Vitis vinifera*) plantations (I17, E3) (Powell, 2008).

> *"For example, if a disease emerges, as it did with phylloxera in wine, it was diversity, the existence of an American grapevine, I think, that allowed the European grapevine to survive."* (I17, E3).

*Insect pests* (*n*=1), a *Collective impoverishment* (n=1), *Public health issues* (*n*=1) and *Psychological impact* (*n*=1) (I20, E3) also are concerning for some participants.

> *"The fact that the next generation will know that, because of me, or my parents' fault, they will never be able to see an Iberian lynx. I think it psychologically impacts people (…) that we know it was our fault that we lost so much diversity. It's something that affects me; it is something that makes me think at night."* (I20, E3).

f) The importance of preserving biodiversity

Question 9 answers concerning the importance of preserving biodiversity were grouped in a category tree (Figure 15). Only eleven out of twenty participants substantiated their answers, with the remaining participants indicating that their previous responses had already demonstrated their points of view on this matter. All participants agreed that it is essential to preserve biodiversity.

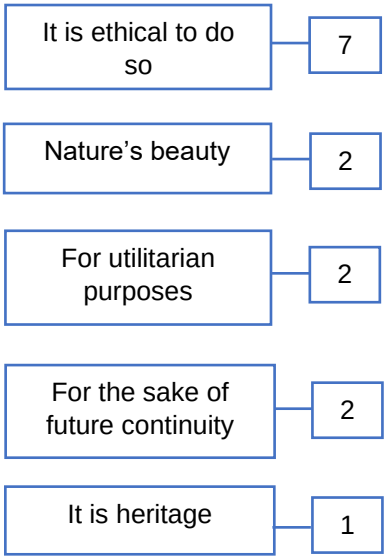


**Figure 15.** Categorization of the reasons mentioned by the participants on why it is important to preserve biodiversity.

The tree includes five categories. The most common category focuses on the ethical foundation of preserving biodiversity (*n*=7) (I13, E2). This is a category transversal to all gender groups considered in this study. Four of the respondents were male, two were female, and one identified as *Other.* Additionally, the participants belong to the three youngest age groups (18-24, *n*=4; 25-34, *n*=1; 35-44, *n*=2).

> *"All living beings deserve to live in this world, we are not the only ones."* (I13, E2).

The beauty of nature (I17, E4), its utilitarian dimension (I17, E5), and the fact that it must be preserved to allow continuity for future generations (I7, E1), were equally mentioned (*n*=2).

> *"Even if it is just for the beauty of animals, which are fantastic, and plants. It is stupid to destroy it, isn't it?"* (I17, E4)

> *“But also, on a somewhat utilitarian criterion. If we have less diversity, we will enjoy less the positive things that nature gives us.”* (I17, E5).

> “(…) *so that we can provide continuity and, in my case, so that my daughters can have a full understanding of everything.”* (I7, E1).

Lastly, one of the interviewees called attention to the fact that biodiversity is a heritage that needs to be protected (I14, E4).

> *“It is a heritage that I believe must be preserved.”* (I14, E4).

g) <u>What can we do to preserve biodiversity?</u>

The following categorization encompasses the answers to question 10 on how human beings can act in favor of biodiversity preservation (Figure 16).

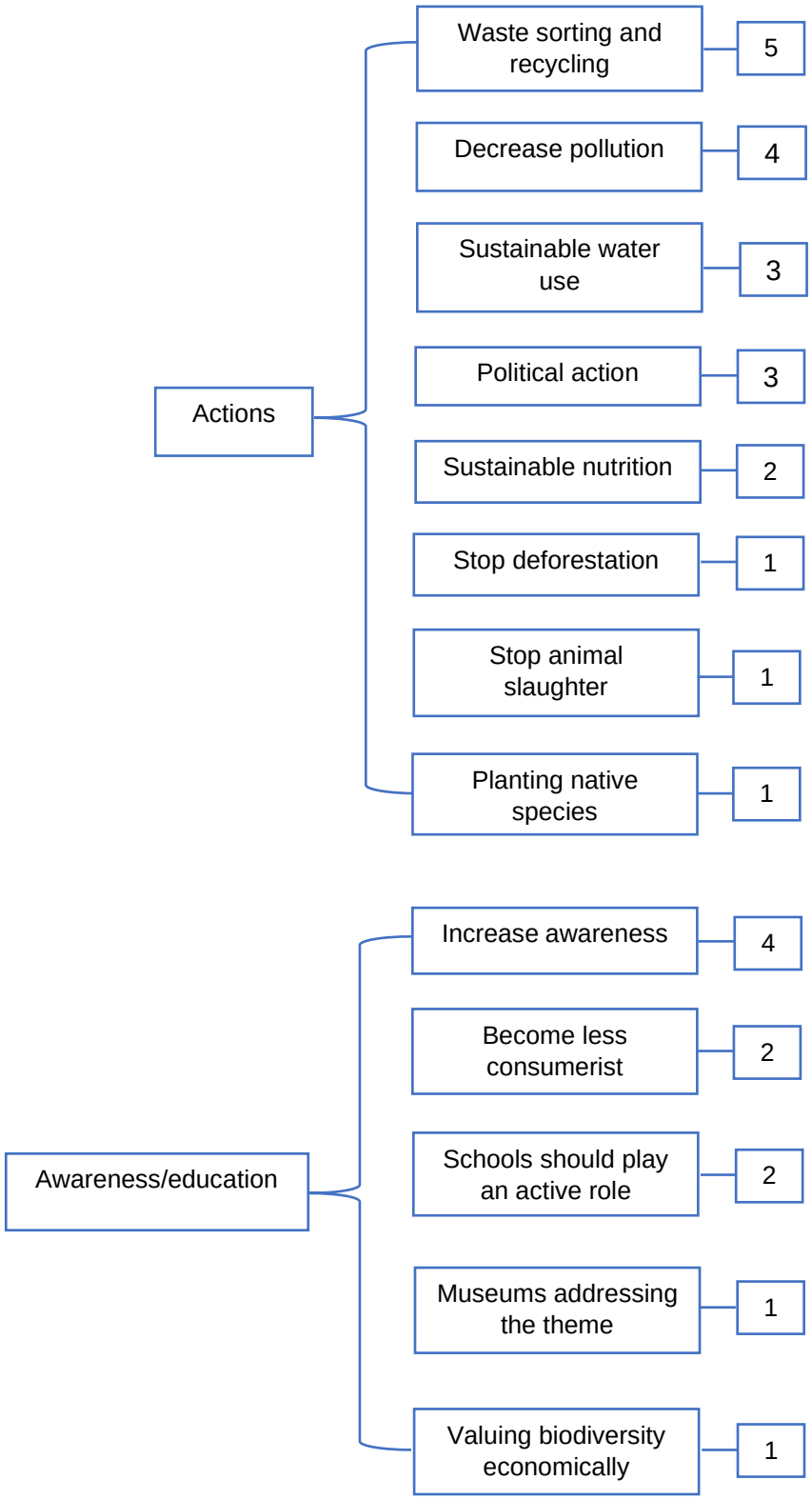


**Figure 16.** Categorization of ways to preserve biodiversity.

The examples in Figure 16 represent the answers provided by seventeen of the twenty interviewees. Regarding the three visitors who did not provide an example, two of them belong to the 18-24 age group, one of them was in the 25-34 age group, and all of them are male. Additionally, they claimed that they would love to know what can be done to preserve biodiversity but were unsure of how to do it.

The category tree on ways to preserve biodiversity is divided into two categories: *Actions* and *Awareness/education.*

Within the category *Actions,* the *Waste sorting and recycling* subcategory (*n*=5) was the most frequently mentioned. This is followed by *Decrease pollution* (*n*=4), naturally associated with climate change.

*Sustainable water usage* (*n*=3) and *Political action* (*n*=3) were also addressed; one interviewee emphasized the need for *greater political drive and influence in the decision-making process* (I1, E2).

Actions such as *Sustainable nutrition* (n=2), *Stop deforestation* (n=1), *Stop animal slaughter* (n=1), and *Planting native species* (n=1), are also mentioned.

The most prominent subcategory in the *Awareness/Education* category is *Increase Awareness* (*n*=4) on this topic. The subcategories *Become less consumerist,* and *Schools should play an active role* had the same number of mentions (*n*=2). Furthermore, *Museums addressing the theme* was highlighted by a visitor (*n*=1). Finally, an interviewee mentioned that biodiversity should be economically valued (I14, E5).

> *"For instance, the air we breathe has no monetary value. Therefore, in the field of biodiversity, there would need to be ways to extract this value in light of the detrimental effects of the lack of biodiversity."* (I14, E5).

For the category *Actions* there were eleven respondents, six of which were female (55%), four were male (36%) and one identified as *Other* (9%).

For the category *Awareness/education* there were nine respondents, six of which were male (67%), and three were female (33%).

Considering the number of women who took part in this study (*n*=8) and that six of them gave an example that fit in the *Actions* category, there seems to be a tendency for female participants to think more of actions to preserve biodiversity, than in awareness initiatives.

Three of the participants gave examples belonging to both categories.

h) Contribution of the visit to personal growth

The last category tree concerns question 11, about the visit's contribution to the interviewees' personal development, that is, if it turned out to be a positive experience for the visitor. All visitors agreed that it contributed to their personal growth, but only seven out of twenty respondents substantiated their opinion, as the interviewer did not ask for a justification.

Figure 17 presents the categorization of the answers to question 11.

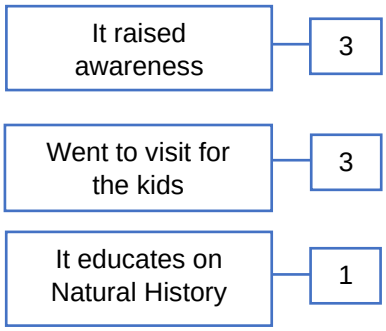


**Figure 17.** Categorization of the responses to the interview's question 11.

Three interviewees mentioned that the visit raised awareness on the subject. One of them even added that it amplifies one's vision on the world (I19, E2).

> *"I believe all these activities are crucial for our development, for understanding the world as it is, and for fostering a more decentralized, less egocentric perspective."* (I19, E2).

Three other interviewees admitted that they went to visit because of their children, either because the child intends to pursue a career in Biology, or because they learned about this place by a recommendation from the child's teacher (I16, E1).

> *"My son's history teacher recommended to visit. We came with the intention of getting to know Sophia de Mello Breyner's house, and we ended up discovering a different situation; it just made things more interesting."* (I16, E1).

Finally, an interviewee emphasized that the visit enables one to be educated on Natural History and understand the origins of concepts, theories, and knowledge (I3, E3).

> *"I think it's always beneficial to see these things and reflect on how we got here, don't you? The great biologists* (laughs), *who weren't called biologists yet, but the ones who created all the notions and everything and I think this place is very good in that matter."* (I3, E3).

## 4. DISCUSSION

This study provides an overview of Portuguese people's perceptions on the Anthropocene, by exploring the visitors' experience in interacting with biodiversity-related contents in the Hall of Biodiversity - Ciência Viva Center | MHNC-UP. Visitors' perceptions on these topics were analyzed through questionnaire implementation and by carrying out interviews. A sample comprised of 11$^{th}$ grade students who were attending Biology and Geology as an optional class (and who had some prior knowledge on biological sciences) was used for the questionnaires and a sample comprised of visitors from various professional/academic backgrounds and levels, age groups, and districts was used for the interviews.

This section is organized in nine topics, in which the results of questionnaires and interviews are jointly discussed.

### 4.1. The concept *Biodiversity*

When asked about their knowledge on *Biodiversity,* most of the questionnaire participants indicated that they knew its meaning. However, when asked to describe what it meant to them, the average scores concentrated at the midpoint of the scoring rubric, meaning that most of the students from both experimental and control groups considered *Biodiversity* as the diversity of living beings, of life or in the biosphere. In fact, the most highlighted notions were *Diversity, Living beings,* and *Species.* These findings are similar to those in other research studies focusing on students, showing that there is a tendency to

not include genetic and ecosystem diversity when describing *Biodiversity*, suggesting a superficial understanding of the concept (European Commission, 2007; Kilinc et al., 2013; Menzel & Bögeholz, 2009). This can be due to an etymological interpretation on the concept, as *Biodiversity* is the amalgamation of *bio-* (short for biological) and *diversity* (Kilinc et al., 2013; Menzel & Bögeholz, 2009). Despite scoring slightly higher after the visit, the variation was not significant, nor were the differences between experimental and control groups. Nevertheless, scientific terminology as well as new concepts emerged, resulting from the engagement with sections of the exhibition: the diversity of colours, shapes, sizes, genetics, and even concepts on evolution were highlighted.

Although in the interviews most respondents indicated that they had heard of and know the meaning of *Biodiversity*, the fact is that it is a wide-ranged concept, integrated into different societal dimensions and, as such, interpreted according to the context in which it is used (Adom et al., 2019; European Commission, 2015; van Weelie & Wals, 2010). Thus, it is typical for this concept not to be well cemented, especially amongst the lay public; hence it is very frequent for mediating concepts such as *nature, greenness, landscape, beauty, balance, food-chain,* to be used in support of representations of the notion (Buijs et al., 2010; Fischer & Young, 2007). However, as suggested by Buijs et al. (2010), the fact that people do not use scientific terminology to describe the term does not mean that they do not have favorable attitudes towards biodiversity and, therefore, towards its preservation. Therefore, it is interesting that the interviewees have pointed out that the Hall of Biodiversity presents a broad representation of *Biodiversity*, contemplating different contexts and various ways in which biodiversity can be evidenced, allowing them to increase their knowledge about this theme.

According to the Special Eurobarometer Nº481 (European Commission, 2019), Portugal stands as one of the countries with the highest comprehension rates of the concept *Biodiversity.* However, this might not actually be the case, since asking someone if they know the meaning of a concept is not the same as asking them to describe it. Studies have shown that self-reported knowledge does not always correspond to an objective assessment of that knowledge (Durant & Legge, 2016; Huxster et al., 2015).

### 4.2. The concept *Anthropocene*

When asked about their understanding of the concept *Anthropocene,* most of the interviewees had not heard of it before and did not know its meaning. The five people who

did know its meaning explained it as the age that is being dominated by human influence or by using similar notions. Given that the study sample included at least one interviewee in each age group considered, the results suggest that this is a transversal scenario across different age groups.

Regarding the high school students, most of them did not know the meaning of Anthropocene, and only a few of them had heard of it before. Perialdo et al. (2022) reported similar results. After the visit, the number of respondents who mentioned they had heard about it increased, whether knowing or not its meaning; this could be due to the fact that they had heard of it in the pre-test questionnaire. However, the rate of response to the question in which they were asked to describe what *Anthropocene* meant to them improved by 50%. In this question, there was a slight increase in the quality of the answers, but, as stated previously, this variation was not significant, nor were the lower scores registered in the control group. The experimental group answers tended to provide values between 4 and 5. Thus, most of the students who answered demonstrated a limited knowledge of the concept, mentioning that it represents an age of Earth's history. However, some students knew that this notion is related to human beings, even if this was just due to the etymology of the word (*Anthropo* – Human).

When describing the meaning of *Anthropocene*, some confusion around the word *Arthropods* arose: one respondent highlighted the notion of *Arthropods* and mentioned the notion of *Insects*. In addition, there was also some confusion around the concept *Hominids*, mentioned by two students from the control group, perhaps thinking that it is a synonym for *Human beings.* But the most prevalent misconception refers to the terminology of geological ages. The most highlighted age was *Period,* followed by *Era.* Only one student correctly referred to the *Anthropocene* as an epoch. Plus, since this concept is still in construction, some students mentioned that it corresponds to an age where human beings emerged, or are predominant, or are simply present. Curiously, *Human action* was not mentioned by any student from the control group. Regarding the interviews, one participant was unsure of the meaning of *Anthropocene,* referring that it had something to do with the primary origins of species.

However, the respondents' knowledge about the interaction and potential impact of humans with biodiversity appeared to be solid, as demonstrated by the responses to question C5 in both groups. The visit to the Hall of Biodiversity's permanent exhibition

reinforced and increased this knowledge, although not statistically significantly. Nevertheless, when comparing the results of question C5a for the post-test and the control group, there was a significant variation: after the visit, the respondents tended to provide more correct answers. This question is directly related to the exhibition section referring to artificial selection, in which the example of maize and the dilemma between food productivity vs. genetic diversity are worked through. Furthermore, when asked if the human beings are transforming agents of nature, the respondents in both the experimental and control groups tended to agree. This tendency increased even further after the visit to the permanent exhibition, meaning that the human-nature interactions portrayed in the exhibition significantly influenced the visitors' perception on this subject.

Similarly, the examples of human-nature interactions present in the exhibition were correctly identified by the interviewees. The most highlighted one was the artificial selection of maize, which demonstrates how humans can influence the evolutionary process of other species. Similarly, the domestication of the dog was also mentioned. The classic example of natural selection was also mentioned, and the way in which it was boosted by the Industrial Revolution.

The most utilitarian reasons for the preservation of biodiversity were also highlighted as examples of human-nature interaction, namely, the harvest of seeds and medicines designed from active principles extracted from nature. Traveling was also an example of this interaction, whether it was the colonization of Earth by human beings in the past, current air travel, or even Darwin's voyages and discoveries. All these examples reflect human beings' role in understanding but also shaping biodiversity.

*Human Diversity* was mentioned by an interviewee, who explained that human beings are also part of planet Earth's biodiversity. This was also recognized by the vast majority of the experimental group respondents in the questionnaires, both before and after the visit, since they tended to agree with the statement in C5e). This is in line with findings obtained in other studies (Buijs et al., 2010; Sumares & Fidélis, 2009; Vining et al., 2008).

The low knowledge about the meaning of *Anthropocene* may be due to the fact that this is a recent concept that is not commonly disseminated on school curricula around the world (Bagoly-Simó, 2021). The dissemination process of this concept may be challenging given that its recognition as a geological age is not yet official (Robin et al., 2014).

Nevertheless, participants are well aware that human beings can greatly influence biodiversity and the natural world and do have knowledge on the matter. The Hall of Biodiversity's permanent exhibition had a positive influence on the knowledge and perceptions of the participants, with specific sections and modules, such as *Artificial Selection*, contributing greatly to widen their understanding on the subject.

### 4.3. Human impacts on biodiversity

Even though the respondents to the questionnaires were not polled regarding human impacts on biodiversity, most of them tended to agree that humans can act in ways that endanger biodiversity and that the human-centered perspective has historically resulted in undue biodiversity exploitation.

Concerning the human actions that were mentioned by the interviewees, the most frequently highlighted were *Deforestation and habitat destruction, Unsustainable production and consumption,* and *Pollution (air, soil, water, waste). Overfishing and hunting, Invasive species,* and *Man-made disasters* were also mentioned. Considering the Special Eurobarometer Nº481 results for Portuguese perceptions regarding biodiversity (European Commission, 2019), it is interesting to see that topics such as "*Intensive farming, intensive forestry, overfishing*", "*Conversion of natural areas to other land uses",* "*Modification or fragmentation of natural areas by transport, water, and energy infrastructure projects"*, are less relevant for the Portuguese population than "*Man-made disasters"*. Therefore, the outcomes of the present study reflect a contrary tendency to that observed in this observatory. The great concern shown in the Special Eurobarometer Nº481 (European Commission, 2019) regarding man-made disasters may be due to the television coverage of these issues, having in mind that this outlet is still the primary means of information for many Portuguese people, and that generalist channels prefer to focus on environmental disasters and, typically, in a sensationalist way, even though environmental-related topics are still underrepresented (Balbé, 2013; European Parliament, 2022). According to the Special Eurobarometer Nº481, "*Pollution of air, soil and water"* remains as the top threat to biodiversity (European Commission, 2019), something that the interviewees frequently brought up and which is in line with other studies (Bernardo et al., 2021; S. Oliveira et al., 2020). Plastic pollution, a problem that has grown in importance in recent years, was not considered in this Eurobarometer, but was mentioned in this study.

Regarding invasive species, this threat was mentioned by two participants with formal training in Biology and one who pursued Electrical Engineering. This topic has gained importance in recent years, but the perception of its relevance seems to be influenced by an academic education in biological or environmental science (Cordeiro et al., 2020). This threat is considered the least relevant of those considered in the Special Eurobarometer Nº481 (European Commission, 2019).

According to the interviewees, human beliefs are also threats to biodiversity. It was stated by two interviewees that carelessness about biodiversity can greatly affect it. A study conducted by Earl et al. (2012) shows that although there is, in a broad and abstract sense, concern towards this issue, this may not happen on a more concrete and practical level; this may be related to political priorities and lack of motivation and to the difficulty in attributing biodiversity an economic value. Six interviewees considered that humans are selfish and that this way of thinking can lead to grave damage to biodiversity. Other studies, involving school students, have reported that there is a great concern on the carelessness and selfishness of humans, which can deeply affect biodiversity (Erdoğan et al., 2008; Kilinc et al., 2013). Lastly, *Discrimination against some animals* was also concerning to one respondent. This issue is something to pay attention to, as charismatic species tend to receive more public attention, which may bias conservation action (Clucas et al., 2008; Kim et al., 2014; S. Oliveira et al., 2020; Sitas et al., 2009). Additionally, this discrimination may also be due to the fear that populations have of some animals, such as the wolves and sharks (Pepin-Neff & Wynter, 2018; Torres & Fonseca, 2016).

### 4.4. Biodiversity loss effects

In what comes to biodiversity loss effects mentioned by the interviewees, future concerns emerged, such as a *Great impact on future generations* and the *Anticipation of human extinction.* These concerns are common in studies on future perceptions about the human species, but which are not specifically focused on biodiversity loss, and encompass a wide range of issues such as technological progress, natural disasters, and overpopulation (Randle & Eckersley, 2015; Tonn, 2009).

*Ecological imbalance* was one of the most highlighted biodiversity loss effects in this study. Other studies show that the functional importance of ecosystems and nature's balance are key concerns of the Portuguese population regarding the preservation of

biodiversity (Bernardo et al., 2021; Vieira da Silva et al., 2017). Vieira da Silva et al. (2017) suggest that this may be caused by an anthropocentric view on ecosystem services, or by increased scientific dissemination on ecosystem functioning and the repercussions of its degradation. Furthermore, the authors also noticed that the participants attributed importance to the commercial aspect of biodiversity. Similarly, the *Decrease of species of economic interest* was also something that was mentioned by the interviewees in this study. Plus, in the Special Eurobarometer Nº481 (European Commission, 2019) the Portuguese tended to totally agree with the statement "*Biodiversity is indispensable for the production of good such as food, materials and medicine".*

*Species extinction* was another frequently highlighted subcategory. Now, this is an interesting result, as it can be explained by an increment of knowledge on biodiversity: visitors seem to have integrated the genetic diversity component in their answers, which can be linked, for example, to the room *Genetic diversity vs Uncertainty,* where attention is called to the fact that a decrease in genetic diversity can limit a species' chance of survival. This can also be explained by an acquired knowledge on interspecies' dynamics and biotic interactions, which can lead to the perception that coextinction can be a cascading effect of a given species' extinction. This answer can also result from redundant thinking, having little knowledge of the subject, or even the possibility of having a blank while answering. These outcomes pave the way for further research to be conducted on this specific reaction and topic.

*Insect pests* could be included in the *Ecological imbalance* subcategory. However, this represents a specific example of ecological imbalance. These two categories were considered independently, as the *Ecological imbalance* category included answers that portrayed more abstract issues: the respondents often mentioned the need to maintain balance in nature or general topics about trophic interactions. Past research has shown that this is indeed a problematic issue related to biodiversity loss (Karp et al., 2013; Oliver et al., 2015; van Bael et al., 2008).

Regarding health, three topics were highlighted*: Reduction of solutions in disease treatments*, which can be a problem not only for humans but also for other species (as evidenced by the excerpt), *Public health issues*, and *Psychological impact*. These three subcategories were less mentioned by respondents. In the Special Eurobarometer Nº481 (European Commission, 2019), health is also mentioned by the Portuguese respondents,

with 72% totally agreeing that nature is crucial to our health and well-being. In addition, in two other studies conducted in Portugal, the participants emphasized the importance of biodiversity's medicinal potential for preserving health (Bernardo et al., 2021; Vieira da Silva et al., 2017). Furthermore, studies show that being in contact with nature has a positive impact on human health, including mental health (Houlden et al., 2018; Menardo et al., 2021).

Lastly, an interviewee mentioned, again from an abstract point of view, that the loss of biodiversity represents a *Collective impoverishment.* This category reflects the notion that humans are part of biodiversity, and therefore in connection with its various elements, and that because of this, losing one element of this intricate biological network can result in a loss for every party involved.

### 4.5. The importance of preserving biodiversity

All the interviewees, from different academic and professional backgrounds, highlighted the importance of preserving biodiversity. This vision is also shared by the questionnaire respondents, and it is reinforced by their disagreement with the statement that refers that there are species that are not worth preserving.

The reasons that came up from the interviews had to do with an ethical view on biodiversity preservation, its aesthetical component, its ability to provide services to humans, its relevance as a legacy for future generations, and the natural heritage it represents which must be preserved.

The most common reason for preserving biodiversity amongst the interviewees was because *It is ethical to do so,* meaning that biodiversity should be preserved regardless of how valuable it is to humans for its intrinsic value and uniqueness (Loreau, 2014; Mutia, 2009). For the questionnaire respondents in the experimental group, both before and after the visit, this was the second least relevant principle, but the most important to the control group. However, the visit to the Hall of Biodiversity significantly increased their tendency to agree that it is important to preserve biodiversity for its ethical character. According to the Special Eurobarometer Nº481 (European Commission, 2019) results, the Portuguese population attribute the greatest relevance to the criterion "*We have a responsibility to look after nature".*

Environmental ethics, which aims to develop ethical rules to guide our behaviour toward nature and biodiversity in particular, is founded on this perspective, and many conservation projects rely on this approach (W. B. Adams, 2004; Callicott, 1995; Rolston, 1988). However, Loreau (2014) argues that characterizing this perspective as 100% objective and rational is not correct, as ethics is a human construct, meaning that human subjectivity is considered when recognizing the intrinsic value of non-human entities. Plus, human ethics is driven by moral emotions, such as empathy, pride, shame and guilt and its study in global changes has grown (Swim & Bloodhart, 2015). In turn, rationality and emotion complement each other, as rationality acts as an organizer of emotions (Loreau, 2014). However, in Sumares & Fidélis (2009, p. 128), some Portuguese municipality employees argue that this type of valuing can be "*too academic, too detached from the harsh realities of actual planning, licensing and governance, and ultimately as too fundamentalist"*. Another perspective on the subject is that many human beings consider themselves superior to other species, something that goes against this argument (Singer, 2009).

The aesthetic principle was also mentioned by two interviewees. This was considered the least relevant criterion for the experimental group, both before and after the visit, and for the control group. The visit had a positive influence on the participants' perspectives regarding this principle, as the tendency for attributing more importance to it increased significantly. However, there may exist a certain dissonance for perceiving something in an abstract context comparing to a concrete context (Vieira da Silva et al., 2017). When asked to describe a curiosity that they learned during the visit, the third most relevant category was the *Aesthetic Principle,* with the diversity of eggs being consistently mentioned; this was also the most frequently mentioned principle. However, we cannot be certain that just because the respondents found the fact that there is a great diversity of eggs more interesting, they attribute greater importance to aesthetics than to any other principle. What we can assume is that it positively influenced their perception on this type of valuing. In their study, Vieira da Silva (2017) showed that the aesthetic criterion for valuing biodiversity was the least important and perceived as futile in an abstract context, when the participants were asked directly which criteria they found most relevant towards biodiversity conservation. However, when framed within a practical context, this criterion gained relevance; it was demonstrated that the participants' willingness to pay for the conservation of species was higher considering the most attractive species.

The aesthetic value of a species might affect empathy (Serpell, 2004; Tisdell, 2014) and this could have a positive effect on attitudes towards biodiversity (Yue et al., 2021). In fact, being in favour of biodiversity conservation while having its aesthetic value in mind does seem, at first glance, futile. Nevertheless, if we think about how nature's beauty makes us feel, this principle does not seem as futile as previously though. Recreational interests like bird watching, nature hiking, or simply being in touch with nature, makes us feel good, positively influencing our immaterial wellbeing (Mutia, 2009). These activities integrate an array of existing cultural ecosystem services, and as such they have utility and worth for the human-being, even though they are often undervalued in politics, and decision-making (Hirons et al., 2016).

Two interviewees stressed the utilitarian value of biodiversity, i.e. a perspective based on the needs of human beings (Mutia, 2009). For the experimental group, both before and after the visit, the scientific and economic principles represented the two most relevant types of reasons for preserving biodiversity, but in the control group participants stood between the ethical and the aesthetic values. Even though there were significant differences in the perceived relevance of the scientific principle between the pre-test and the control group, the tendency to agree with this type of valuation increased even further after the visit.

The utilitarian vision of biodiversity has shifted from a traditional economic perspective, based merely on economic growth, to one supported on ecosystem services and sustainable resource management (Loreau, 2014; Millennium Ecosystem Assessment, 2005). Nevertheless, Loreau (2014) claims that treating biodiversity exclusively as a provider of goods might be risky since economic considerations sometimes take precedence over efforts to conserve biodiversity. The Special Eurobarometer Nº481 (European Commission, 2019) results suggest the Portuguese population attributes great importance to preserving biodiversity for provisioning services, such as food, medicine, materials, and to the economic growth.

The categories *For the sake of future continuity* and *It is heritage* can integrate non-utilitarian and utilitarian perspectives, as material and immaterial biodiversity heritage are both essential to future generations.

### 4.6. What can be done to preserve biodiversity?

Although a survey of measures for the preservation of biodiversity was not carried out using the questionnaire, most respondents revealed a willingness to act against the negative impacts that humans have on the natural world, as they tended to agree that these must be minimized and that humans have a responsibility to act towards biodiversity preservation.

This topic was the one that fostered the greatest number of examples among the interviewees. The suggestions presented by these respondents focused on both awareness-raising and practical initiatives. Measures have emerged regarding the political, social, and economic spheres, which can be conducted individually and collectively.

The most frequently highlighted category was *Waste sorting and recycling*, which is not surprising since, from an early age, this theme has been ingrained in the Portuguese population, because it is increasingly integrated both into the school curriculum and in awareness-raising campaigns through other means (Padrão, 2015). In fact, a report published in 2019 shows that most Portuguese citizens tend to recicle (87,7) (Novo Verde, 2019). However, the recycling rate of municipal waste in Portugal in 2019 and 2020 does not match those findings, as it is much lower than expected (28,9% and 26,5%, respectively) (European Commission, 2022).

Some of the actions that the interviewees proposed affect directly the impacts caused by human hand, as for instance *nipping the evil in the bud* to mitigate it. (e.g., *Stop animal slaughtering, Stop deforestation, Decrease pollution*). In turn, transitory measures of behaviour, whether individual or collective, were also suggested, such as *Sustainable water use*, adopting a *Sustainable nutrition, Planting native species, Increase awareness* on the subject, and *Being less consumerist.* Additionally, the importance of educating citizens was emphasized, whether through formal education, with schools playing an active role, or informal education, through the preservation of *Museums addressing the theme*. The latter represents an ex-situ conservation measure (Mutia, 2009).

Measures such as *Waste sorting and recycling, Increase awareness*, participating in restoration activities *(e.g., Planting native species),* and *Sustainable water usage* were also highlighted in another study conducted in Portugal (S. Oliveira et al., 2020).

Systemic measures were also subject to scrutiny by the respondents. One interviewee explained that an economic valuation of biodiversity should be carried out. The economic valuation of biodiversity through its ecosystem services is already something that is ongoing, following a more utilitarian perspective, which could positively impact biodiversity conservation; this type of valuation considers both the economic benefits of ecosystem services and the harm caused by their degradation (Laurans et al., 2013). Three interviewees emphasized political action, which was also noted in three studies involving students in higher education in Portugal (Aleixo et al., 2021; Morgado et al., 2017; Vargas-Callejas et al., 2018). Furthermore, Morgado et al. (2017) showed that Portuguese university students place greater responsibility for environmental protection on governments than on the individual citizen.

It is important to note that all the actions suggested demonstrate a previous awareness of this issue, indicating that there is a knowledge about environmental issues. Three respondents demonstrated that they do not know what can be done but would like to be instructed. The Special Eurobarometer Nº481 (European Commission, 2019) showed that 3% of Portuguese people do not know what to do to protect biodiversity.

According to the Special Eurobarometer Nº481 (European Commission, 2019), the Portuguese population attributes the greatest importance to "*better inform citizens about the importance of biodiversity",* followed by "*better implement existing nature and biodiversity conservation rules"*, "*restore nature and biodiversity to compensate for damage caused by human activities of infrastructure outside protected areas",* and by "*strengthen existing nature and biodiversity conservation rules".* Although general awareness and conservation measures were suggested, only one interviewee suggested a restoration measure, which in turn also represents a conservation measure: *Planting native species.* In turn, the interviewees did not address any measures about protected areas or promoting research into the topic.

### 4.7. Gender, district, and frequency of visit comparisons

Gender differences on perceptions regarding environmental topics have been largely reported in the literature (Arcury, 1990; García-Vinuesa et al., 2020).

In this study, differences between male and female questionnaire participants were found regarding one knowledge-related topic, and three attitude-related topics.

Concerning knowledge, when asked to describe the meaning of *Anthropocene,* male participants tended to score higher than female participants, both before and after the visit, which is in line with other studies concerning gender differences on knowledge about scientific topics (Diamantopoulos et al., 2003; Fisher et al., 2020; García-Vinuesa et al., 2020).

However, regarding the attitudinal dimension, studies show that women typically have deeper concerns and are more sensitive towards environmental issues, and are keener on environmental risk perception (Aleixo et al., 2021; Chaplin & Wyton, 2014; García-Vinuesa et al., 2020; Mohai, 1997). In the present study, female participants had a greater propensity to agree more with preserving biodiversity for its aesthetic component, in the control group and the pre-test. This trend was reversed after the visit, although not significantly. Similarly, before the visit, female participants were more eager to agree that humans have a responsibility to preserve biodiversity, something that was balanced after the visit. Although not significant, these trend reversals can suggest that visiting the Hall of Biodiversity's permanent exhibition may have a different impact according to the visitor's gender.

Concerning the interviews, and particularly the *What can be done to preserve biodiversity* topic, although a quantitative analysis was not carried out, most of the participants who mentioned awareness and education measures were male. These data contradict what is reported in the literature, about women typically supporting education and awareness measures more strongly than men (Boyes et al., 2009; Daniel et al., 2004). In turn, women tended to recommend more proactive actions than males, which may also reflect that female participants were more willing to take action. Other studies have also discussed that women are usually more engaged in environmental projects (Diamantopoulos et al., 2003; García-Vinuesa et al., 2020).

Regarding the district comparisons for the questionnaire results, most of the registered differences were reported in the pre-test, meaning that these differences are not related with the visit, but could be related to the environmental awareness initiatives carried out in the participant schools and districts. The differences in the control groups could also be related to this, since this group was composed of just one high school class from Porto. The only topic that had a significant variation in the post-test concerns the preservation of biodiversity considering an aesthetic perspective, that stronger influenced the Braga group. This could have been due to the fact that the visits were conducted by different guides, even

within the Aveiro group and within the Braga group, since each school was separated in subgroups, for logistic purposes. As stated previously, visits are personalized according to the group's motivations and interests, so it is possible that within the Braga group greater attention and debate arose around the aesthetic principle.

Finally, in what comes to comparisons based on whether or not the participants were visiting the Hall of Biodiversity for the first time, the size of the group of students that had previously visited is quite small, compared to those who were visiting for the first time. Therefore, the significant differences reported are negligible.

### 4.8. Exhibition rooms and collections that have a memorable impact

There were several instances in which the participants mentioned aspects of the exhibition. In addition to mentioning general reasons for which the Hall of Biodiversity increased its understanding of *Biodiversity*, the interviewees also highlighted some sections of the exhibition. The section related to the preservation of biodiversity was the most prevalent in the first category tree, but *Diversity of Colours, Diversity of Shapes, Diversity of Sizes, Artificial Selection, Human Diversity, Speciation and Theatre of Senses* were also mentioned. These sections allowed the visitor to get in touch with different types of evidence of biological diversity, expanding their interpretation of the concept. In turn, curiosities from various sections of the exhibition were shared in question A2 of the post-test questionnaire, with a main emphasis on the *Theatre of Senses, Diversity of Sizes* and *Aesthetic Principle.* In fact, when questioned about their expectations for the exhibition, it was reasonable for the experimental and control groups to anticipate broad categories and ideas like *Biodiversity, Species diversity,* and *Living beings' diversity,* and others that meet what is expected in Natural History and science museums (e.g., *Fossil, Extinction, Knowledge, Research, Photographs*) (Allmon, 1994; MacFadden et al., 2007; Melber & Abraham, 2002). This question makes students think about more general ideas related to the name of the place to visit because, as previously discussed, students do not have a strong understanding of *Biodiversity*. Yet, after the visit, in addition to the significant predominance of terms related to the sections mentioned above, such as *Heartbeat, Body size, Eggs and Eyesight,* notions such as *Diversity* and *Species* remained dominant. It is also interesting that *Animals* and *Mammals* have a significant variation between pre- and post-test, which may indicate a greater affinity of these students with these living beings (Carr, 2016; Woods, 2000). Furthermore, the significant variation in the use of *Preservation* between the control

and the experimental group in the post-test is curious. Perhaps because the questionnaire included several questions on this topic, it may have biased the expectations of the students in the control group. Plus, although this room is frequently mentioned (both overall and subdivided into its principles) in question A2, the curiosities mentioned by the students were presented in various ways, as is the case of using the term *Eggs*, when referring to the aesthetic principle.

In addition to the sections of the exhibition that were mentioned by the interviewees, the curatorship of the collections was also referred in what comes to human-nature interactions discussed in the point *The concept Anthropocene*. In the latter case, the conservation of the blue whale skeleton and the taxidermies present in the *Sexual Selection* room were highlighted. The interview excerpt referring to the taxidermy case concerns the empathy one could manifest towards another entity. What happens, in this case, is the anthropomorphism of these animals (now taxidermies), a propensity to attribute human traits and feelings to non-human beings, entities, or objects (Epley et al., 2007; Gray et al., 2007). Conservation-oriented anthropomorphism has received criticism from several authors, whether for focusing more on charismatic species, or on individuals rather than on populations, or even because emotion would have too much power in that matter (Griffin et al., 2020; Hayward et al., 2019; Johnson et al., 2019). Yet, studies indicate that this process increases empathy, and this can be relevant to pro-environmental behaviors and wildlife conservation (Batt & Davies, 2009; Chan, 2012; Tam et al., 2013; Yue et al., 2021). Two students also mentioned taxidermies in the questionnaires. This case of empathy may also be explored in *Diversity of Sizes* and *Theater of Senses*, highlighted in the interviews and, with a stronger emphasis, in the questionnaires. These two rooms have interactive modules that allow the visitor to perceive the world from another being's point of view. This process is called perspective-taking, which can contribute to develop empathy (Batson et al., 1997; Galinsky et al., 2008), therefore promoting positive attitudes toward biodiversity (Sevillano et al., 2007; Swim & Bloodhart, 2015).

### 4.9. Visiting the Hall of Biodiversity: an interactive, recollective and shared experience

Feedback from participants regarding the visit to the Hall of Biodiversity focused on various aspects of the experience.

Interviewees of all age groups mentioned that interactivity is a crucial aspect of the permanent exhibition. Despite the low representation of some age groups in this study, it is interesting how this component was transversal to all covered in the interviews. Studies report that interactive experiences, particularly concerning digital modules, are more attractive to younger audiences (Ch'ng et al., 2019). Additionally, in the present study, the hands-on experiences positively impacted the experience of these visitors, both for their playful and educational aspects, which is in line with what has been stated by other authors (D. Anderson & Lucas, 1997; Caulton, 2002; Falk & Dierking, 2000; Heath & vom Lehn, 2008). However, further studies must be developed under this subject, as some authors claim that a museum which offers hands-on exhibitions does not necessarily foster and enhanced understanding of a particular subject (Haywood & Cairns, 2006; Hughes, 2007).

Regarding the possibility of a shared experience enhancing knowledge assimilation, whether it be with a friend or with the museum's guide, the fact is that interacting with someone could greatly influence one's experience in museums (Ash, 2004; Bamberger & Tal, 2008b; Shaby et al., 2019b). Furthermore, museum guides and explainers have a key role in raising awareness, in facilitating one's comprehension on a certain subject, and in enhancing a visitor's engagement with the exhibition (Anđelković et al., 2022; Bajrami et al., 2022; Shaby et al., 2019c). In this case, the visitors viewed the guide's performance as something positive and enjoyable, mentioning that it had a positive impact on improving their understanding of *Biodiversity.* These results are in line with Wagensberg (2005) conceptualization of a museum's success in terms of generated conversation.

The fact that the visit allows remembering previously acquired knowledge was mentioned by some interviewees and questionnaire respondents. Studies show that previous experiences and knowledge can influence how visitors interpret an object in display or a concept addressed (D. Anderson et al., 2000; Bamberger & Tal, 2008b). However, this influence is not necessarily positive, as it may lead to misunderstandings of the phenomenon observed (Hauan & Kolstø, 2014; Henriksen & Jorde, 2001), therefore needing further research to be conducted. As they have had previous contact with some of the content covered in the exhibition, there may be a tendency to trigger debate among visitors, which may enrich the visitor's experience, as previously mentioned (Gilbert & Priest, 1997).

According to the interviewees and the majority of the students, the visit to the Hall of Biodiversity contributed positively to their personal growth, promoting, for some, a desire to return. Whether it was within the scope of a field trip, because they were led by their children, or simply because they were curious about it, it proved to be an enriching experience. The uptake of new knowledge by visiting the permanent exhibition represents a suitable learning method and increases awareness of the topic. As it represents a good experience at the didactic and recreational level, it is necessary to place more effort in advertising these informal education institutions in a significant manner amongst the general audience.

## 5. CONCLUSION, LIMITATIONS AND FUTURE RESEARCH

The present study integrates the few research that exists on perceptions regarding the Anthropocene, focusing on the impacts on biodiversity. The interviews lead to reflections on the role of human beings and what actions and beliefs impact the environment and biodiversity in particular, the consequences of these actions, the importance of preserving biodiversity and how we can contribute to preserving the natural world. The questionnaires allowed an analysis of the knowledge and attitudes regarding the Anthropocene and biodiversity, supported by reports of a new generation increasingly interested in the fight for environmental justice (McKay, 2010). The impact of visiting the Hall of Biodiversity's permanent exhibition in the participants' perceptions was analyzed in both methodological components.

The concept *Anthropocene* emerged to contextualize a changing world catalytically powered by human action. Since its definition as a geological time unit has not yet been officialized, its dissemination and, in turn, understanding is still unsurprisingly low among the participants in this study. Although knowledge about the meaning of *Anthropocene* is low, the fact is that participants recognized that humans have been and are acting as transformer of a multitude of situations in the natural world and that it is essential to preserve this natural heritage. However, as stated by one interviewee, the human-nature interaction is not always negative as it can also lead to harmonies. Plus, recognizing that human beings are part of our planet's biodiversity can be essential to eliminate the human-nature divide that endures in Western societies and that enhances many of the undue exploitations of biodiversity and nature, in general (Dickinson, 2016; Vining et al., 2008).

The role of affective engagement was highlighted, especially through the empathy provoked by some features of the exhibition. The truth is that not only is knowledge one of the variables to consider when building more favourable attitudes towards environmental issues, but emotions also play a role in this relationship, something that could be fundamental for the structuring of environmental education programs (Pooley & O'Connor, 2000).

Something that was observed in other studies and also evidenced in this one is that there may be a dissonance of perceptions, when applied to an abstract context or to a concrete context, or when discussing self-reported knowledge compared to objective assessment. For future studies, it will be interesting to develop methodologies that allow us to understand whether this dissonance is, in fact, significant and understand the reasons behind it.

Gender differences in perceptions were also reported in this study, which go in line with studies that describe more favourable attitudes by women concerning environmental issues. However, the visit to the Hall of Biodiversity could have a different impact depending on the person's gender. Further and more inclusive research should be conducted to fully assess this dimension.

One of the limitations of this study was the size of the samples, both in the questionnaires and in the interviews. In fact, some of the unexpected results may be due to the asymmetries between the size of the experimental group and the control group. Additionally, the control group is quite small, consisting only of a class from a school in Porto. Furthermore, there is a low representation of both age groups and education levels in the interviews, as well as gender in both methodologies applied. In addition, it would be interesting to include the perceptions of students from other fields of study, such as Economics, or Arts, but this was not possible since, during the questionnaire's application time frame, most of the visiting high school classes were from the Science and Technology field. Another limitation has to do with logistical issues in the application of the questionnaires, since there were some constraints related to the time spent filling them in, that was included in the total duration of the visit. As such, it was not possible to make a broader analysis of biodiversity loss effects, human impacts, and measures to preserve biodiversity, as was the case of the interviews. Plus, the context in which the study was carried out prevents a generalization of the perceptions analyzed for the Portuguese public,

since it is not an exclusively random sample (Coelho et al., 2016), and, therefore, depended on visiting the Hall of Biodiversity. In addition, this study represents a short-term analysis, requiring further longitudinal research to fully understand its impact on people's perceptions. Regarding the interviews, there was an interviewer bias in the delineation of the interview script. Unlike the *Anthropocene* concept, respondents were not asked to define the meaning of *Biodiversity* because it was assumed *a priori* that most of the public would already be familiar with it, even in a simplified way.

Nevertheless, the role of the Hall of Biodiversity's permanent exhibition was highlighted by its extensive collection, the creative and practical ways of transmitting to the public how biological diversity can manifest, its solid interactive component, how it allows efficient assimilation of knowledge with which the visitor may have had contact in the past, and how it allows for debate and exchange of ideas. These findings consolidate the importance of museums for shaping people's perceptions, for contributing to their personal growth and for the development of a more aware and active society involved in making a positive change concerning environmental issues.

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# APPENDICES

## **Appendix A –** Pre-test questionnaire applied to the experimental group.

Questionário Pré-Visita

Descrição do estudo:

O presente estudo pretende analisar o impacto da visita à exposição permanente da Galeria da Biodiversidade – Centro Ciência Viva do Museu de História Natural e da Ciência da Universidade do Porto nas perceções sobre o Antropocénico.

Neste contexto, ser-lhe-á pedido que responda, individualmente, a um questionário antes e após a sua visita. O tempo estimado de resposta a cada questionário é de 5 minutos.

Perfil do visitante

Idade: ____

Género: Feminino: ___ Masculino___ Outro: ___ Prefiro não responder: ___

Distrito: _____

Nível de escolaridade: _____

Área de estudos/profissional: _____

É a primeira vez que visita a Galeria da Biodiversidade?

Sim: ____ Não:____

Se a resposta foi "Não":

1) Há quanto tempo foi a sua última visita?

Menos de 6 meses___ 6 meses a um ano___ Mais de um ano___

2) Quantas vezes visitou a Galeria da Biodiversidade (excluindo esta visita)?

Uma vez___ Duas vezes___ Três ou mais vezes___

Parte 1 – Análise de conhecimentos

C1) Selecione com um X a opção que melhor se adequa:

a) Já ouvi falar do termo "biodiversidade" e sei o que significa ___
b) Já ouvi falar do termo "biodiversidade", mas não sei o que significa ___
c) Nunca ouvi falar do termo "biodiversidade" ___

C2) Se selecionou as opções a) ou b), indique-nos o que é para si "biodiversidade".

_____

_____

C3) Selecione com um X a opção que melhor se adequa:

a) Já ouvi falar do termo "Antropocénico" e sei o que significa ___
b) Já ouvi falar do termo "Antropocénico", mas não sei o que significa ___
c) Nunca ouvi falar do termo "Antropocénico" ___

C4) Se selecionou as opções a) ou b), indique-nos o que é para si "Antropocénico".

_____

_____

C5) Selecione com um X a opção que melhor se adequa:

a) A manipulação genética de alimentos, com a vantagem do aumento e rapidez da sua produção, pode ter como consequência a diminuição da sua diversidade genética*.
   Concordo:___ Discordo:___ Não sei:___
b) A diminuição da diversidade genética pode levar à extinção de uma espécie.
   Concordo:___ Discordo:___ Não sei:___
c) Atividades humanas, como a indústria, podem influenciar a evolução de uma espécie.
   Concordo:___ Discordo:___ Não sei:___
d) Atividades humanas, como a indústria, podem levar à extinção de uma espécie.
   Concordo:___ Discordo:___ Não sei:___
e) O ser humano faz parte da biodiversidade do planeta Terra.
   Concordo:___ Discordo:___ Não sei:___

* Todos os seres vivos têm na sua constituição genes responsáveis, em grande parte, pelas diferentes características que os compõem. Diversidade genética é utilizada para definir toda a variação que existe ao nível do conjunto de genes presentes num grupo (espécie, raça ou população).

Parte 2 – Análise de atitudes

A1) Selecione com um X a opção que melhor se adequa:

| | Concordo totalmente | Concordo | Indiferente | Discordo | Discordo totalmente | Não sei |
|---|---|---|---|---|---|---|
| a) É importante preservar a biodiversidade. | | | | | | |
| b) A biodiversidade deve ser preservada porque é bela. | | | | | | |
| c)A biodiversidade deve ser preservada porque existe. | | | | | | |
| d)A biodiversidade deve ser preservada porque fornece ao ser humano recursos (por exemplo, alimentos). | | | | | | |
| e)A biodiversidade deve ser preservada porque permite o avanço científico (por exemplo, medicamentos). | | | | | | |

| | Concordo totalmente | Concordo | Indiferente | Discordo | Discordo totalmente | Não sei |
|---|---|---|---|---|---|---|
| f)Existem espécies que não valem a pena preservar. | | | | | | |
| g) O ser humano é um agente transformador da natureza. | | | | | | |
| h) O impacto negativo que o ser humano tem na natureza deve ser minimizado. | | | | | | |
| i) O ser humano executa ações que comprometem a biodiversidade. | | | | | | |
| j) O ser humano tem a responsabilidade de preservar a biodiversidade. | | | | | | |
| k) Preservar a biodiversidade implica preservar a espécie humana. | | | | | | |
| l) No passado, a visão centrada no ser humano levou a uma exploração indevida da biodiversidade. | | | | | | |

A2) O que espera encontrar na visita à exposição permanente da Galeria da Biodiversidade?

_____
_____
_____
_____

Comentários:

_____
_____
_____
_____
_____

**Appendix B –** Post-test questionnaire applied to the experimental group.

Questionário Pós-Visita

Parte 1 – Análise de conhecimentos

C1) Selecione com um X a opção que melhor se adequa:

a) Já ouvi falar do termo "biodiversidade" e sei o que significa ___
b) Já ouvi falar do termo "biodiversidade", mas não sei o que significa ___
c) Nunca ouvi falar do termo "biodiversidade" ___

C2) Se selecionou as opções a) ou b), indique-nos o que entende por "biodiversidade"?

_____

_____

_____

C3) Selecione com um X a opção que melhor se adequa:

a) Já ouvi falar do termo "Antropocénico" e sei o que significa ___
b) Já ouvi falar do termo "Antropocénico", mas não sei o que significa ___
c) Nunca ouvi falar do termo "Antropocénico" ___

C4) Se selecionou as opções a) ou b), indique-nos o que entende por "Antropocénico".

_____

_____

C5) Selecione com um X a opção que melhor se adequa:

a) A manipulação genética de alimentos com a vantagem do aumento e rapidez da sua produção, pode ter como consequência a diminuição da sua diversidade genética*.
   Concordo:___ Discordo:___ Não sei:___
b) A diminuição da diversidade genética pode levar à extinção de uma espécie.
   Concordo:___ Discordo:___ Não sei:___
c) Atividades humanas, como a indústria, podem influenciar a evolução de uma espécie.
   Concordo:___ Discordo:___ Não sei:___
d) Atividades humanas, como a indústria, podem levar à extinção de uma espécie.
   Concordo:___ Discordo:___ Não sei:___
e) O ser humano faz parte da biodiversidade do planeta Terra.
   Concordo:___ Discordo:___ Não sei:___

* Todos os seres vivos têm na sua constituição genes responsáveis, em grande parte, pelas diferentes características que o compõem. Diversidade genética é utilizada para definir toda a variação que existe ao nível do conjunto de genes presentes num grupo (espécie, raça ou população).

Parte 2 – Análise de atitudes

A1) Selecione com um X a opção que melhor se adequa:

| | Concordo totalmente | Concordo | Indiferente | Discordo | Discordo totalmente | Não sei |
|---|---|---|---|---|---|---|
| a) É importante preservar a biodiversidade. | | | | | | |
| b) A biodiversidade deve ser preservada porque é bela. | | | | | | |
| c) A biodiversidade deve ser preservada porque existe. | | | | | | |
| d) A biodiversidade deve ser preservada porque fornece ao ser humano recursos (por exemplo, alimentos). | | | | | | |

| | Concordo totalmente | Concordo | Indiferente | Discordo | Discordo totalmente | Não sei |
|---|---|---|---|---|---|---|
| e) A biodiversidade deve ser preservada porque permite o avanço científico (por exemplo, medicamentos). | | | | | | |
| f) Existem espécies que não vale a pena preservar. | | | | | | |
| g) O ser humano é um agente transformador da natureza. | | | | | | |
| h) O impacto negativo que o ser humano tem na natureza deve ser minimizado. | | | | | | |
| i) O ser humano executa ações que comprometem a biodiversidade. | | | | | | |
| j) O ser humano tem a responsabilidade de preservar a biodiversidade. | | | | | | |

| | Concordo totalmente | Concordo | Indiferente | Discordo | Discordo totalmente | Não sei |
|---|---|---|---|---|---|---|
| k) Preservar a biodiversidade implica preservar a espécie humana. | | | | | | |
| l) No passado, a visão centrada no ser humano levou a uma exploração indevida da biodiversidade. | | | | | | |
| m) A visita à Galeria da Biodiversidade contribuiu para o meu desenvolvimento pessoal. | | | | | | |

A2) O que ficou a saber durante a visita à exposição permanente da Galeria da Biodiversidade (um conceito novo, algo que o possa ter surpreendido,...) ?

_____

_____

_____

Comentários:

_____

_____

_____

_____

_____

**Appendix C –** Question C2 and Question C4 scoring rubrics.

**C2 –** ***If you selected options a) or b), tell us what Biodiversity means to you.***

**12 points** – Biodiversity refers to the diversity of life at all levels of biological organization, and can be categorized into genetic diversity (e.g., between individuals, or populations of the same species), species diversity (between different species), ecosystems diversity, encompassing evolutionary and ecological processes that sustain life.

**10 points** – Mentions the diversity of life at two levels (e.g., genetic and species diversity) AND mentions the concept of interaction between living beings.

**8 points** – Mentions the diversity of life at two levels (e.g., genetic and species diversity) OR mentions the concept of interaction between living beings.

**6 points** – Diversity of living beings, or diversity of life, or diversity in the biosphere.

**4 points** – Diversity of species.

**2 points** – Diversity of plants and animals.

**C4 –** ***If you selected options a) or b), tell us what Anthropocene means to you.***

**10 points** - It is, unofficially, the most recent epoch in Earth's history, that belongs to the Cenozoic, marked by the significant impact of human beings on the natural world.

**8 points** – It is an epoch of Earth's history, marked by the significant impact of human beings on the natural world

**6 points** - It is an epoch of Earth's history marked by the emergence of the human being, or the beginning of human activity, or where the human predominates

**4 points** – Most recent epoch in Earth's history OR It belongs to the Cenozoic Era OR Unit of geological time that the scientific community wants to formalize.

**2 points** – It is an epoch of Earth's history OR a time of history

**1 point** - It has to do with environmental changes enhanced by the human being OR something that has to do with human action OR the world affected by human action

**0 points** - *I don't remember its meaning* OR *I don't know* OR wrong meaning.

Note: Answers where the wrong geological unit of time is used instead of *epoch*, such as *period*, were accounted for and evaluated according to the scoring rubric. The

quantification of the used notions, such as the geological units of time, can be found in Appendix M.

**Appendix D –** Consent form for the experimental group, according to the EU General Data Protection Regulation (2016).

**TERMO DE CONSENTIMENTO LIVRE E ESCLARECIDO**

Caro/a Senhor/a,

O meu nome é Ana Carolina Vieira de Sousa. Sou estudante do mestrado em Biologia Aplicada na Universidade de Aveiro e estou a fazer um estudo sobre o impacto da exposição permanente da Galeria da Biodiversidade – Centro Ciência Viva | Museu de História Natural e da Ciência da Universidade do Porto nas perceções dos visitantes relativas ao Antropocénico. Desta forma, irei analisar as perceções, conhecimentos e atitudes dos visitantes em relação a esta temática.

Para a realização da pesquisa gostaria de aplicar dois questionários ao seu educando, com perguntas relacionadas à interação ser humano-natureza, revolvendo em torno da Biodiversidade, antes e após a visita. Se se sentir à vontade para o seu educando colaborar com esta pesquisa irei, então, aplicar os dois questionários em questão.

Os consentimentos assinados serão guardados na Galeria da Biodiversidade e apenas as respostas ao questionários, que não contêm qualquer elemento identificativo dos participantes, serão recolhidas por mim para utilizar no estudo. Se a meio do preenchimento de um dos questionários o seu educando desistir de colaborar neste estudo não será prejudicado de forma alguma. Após a visita, poderá não ser possível desistir do estudo e/ou pedir para eliminar os dados, uma vez que não haverá uma forma de identificar as respostas dadas por cada participante.

A opinião do seu educando será muito importante para o nosso estudo, pois os dados coletados nos questionários contribuirão para o aumento do conhecimento sobre o potencial educativo deste equipamento cultural, dentro da temática do Antropocénico. As informações coletadas irão fazer parte de um trabalho que poderá ser publicado em revistas científicas, além de serem utlizadas na tese de mestrado para ser entregue na Universidade de Aveiro. Em qualquer dos casos, nunca será publicada informação sobre a identidade dos participantes. O prazo de conservação dos dados recolhidos e dos consentimentos assinados será de dois anos.

Caso o/a senhor/a concorde com a participação do seu educando no preenchimento dos questionários, peço que assine o termo de consentimento abaixo e o entregue ao seu educando para trazer no dia da visita à Galeria da Biodiversidade. Caso não concorde com a participação do seu educando, não precisa de assinar e devolver o documento, A sua decisão será respeitada e não implicará qualquer consequência para si ou para o seu educando.

Em caso de dúvida, por favor contacte-me. Desde já agradeço a sua colaboração. O meu endereço de trabalho localiza-se na Universidade de Aveiro, Departamento de Biologia, Universidade de Aveiro, Campus Universitário de Santiago, 3810-193 Aveiro, Portugal, Telefone:(+351)935074938, E-mail: anacarolinavieirasousa8@ua.pt

**Consentimento**

Eu, abaixo assinado, _____ (nome do EE), Encarregado de Educação de _____ (nome do educando), compreendi a informação que me foi fornecida sobre o estudo que está a ser realizado na Galeria da Biodiversidade – Centro Ciência Viva | Museu de História Natural e da Ciência da Universidade do Porto, pela estudante Ana Carolina Vieira de Sousa, no âmbito da sua dissertação de mestrado em Biologia Aplicada na Universidade de Aveiro, e para o qual é pedida a participação do meu educando.

Sei que poderá desistir do estudo a qualquer momento, sem ter que dar justificações e sem que isso possa trazer-lhe quaisquer consequências.

Nestas circunstâncias,

☐ aceito que o meu educando participe neste estudo, tal como descrito na informação acima.

_____
Assinatura do encarregado de educação

_____, ____ / ____ / ____.
Local dia mês ano

## **Appendix E –** Questionnaire applied to the control group.

Questionário

Descrição do estudo:

O presente estudo pretende analisar o impacto da visita à exposição permanente da Galeria da Biodiversidade – Centro Ciência Viva do Museu de História Natural e da Ciência da Universidade do Porto nas perceções sobre o Antropocénico.

Neste contexto, ser-lhe-á pedido que responda, individualmente, a um questionário antes e após a sua visita. O tempo estimado de resposta a cada questionário é de 5 minutos.

Perfil do visitante

Idade: ____

Género: Feminino: ___ Masculino___ Outro: ___ Prefiro não responder: ___

Distrito: _____

Nível de escolaridade: _____

Área de estudos/profissional: _____

É a primeira vez que visita a Galeria da Biodiversidade?

Sim: ____ Não:____

Se a resposta foi "Não":

1) Há quanto tempo foi a sua última visita?

Menos de 6 meses___ 6 meses a um ano___ Mais de um ano___

2) Quantas vezes visitou a Galeria da Biodiversidade (excluindo esta visita)?

Uma vez___ Duas vezes___ Três ou mais vezes___

Parte 1 – Análise de conhecimentos

C1) Selecione com um X a opção que melhor se adequa:

a) Já ouvi falar do termo "biodiversidade" e sei o que significa ___
b) Já ouvi falar do termo "biodiversidade", mas não sei o que significa ___
c) Nunca ouvi falar do termo "biodiversidade" ___

C2) Se selecionou as opções a) ou b), indique-nos o que é para si "biodiversidade".

_____

_____

_____

C3) Selecione com um X a opção que melhor se adequa:

a) Já ouvi falar do termo "Antropocénico" e sei o que significa ___
b) Já ouvi falar do termo "Antropocénico", mas não sei o que significa ___
c) Nunca ouvi falar do termo "Antropocénico" ___

C4) Se selecionou as opções a) ou b), indique-nos o que é para si "Antropocénico".

_____

_____

_____

C5) Selecione com um X a opção que melhor se adequa:

a) A manipulação genética de alimentos, com a vantagem do aumento e rapidez da sua produção, pode ter como consequência a diminuição da sua diversidade genética*.
   Concordo:___ Discordo:___ Não sei:___
b) A diminuição da diversidade genética pode levar à extinção de uma espécie.
   Concordo:___ Discordo:___ Não sei:___
c) Atividades humanas, como a indústria, podem influenciar a evolução de uma espécie.
   Concordo:___ Discordo:___ Não sei:___
d) Atividades humanas, como a indústria, podem levar à extinção de uma espécie.
   Concordo:___ Discordo:___ Não sei:___
e) O ser humano faz parte da biodiversidade do planeta Terra.
   Concordo:___ Discordo:___ Não sei:___

* Todos os seres vivos têm na sua constituição genes responsáveis, em grande parte, pelas diferentes características que os compõem. Diversidade genética é utilizada para definir toda a variação que existe ao nível do conjunto de genes presentes num grupo (espécie, raça ou população).

Parte 2 – Análise de atitudes

A1) Selecione com um X a opção que melhor se adequa:

| | Concordo totalmente | Concordo | Indiferente | Discordo | Discordo totalmente | Não sei |
|---|---|---|---|---|---|---|
| a) É importante preservar a biodiversidade. | | | | | | |
| b) A biodiversidade deve ser preservada porque é bela. | | | | | | |
| c) A biodiversidade deve ser preservada porque existe. | | | | | | |
| d) A biodiversidade deve ser preservada porque fornece ao ser humano recursos (por exemplo, alimentos). | | | | | | |
| e) A biodiversidade deve ser preservada porque permite o avanço científico (por exemplo, medicamentos). | | | | | | |

| | Concordo totalmente | Concordo | Indiferente | Discordo | Discordo totalmente | Não sei |
|---|---|---|---|---|---|---|
| c) A biodiversidade deve ser preservada porque existe. | | | | | | |
| d) A biodiversidade deve ser preservada porque fornece ao ser humano recursos (por exemplo, alimentos). | | | | | | |
| e) A biodiversidade deve ser preservada porque permite o avanço científico (por exemplo, medicamentos). | | | | | | |
| f) Existem espécies que não valem a pena preservar. | | | | | | |
| g) O ser humano é um agente transformador da natureza. | | | | | | |

| | Concordo totalmente | Concordo | Indiferente | Discordo | Discordo totalmente | Não sei |
|---|---|---|---|---|---|---|
| h) O impacto negativo que o ser humano tem na natureza deve ser minimizado. | | | | | | |
| i) O ser humano executa ações que comprometem a biodiversidade. | | | | | | |
| j) O ser humano tem a responsabilidade de preservar a biodiversidade. | | | | | | |
| k) Preservar a biodiversidade implica preservar a espécie humana. | | | | | | |
| l) No passado, a visão centrada no ser humano levou a uma exploração indevida da biodiversidade. | | | | | | |

A2) Se algum dia visitar a Galeria da Biodiversidade, o que espera encontrar?

_____

_____

_____

Comentários:

_____

_____

_____

_____

_____

**Appendix F –** Consent form for the control group, according to the EU General Data Protection Regulation (2016).

**TERMO DE CONSENTIMENTO LIVRE E ESCLARECIDO**

Caro/a Senhor/a,

O meu nome é Ana Carolina Vieira de Sousa. Sou estudante do mestrado em Biologia Aplicada na Universidade de Aveiro e estou a fazer um estudo sobre o impacto da exposição permanente da Galeria da Biodiversidade – Centro Ciência Viva | Museu de História Natural e da Ciência da Universidade do Porto nas perceções dos visitantes relativas ao Antropocénico. Desta forma, irei analisar as perceções, conhecimentos e atitudes dos visitantes em relação a esta temática.

Para a realização da pesquisa gostaria de aplicar um questionário ao seu educando, com perguntas relacionadas à interação ser humano-natureza, revolvendo em torno da Biodiversidade. O questionário em questão funcionará como controlo do estudo, uma vez que a turma do seu educando não efetuou visita à Galeria da Biodiversidade – Centro Ciência Viva | Museu de História Natural e da Ciência da Universidade do Porto. Se se sentir à vontade para o seu educando colaborar com esta pesquisa irei, então, aplicar o questionário em questão.

Os consentimentos assinados serão guardados na Galeria da Biodiversidade e apenas as respostas ao questionário, que não contém qualquer elemento identificativo dos participantes, serão recolhidas por mim para utilizar no estudo. Se a meio do preenchimento do questionário o seu educando desistir de colaborar neste estudo não será prejudicado de forma alguma. Após a visita, poderá não ser possível desistir do estudo e/ou pedir para eliminar os dados, uma vez que não haverá uma forma de identificar as respostas dadas por cada participante.

A opinião do seu educando será muito importante para o nosso estudo, pois os dados coletados nos questionários contribuirão para o aumento do conhecimento sobre o potencial educativo deste equipamento cultural, dentro da temática do Antropocénico. As informações coletadas irão fazer parte de um trabalho que poderá ser publicado em revistas científicas, além de serem utilizadas na tese de mestrado para ser entregue na Universidade de Aveiro. Em qualquer dos casos, nunca será publicada informação sobre a identidade dos participantes. O prazo de conservação dos dados recolhidos será de dois anos.

Caso o/a senhor/a concorde com a participação do seu educando no preenchimento dos questionários, peço que assine o termo de consentimento abaixo e o entregue ao seu educando para trazer no dia da visita à Galeria da Biodiversidade. Caso não concorde com a participação do seu educando, não precisa de assinar e devolver o documento. A sua decisão será respeitada e não implicará qualquer consequência para si ou para o seu educando.

Em caso de dúvida, por favor contacte-me. Desde já agradeço a sua colaboração. O meu endereço de trabalho localiza-se na Universidade de Aveiro, Departamento de Biologia, Universidade de Aveiro, Campus Universitário de Santiago, 3810-193 Aveiro, Portugal, Telefone:(+351)935074938, E-mail: anacarolinavieirasousa8@ua.pt

**Consentimento**

Eu, abaixo assinado, _____ (nome do EE), Encarregado de Educação de _____ (nome do educando), compreendi a informação que me foi fornecida sobre o estudo que está a ser realizado na Galeria da Biodiversidade – Centro Ciência Viva | Museu de História Natural e da Ciência da Universidade do Porto, pela estudante Ana Carolina Vieira de Sousa, no âmbito da sua dissertação de mestrado em Biologia Aplicada na Universidade de Aveiro, e para o qual é pedida a participação do meu educando.

Sei que poderá desistir do estudo a qualquer momento, sem ter que dar justificações e sem que isso possa trazer-lhe quaisquer consequências.

Nestas circunstâncias,

☐ aceito que o meu educando participe neste estudo, tal como descrito na informação acima.

_____

Assinatura do encarregado de educação

_____, ____ / ____ / ____.

Local dia mês ano

## **Appendix G –** Interview script.

Entrevista semi-estruturada

Perfil do visitante

Idade: 18-24:___ 25-34:___ 35-44:___ 45-54:___ 55-64:___ + 64:___

Género: Feminino: ___ Masculino___ Outro: ___ Prefiro não responder: ___

Distrito: _____

Nível de escolaridade:

- Ensino básico 1.º ciclo: ____
- Ensino básico 2.º ciclo: ____
- Ensino básico 3.º ciclo: ____
- Ensino secundário: ____
- Curso técnico superior profissional: ____
- Bacharelato: ____
- Licenciatura: ____
- Mestrado: ____
- Doutoramento: ____

Área de estudos/profissional: _____

É a primeira vez que visita a Galeria da Biodiversidade?

Sim: ____ Não:____

Se a resposta foi "Não":

1) Há quanto tempo foi a sua última visita?

Menos de 6 meses___ 6 meses a um ano___ Mais de um ano___

2) Quantas vezes visitou a Galeria da Biodiversidade (excluindo esta visita)?

Uma vez___ Duas vezes___ Mais do que duas vezes___

Perceções

1) Está familiarizado com o conceito "biodiversidade"?
   a. Já ouviu falar e sabe o significado
   b. Já ouviu falar, mas não sabe o significado
   c. Nunca ouviu falar

2) Acha que a visita à exposição permanente o ajudou a compreender melhor o conceito "biodiversidade"? Porquê?

3) Está familiarizado com o conceito "Antropocénico"?

a. Já ouviu falar e sabe o significado
b. Já ouviu falar, mas não sabe o significado
c. Nunca ouviu falar
    1. Se sim: Ao longo da exposição, identificou algum exemplo da interação do ser humano com o meio ambiente? Qual?
    2. Se não: explicação do conceito "Antropocénico": O Antropocénico diz respeito, não oficialmente, à época geológica mais recente da história da Terra, marcada pelo impacto significativo da atividade humana no mundo natural, nos ecossistemas e no clima. Ao longo da exposição, identificou algum exemplo da interação do ser humano com o meio ambiente? Qual?

4) Acha que a atividade humana pode ter um impacto negativo na biodiversidade? Se sim, pode dar um exemplo?

5) Acredita que o ser humano tem responsabilidade sobre a diminuição da diversidade de espécies que tem sido observada nos últimos anos? Se sim, pode dar um exemplo?

6) Prevê algum cenário futuro negativo, com a diminuição da diversidade de espécies?

7) Acha que o ser humano será prejudicado pelo seu impacto na biodiversidade? Se sim, pode dar um exemplo?

8) Acredita que a visão centrada no ser humano levou a uma exploração indevida da biodiversidade? Se sim, pode dar um exemplo?

9) Considera que é importante preservar a biodiversidade? Porquê?

10) Tem ideia do que podemos fazer para preservar a biodiversidade? Se sim, pode dar um exemplo?

11) Considera que a visita à Galeria da Biodiversidade contribuiu para o seu desenvolvimento pessoal?

**Appendix H -** Consent form for the interview participants, according to the EU General Data Protection Regulation (2016).

**TERMO DE CONSENTIMENTO LIVRE E ESCLARECIDO**

Caro Senhor/a,

O meu nome é Ana Carolina Vieira de Sousa. Sou estudante do mestrado em Biologia Aplicada na Universidade de Aveiro e estou a fazer um estudo sobre o impacto da exposição permanente da Galeria da Biodiversidade – Centro Ciência Viva | Museu de História Natural e da Ciência da Universidade do Porto nas perceções dos visitantes relativas ao Antropocénico. Desta forma, irei analisar as perceções, conhecimentos e atitudes dos visitantes em relação a esta temática.

Para a realização da pesquisa gostaria de entrevistar alguns visitantes, como o/a senhor/a. Se se sentir à vontade para colaborar com esta pesquisa irei, então, aplicar uma entrevista com perguntas relacionadas com a interação ser humano-natureza, revolvendo em torno da Biodiversidade. Se o/a senhor/a permitir, o áudio das entrevistas será gravado por meio de um aparelho eletrónico (câmara de filmar, gravador ou telemóvel). Os consentimentos assinados ficarão à guarda da Galeria da Biodiversidade e apenas a gravação da entrevista será guardada por mim para utilizar no estudo. Os áudios serão eliminados após a transcrição da entrevista e, a partir desse momento, a informação a utilizar no estudo será anónima. Se a meio da entrevista o/a senhor/a desistir de colaborar com este estudo não será prejudicado de forma alguma. Se decidir desistir mais tarde, poderá não ser possível atender ao seu pedido, uma vez que, após a transcrição da entrevista, não haverá forma de identificar as respostas dadas por cada participante.

A sua opinião será muito importante para o nosso estudo, pois os dados coletados nas entrevistas contribuirão para o aumento do conhecimento sobre o potencial educativo deste equipamento cultural, dentro da temática do Antropocénico. As informações coletadas irão fazer parte de um trabalho que poderá ser publicado em revistas científicas, além de serem utilizadas na tese de mestrado para ser entregue na Universidade de Aveiro. Em qualquer dos casos, nunca será publicada informação sobre a identidade dos participantes. O prazo de conservação dos dados recolhidos e dos consentimentos assinados será de dois anos.

Caso concorde em participar na entrevista, peço que assine este termo de consentimento, que também será assinado por mim, que sou a investigadora responsável. Dessa forma, uma cópia ficará comigo e a outra consigo. Caso prefira não facultar esta entrevista, a sua decisão será respeitada e não implicará qualquer consequência para si. Em caso de dúvida, por favor pergunte. Desde já agradeço a sua colaboração. O meu endereço de trabalho é na Universidade de Aveiro, Departamento de Biologia, Universidade de Aveiro, Campus Universitário de Santiago, 3810-193 Aveiro, Portugal, Telefone (+351)935074938, E-mail: anacarolinavieirasousa8@ua.pt

Presente a informação supra,

☐ Aceito participar no projeto e dou o meu consentimento para o tratamento de dados pessoais subjacente._

| | |
|---|---|
| _____ | _____ |
| Ana Carolina Vieira de Sousa | Assinatura do voluntário |

(Investigador Responsável)

_____, ____ / ____ / ____.

Local dia mês ano

**Appendix I –** Pre- vs. Post-test, and Experimental vs. Control group results of questions C1, C2, C3, C4 and A1.

| Q | Pre/ Post | Descriptive statistics | | | | Paired-samples *t*-test | | | Effect size | Wilcoxon signed-rank test | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *n* | *M* | *SD* | *Mdn* | *t* | *df* | *p* | Cohen's *d* | *z* | *p* |
| **C1** | Pre | 116 | 2,84 | 0,429 | 3 | -1,989 | 115 | **0,049*** | 0,185 | -1,826 | 0,07 |
| | Post | 116 | 2,92 | 0,299 | 3 | | | | | | |
| **C2** | Pre | 112 | 5,98 | 1,811 | 6 | -1,274 | 111 | 0,205 | 0,12 | -1,192 | 0,23 |
| | Post | 112 | 6,16 | 1,901 | 6 | | | | | | |
| **C3** | Pre | 115 | 1,46 | 0,741 | 1 | -5,154 | 114 | **<0,001*** | 0,481 | -4,488 | **<0,001*** |
| | Post | 115 | 1,78 | 0,896 | 1 | | | | | | |
| **C4** | Pre | 29 | 4,79 | 2,833 | 6 | -1,947 | 28 | 0,062 | 0,362 | -2,032 | **0,042*** |
| | Post | 29 | 5,34 | 2,781 | 6 | | | | | | |
| **A1a)** | Pre | 116 | 4,99 | 0,093 | 5 | 1,420 | 115 | 0,158 | 0,132 | -1,414 | 0,157 |
| | Post | 116 | 4,97 | 0,159 | 5 | | | | | | |
| **A1b)** | Pre | 114 | 3,71 | 0,948 | 4 | -2,724 | 113 | **0,007*** | 0,255 | -2,593 | **0,010*** |
| | Post | 114 | 3,93 | 0,859 | 4 | | | | | | |
| **A1c)** | Pre | 111 | 3,86 | 1,022 | 4 | -3,912 | 110 | **<0,001*** | 0,371 | -3,533 | **<0,001*** |
| | Post | 111 | 4,20 | 0,893 | 4 | | | | | | |
| **A1d)** | Pre | 115 | 4,39 | 0,734 | 5 | -1,268 | 114 | 0,207 | 0,118 | -1,271 | 0,204 |
| | Post | 115 | 4,46 | 0,692 | 5 | | | | | | |
| **A1e)** | Pre | 116 | 4,49 | 0,752 | 5 | -0,673 | 115 | 0,503 | 0,062 | -1,025 | 0,305 |
| | Post | 116 | 4,53 | 0,751 | 5 | | | | | | |
| **A1f)** | Pre | 108 | 4,53 | 0,922 | 5 | -1,105 | 107 | 0,271 | 0,106 | -1,009 | 0,313 |
| | Post | 108 | 4,62 | 0,758 | 5 | | | | | | |
| **A1g)** | Pre | 115 | 4,60 | 0,686 | 5 | -2,176 | 114 | **0,032*** | 0,203 | -2,085 | **0,037*** |
| | Post | 115 | 4,75 | 0,475 | 5 | | | | | | |
| **A1h)** | Pre | 116 | 4,85 | 0,579 | 5 | -0,446 | 115 | 0,657 | 0,041 | -0,082 | 0,934 |
| | Post | 116 | 4,88 | 0,399 | 5 | | | | | | |
| **A1i)** | Pre | 116 | 4,86 | 0,415 | 5 | 0,942 | 115 | 0,348 | 0,087 | -0,943 | 0,346 |
| | Post | 116 | 4,83 | 0,379 | 5 | | | | | | |
| **A1j)** | Pre | 116 | 4,70 | 0,593 | 5 | -0,761 | 115 | 0,448 | 0,071 | -0,581 | 0,561 |
| | Post | 116 | 4,74 | 0,496 | 5 | | | | | | |
| **A1k)** | Pre | 106 | 4,31 | 0,832 | 4 | -0,410 | 105 | 0,682 | 0,040 | -0,551 | 0,582 |
| | Post | 106 | 4,34 | 0,779 | 4 | | | | | | |
| **A1l)** | Pre | 103 | 4,42 | 0,786 | 5 | -0,862 | 102 | 0,391 | 0,085 | -0,990 | 0,322 |
| | Post | 103 | 4,50 | 0,752 | 5 | | | | | | |

Q – question. *n* - number of observations. *M* - Mean. *SD* - Standard deviation. *Mdn* - Median. *t*- t-value. *df* - degrees of freedom. *z* - z-value. *p* - p-value (2-tailed). *Results were considered statistically significant for *p* <0,05.

| Q | Pre/ Post/ Cont. | Descriptive statistics | | | | Independent-samples *t*-test | | | Effect size | Mann-Whitney U test | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *n* | *M* | *SD* | *M dn* | *t* | *df* | *p* | Cohen's *d* | *U* | *z* | *p* |
| **C1** | Pre | 116 | 2,84 | 0,429 | 3 | 0,523 | 133 | 0,602 | 0,129 | 1019 | -0,876 | 0,381 |
| | Cont. | 19 | 2,79 | 0,419 | 3 | | | | | | | |
| | Post | 116 | 2,92 | 0,299 | 3 | 1,329 | 21,11 a | 0,198 | 0,418 | 948 | -1,976 | **0,048 *** |
| | Cont. | 19 | 2,79 | 0,419 | 3 | | | | | | | |
| **C2** | Pre | 113 | 5,98 | 1,803 | 6 | -0,523 | 130 | 0,602 | 0,130 | 965 | -0,756 | 0,450 |
| | Cont. | 19 | 6,21 | 1,475 | 6 | | | | | | | |
| | Post | 115 | 6,19 | 1,891 | 6 | -0,042 | 132 | 0,966 | 0,010 | 1036 | -0,383 | 0,702 |
| | Cont. | 19 | 6,21 | 1,475 | 6 | | | | | | | |
| **C3** | Pre | 115 | 1,46 | 0,741 | 1 | -1,752 | 132 | 0,082 | 0,434 | 855 | -1,806 | 0,071 |
| | Cont. | 19 | 1,79 | 0,855 | 2 | | | | | | | |
| | Post | 116 | 1,79 | 0,899 | 1 | 0,016 | 133 | 0,987 | 0,004 | 1092 | -0,070 | 0,944 |
| | Cont. | 19 | 1,79 | 0,855 | 2 | | | | | | | |
| **C4** | Pre | 32 | 4,38 | 3,003 | 4 | 1,364 | 40 | 0,180 | 0,494 | 114 | -1,381 | 0,167 |
| | Cont. | 10 | 2,90 | 2,923 | 2 | | | | | | | |
| | Post | 48 | 4,46 | 2,641 | 4 | 1,667 | 56 | 0,101 | 0,580 | 157 | -1,750 | 0,080 |
| | Cont. | 10 | 2,90 | 2,923 | 2 | | | | | | | |
| **A1a)** | Pre | 116 | 4,99 | 0,093 | 5 | 1,232 | 18,10 a | 0,234 | 0,731 | 995 | -2,651 | **0,008 *** |
| | Cont. | 19 | 4,79 | 0,713 | 5 | | | | | | | |
| | Post | 116 | 4,97 | 0,159 | 5 | 1,124 | 18,30 a | 0,276 | 0,613 | 1013 | -1,721 | 0,085 |
| | Cont. | 19 | 4,79 | 0,713 | 5 | | | | | | | |
| **A1b)** | Pre | 115 | 3,70 | 0,946 | 4 | 0,734 | 132 | 0,464 | 0,182 | 989 | -0,698 | 0,485 |
| | Cont. | 19 | 3,53 | 1,172 | 3 | | | | | | | |
| | Post | 115 | 3,91 | 0,874 | 4 | 1,376 | 21,43 a | 0,183 | 0,420 | 883 | -1,410 | 0,158 |
| | Cont. | 19 | 3,53 | 1,172 | 3 | | | | | | | |
| **A1c)** | Pre | 112 | 3,87 | 1,018 | 4 | -1,610 | 127 | 0,110 | 0,419 | 684 | -1,985 | **0,047 *** |
| | Cont. | 17 | 4,29 | 1,047 | 5 | | | | | | | |
| | Post | 115 | 4,18 | 0,894 | 4 | -0,469 | 130 | 0,640 | 0,122 | 873 | -0,771 | 0,440 |
| | Cont. | 17 | 4,29 | 1,047 | 5 | | | | | | | |
| **A1d)** | Pre | 115 | 4,39 | 0,734 | 5 | 2,754 | 20,42 a | **0,012 *** | 0,942 | 636 | -3,215 | **0,001 *** |
| | Cont. | 19 | 3,63 | 1,165 | 4 | | | | | | | |
| | Post | 116 | 4,47 | 0,691 | 5 | 3,035 | 20,12 a | **0,007 *** | 1,080 | 589 | -3,624 | **<0,001*** |
| | Cont. | 19 | 3,63 | 1,165 | 4 | | | | | | | |
| **A1e)** | Pre | 116 | 4,49 | 0,752 | 5 | 1,931 | 133 | 0,056 | 0,478 | 877 | -1,627 | 0,104 |
| | Cont. | 19 | 4,11 | 1,100 | 4 | | | | | | | |
| | Post | 116 | 4,53 | 0,751 | 5 | 2,149 | 133 | **0,033 *** | 0,532 | 840 | -1,918 | 0,055 |
| | Cont. | 19 | 4,11 | 1,100 | 4 | | | | | | | |
| **A1f)** | Pre | 108 | 4,53 | 0,922 | 5 | -0,624 | 124 | 0,534 | 0,159 | 969 | -0,026 | 0,979 |
| | Cont. | 18 | 4,67 | 0,485 | 5 | | | | | | | |
| | Post | 115 | 4,62 | 0,744 | 5 | -0,271 | 131 | 0,786 | 0,069 | 1005 | -0,248 | 0,804 |
| | Cont. | 18 | 4,67 | 0,485 | 5 | | | | | | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **A1g)** | Pre | 116 | 4,59 | 0,685 | 5 | -0,761 | 132 | 0,448 | 0,193 | 966 | -0,615 | 0,539 |
| | Cont. | 18 | 4,72 | 0,461 | 5 | | | | | | | |
| | Post | 115 | 4,75 | 0,475 | 5 | 0,214 | 131 | 0,831 | 0,054 | 995 | -0,350 | 0,726 |
| | Cont. | 18 | 4,72 | 0,461 | 5 | | | | | | | |
| **A1h)** | Pre | 116 | 4,85 | 0,579 | 5 | -0,657 | 132 | 0,512 | 0,166 | 1002 | -0,554 | 0,580 |
| | Cont. | 18 | 4,94 | 0,236 | 5 | | | | | | | |
| | Post | 116 | 4,88 | 0,399 | 5 | -0,673 | 132 | 0,502 | 0,171 | 994 | -0,642 | 0,521 |
| | Cont. | 18 | 4,94 | 0,236 | 5 | | | | | | | |
| **A1i)** | Pre | 116 | 4,86 | 0,415 | 5 | 1,279 | 21,09 [a] | 0,215 | 0,403 | 941 | -1,689 | 0,091 |
| | Cont. | 19 | 4,68 | 0,582 | 5 | | | | | | | |
| | Post | 116 | 4,83 | 0,379 | 5 | 1,038 | 20,57 [a] | 0,311 | 0,347 | 992 | -1,034 | 0,301 |
| | Cont. | 19 | 4,68 | 0,582 | 5 | | | | | | | |
| **A1j)** | Pre | 116 | 4,70 | 0,593 | 5 | 0,454 | 133 | 0,651 | 0,112 | 1034 | -0,563 | 0,573 |
| | Cont. | 19 | 4,63 | 0,597 | 5 | | | | | | | |
| | Post | 116 | 4,74 | 0,496 | 5 | 0,869 | 133 | 0,386 | 0,215 | 1006 | -0,813 | 0,416 |
| | Cont. | 19 | 4,63 | 0,597 | 5 | | | | | | | |
| **A1k)** | Pre | 110 | 4,28 | 0,836 | 4 | 0,645 | 123 | 0,520 | 0,178 | 724 | -0,843 | 0,399 |
| | Cont. | 15 | 4,13 | 0,834 | 4 | | | | | | | |
| | Post | 112 | 4,36 | 0,769 | 4 | 1,048 | 125 | 0,297 | 0,288 | 701 | -1,156 | 0,248 |
| | Cont. | 15 | 4,13 | 0,834 | 4 | | | | | | | |
| **A1l)** | Pre | 105 | 4,42 | 0,782 | 5 | -3,113 | 35,44 [a] | **0,004 *** | 0,528 | 597 | -2,138 | **0,033 *** |
| | Cont. | 16 | 4,81 | 0,403 | 5 | | | | | | | |
| | Post | 110 | 4,48 | 0,751 | 5 | -2,675 | 32,81 [a] | **0,012 *** | 0,461 | 662 | -1,867 | 0,062 |
| | Cont. | 16 | 4,81 | 0,403 | 5 | | | | | | | |

Q – question. Cont. – Control. *n* - number of observations. *M* - Mean. *SD* - Standard deviation. *Mdn* - Median. *t*- t-value. *df* - degrees of freedom. *U* - Mann-Whitney U value. *z* - z-value. *p* - p-value (2-tailed). *Results were considered statistically significant for $p$ <0,05. [a]Levene's Test for Equality of Variances shows that equal variances are not assumed.

**Appendix J –** Pre- vs- Post-test, and Experimental vs. Control groups analysis of notions mentioned by the participants in question C2.

| Question | Notion | Pre/Post | *n* | Absolute frequency | McNemar test *p* |
|---|---|---|---|---|---|
| C2 | Adaptation | Pre | 113 | 0 | 1,000 |
| | | Post | 115 | 1 | |
| | Air | Pre | 113 | 1 | 1,000 |
| | | Post | 115 | 1 | |
| | Animals | Pre | 113 | 8 | 0,063 |
| | | Post | 115 | 3 | |
| | Area | Pre | 113 | 5 | 0,250 |
| | | Post | 115 | 2 | |
| | Bacteria | Pre | 113 | 1 | 1,000 |
| | | Post | 115 | 0 | |
| | Biosphere | Pre | 113 | 5 | 1,000 |
| | | Post | 115 | 4 | |
| | Body Size | Pre | 113 | 0 | 0,250 |
| | | Post | 115 | 3 | |
| | Colour | Pre | 113 | 0 | 0,500 |
| | | Post | 115 | 2 | |
| | Diversity | Pre | 113 | 90 | 1,000 |
| | | Post | 115 | 90 | |
| | Earth | Pre | 113 | 23 | 0,607 |
| | | Post | 115 | 26 | |
| | Ecosystem | Pre | 113 | 8 | 1,000 |
| | | Post | 115 | 8 | |
| | Environment | Pre | 113 | 8 | 0,065 |
| | | Post | 115 | 15 | |
| | Evolution | Pre | 113 | 0 | 1,000 |
| | | Post | 115 | 1 | |
| | Fungi | Pre | 113 | 2 | 1,000 |
| | | Post | 115 | 1 | |
| | Genetics | Pre | 113 | 2 | 1,000 |
| | | Post | 115 | 1 | |
| | Genetic Recombination | Pre | 113 | 1 | 1,000 |
| | | Post | 115 | 1 | |
| | | Pre | 113 | 0 | 0,500 |

| | | | | | |
|---|---|---|---|---|---|
| | Genetic variability | Post | 115 | 2 | |
| | Group | Pre | 113 | 19 | 1,000 |
| | | Post | 115 | 18 | |
| | Habitat | Pre | 113 | 8 | 0,453 |
| | | Post | 115 | 5 | |
| | Interaction | Pre | 113 | 15 | 0,250 |
| | | Post | 115 | 18 | |
| | Intraspecific Diversity | Pre | 113 | 4 | 1,000 |
| | | Post | 115 | 5 | |
| | Kingdom (biology) | Pre | 113 | 1 | 1,000 |
| | | Post | 115 | 0 | |
| | Land | Pre | 113 | 1 | 1,000 |
| | | Post | 115 | 1 | |
| | Life | Pre | 113 | 11 | 0,508 |
| | | Post | 115 | 8 | |
| | Lifestyle | Pre | 115 | 1 | 1,000 |
| | | Post | 115 | 1 | |
| | Living beings | Pre | 113 | 73 | 0,424 |
| | | Post | 115 | 68 | |
| | Macroscopic level | Pre | 113 | 2 | 1,000 |
| | | Post | 115 | 2 | |
| | Mesoscopic level | Pre | 113 | 1 | 1,000 |
| | | Post | 115 | 2 | |
| | Microscopic level | Pre | 113 | 2 | 1,000 |
| | | Post | 115 | 2 | |
| | Morphological variability | Pre | 113 | 0 | 1,000 |
| | | Post | 115 | 1 | |
| | Mutation | Pre | 113 | 1 | 1,000 |
| | | Post | 115 | 1 | |
| | Nature | Pre | 113 | 3 | 1,000 |
| | | Post | 115 | 3 | |
| | Niche (ecology) | Pre | 113 | 0 | 1,000 |
| | | Post | 115 | 1 | |
| | Phenotype | Pre | 113 | 1 | 1,000 |
| | | Post | 115 | 1 | |
| | Phylogeny | Pre | 113 | 0 | 1,000 |
| | | Post | 115 | 1 | |
| | Plants | Pre | 113 | 8 | 0,063 |
| | | Post | 115 | 3 | |
| | Population | Pre | 113 | 1 | 1,000 |
| | | Post | 115 | 1 | |

| | | | | | |
|---|---|---|---|---|---|
| | Shape | Pre | 113 | 0 | 0,250 |
| | | Post | 115 | 3 | |
| | Similarities | Pre | 113 | 1 | 1,000 |
| | | Post | 115 | 0 | |
| | Species | Pre | 113 | 39 | 0,307 |
| | | Post | 115 | 45 | |
| | Time | Pre | 113 | 2 | 1,000 |
| | | Post | 115 | 1 | |
| | Traces | Pre | 113 | 0 | 1,000 |
| | | Post | 115 | 1 | |
| | Trait | Pre | 113 | 3 | 0,500 |
| | | Post | 115 | 1 | |
| | Water | Pre | 113 | 1 | 1,000 |
| | | Post | 115 | 1 | |

*n* - number of observations. *p* - p-value (2-tailed). *Results were considered statistically significant for *p* <0,05. Note: n=112 was considered by applying a test-by-test exclusion.

| **Question** | **Notion** | **Pre/Control** | ***n*** | **Absolute frequency** | **Fisher's exact test** |
|---|---|---|---|---|---|
| | | | | | ***p*** |
| **C2** | Air | Pre | 113 | 1 | 1,000 |
| | | Control | 19 | 0 | |
| | Animals | Pre | 113 | 8 | 0,637 |
| | | Control | 19 | 2 | |
| | Area | Pre | 113 | 5 | 0,265 |
| | | Control | 19 | 2 | |
| | Bacteria | Pre | 113 | 1 | 1,000 |
| | | Control | 19 | 0 | |
| | Balance | Pre | 113 | 0 | 0,144 |
| | | Control | 19 | 1 | |
| | Behaviour | Pre | 113 | 0 | 0,144 |
| | | Control | 19 | 1 | |
| | Biosphere | Pre | 113 | 5 | 1,000 |
| | | Control | 19 | 0 | |
| | Colour | Pre | 113 | 0 | 0,144 |
| | | Control | 19 | 1 | |
| | Diversity | Pre | 113 | 91 | 1,000 |
| | | Control | 19 | 15 | |

| | | | | | |
|---|---|---|---|---|---|
| | Earth | Pre | 113 | 24 | 0,565 |
| | | Control | 19 | 5 | |
| | Ecosystem | Pre | 113 | 8 | 1,000 |
| | | Control | 19 | 1 | |
| | Environment | Pre | 113 | 8 | 1,000 |
| | | Control | 19 | 1 | |
| | Fungi | Pre | 113 | 2 | 1,000 |
| | | Control | 19 | 0 | |
| | Genetics | Pre | 113 | 2 | 1,000 |
| | | Control | 19 | 0 | |
| | Genetic Recombination | Pre | 113 | 1 | 1,000 |
| | | Control | 19 | 0 | |
| | Group | Pre | 113 | 19 | 0,304 |
| | | Control | 19 | 1 | |
| | Habitat | Pre | 113 | 8 | 1,000 |
| | | Control | 19 | 1 | |
| | Interaction | Pre | 113 | 15 | 1,000 |
| | | Control | 19 | 2 | |
| | Intraspecific Diversity | Pre | 113 | 4 | 0,546 |
| | | Control | 19 | 1 | |
| | Kingdom (biology) | Pre | 113 | 1 | 0,268 |
| | | Control | 19 | 1 | |
| | Land | Pre | 113 | 1 | 0,268 |
| | | Control | 19 | 1 | |
| | Life | Pre | 113 | 11 | 0,364 |
| | | Control | 19 | 0 | |
| | Lifestyle | Pre | 113 | 1 | 1,000 |
| | | Control | 19 | 0 | |
| | Living beings | Pre | 113 | 74 | 0,119 |
| | | Control | 19 | 16 | |
| | Macroscopic level | Pre | 113 | 2 | 1,000 |
| | | Control | 19 | 0 | |
| | Mesoscopic level | Pre | 113 | 1 | 1,000 |
| | | Control | 19 | 0 | |
| | Microscopic level | Pre | 113 | 2 | 1,000 |
| | | Control | 19 | 0 | |
| | Mutation | Pre | 113 | 1 | 1,000 |
| | | Control | 19 | 0 | |
| | Nature | Pre | 113 | 3 | 0,467 |
| | | Control | 19 | 1 | |
| | Phenotype | Pre | 113 | 1 | 1,000 |
| | | Control | 19 | 0 | |

| | | | | | |
|---|---|---|---|---|---|
| | Plants | Pre | 113 | 8 | 0,637 |
| | | Control | 19 | 2 | |
| | Population | Pre | 113 | 1 | 1,000 |
| | | Control | 19 | 0 | |
| | Shape | Pre | 113 | 0 | 0,144 |
| | | Control | 19 | 1 | |
| | Similarities | Pre | 113 | 1 | 1,000 |
| | | Control | 19 | 0 | |
| | Species | Pre | 113 | 39 | 0,299 |
| | | Control | 19 | 4 | |
| | Time | Pre | 113 | 2 | 1,000 |
| | | Control | 19 | 0 | |
| | Trait | Pre | 113 | 3 | 1,000 |
| | | Control | 19 | 0 | |
| | Water | Pre | 113 | 1 | 0,268 |
| | | Control | 19 | 1 | |

*n* - number of observations. *p* - p-value (2-tailed). *Results were considered statistically significant for *p* <0,05.

| **Question** | **Notion** | **Post/Control** | ***n*** | **Absolute frequency** | **Fisher's exact test** |
|---|---|---|---|---|---|
| | | | | | ***p*** |
| **C2** | Adaptation | Post | 115 | 1 | 1,000 |
| | | Control | 19 | 0 | |
| | Air | Post | 115 | 1 | 1,000 |
| | | Control | 19 | 0 | |
| | Animals | Post | 115 | 3 | 0,147 |
| | | Control | 19 | 2 | |
| | Area | Post | 115 | 2 | 0,960 |
| | | Control | 19 | 2 | |
| | Balance | Post | 115 | 0 | 0,142 |
| | | Control | 19 | 1 | |
| | Behaviour | Post | 115 | 0 | 0,142 |
| | | Control | 19 | 1 | |
| | Biosphere | Post | 115 | 4 | 1,000 |
| | | Control | 19 | 0 | |
| | Body Size | Post | 115 | 3 | 1,000 |
| | | Control | 19 | 0 | |

| | | | | | |
|---|---|---|---|---|---|
| | Colour | Post | 115 | 2 | 0,370 |
| | | Control | 19 | 1 | |
| | Diversity | Post | 115 | 92 | 1,000 |
| | | Control | 19 | 15 | |
| | Earth | Post | 115 | 26 | 0,771 |
| | | Control | 19 | 5 | |
| | Ecosystem | Post | 115 | 8 | 1,000 |
| | | Control | 19 | 1 | |
| | Environment | Post | 115 | 15 | 0,468 |
| | | Control | 19 | 1 | |
| | Evolution | Post | 115 | 1 | 1,000 |
| | | Control | 19 | 0 | |
| | Fungi | Post | 115 | 1 | 1,000 |
| | | Control | 19 | 0 | |
| | Genetics | Post | 115 | 1 | 1,000 |
| | | Control | 19 | 0 | |
| | Genetic Recombination | Post | 115 | 1 | 1,000 |
| | | Control | 19 | 0 | |
| | Genetic Variability | Post | 115 | 2 | 1,000 |
| | | Control | 19 | 0 | |
| | Group | Post | 115 | 19 | 0,305 |
| | | Control | 19 | 1 | |
| | Habitat | Post | 115 | 5 | 1,000 |
| | | Control | 19 | 1 | |
| | Interaction | Post | 115 | 19 | 0,737 |
| | | Control | 19 | 2 | |
| | Intraspecific Diversity | Post | 115 | 5 | 1,000 |
| | | Control | 19 | 1 | |
| | Kingdom (biology) | Post | 115 | 0 | 0,142 |
| | | Control | 19 | 1 | |
| | Land | Post | 115 | 1 | 0,264 |
| | | Control | 19 | 1 | |
| | Life | Post | 115 | 9 | 0,358 |
| | | Control | 19 | 0 | |
| | Lifestyle | Post | 115 | 1 | 1,000 |
| | | Control | 19 | 0 | |
| | Living beings | Post | 115 | 71 | 0,071 |
| | | Control | 19 | 16 | |
| | Macroscopic level | Post | 115 | 2 | 1,000 |
| | | Control | 19 | 0 | |
| | Mesoscopic level | Post | 115 | 2 | 1,000 |
| | | Control | 19 | 0 | |

| | | | | | |
|---|---|---|---|---|---|
| | Microscopic level | Post | 115 | 2 | 1,000 |
| | | Control | 19 | 0 | |
| | Morphological variability | Post | 115 | 1 | 1,000 |
| | | Control | 19 | 0 | |
| | Mutation | Post | 115 | 1 | 1,000 |
| | | Control | 19 | 0 | |
| | Nature | Post | 115 | 3 | 0,462 |
| | | Control | 19 | 1 | |
| | Niche (ecology) | Post | 115 | 1 | 1,000 |
| | | Control | 19 | 0 | |
| | Phenotype | Post | 115 | 1 | 1,000 |
| | | Control | 19 | 0 | |
| | Phylogeny | Post | 115 | 1 | 1,000 |
| | | Control | 19 | 0 | |
| | Plants | Post | 115 | 3 | 0,147 |
| | | Control | 19 | 2 | |
| | Population | Post | 115 | 1 | 1,000 |
| | | Control | 19 | 0 | |
| | Shape | Post | 115 | 3 | 0,462 |
| | | Control | 19 | 1 | |
| | Species | Post | 115 | 46 | 0,132 |
| | | Control | 19 | 4 | |
| | Time | Post | 115 | 1 | 1,000 |
| | | Control | 19 | 0 | |
| | Traces | Post | 115 | 1 | 1,000 |
| | | Control | 19 | 0 | |
| | Trait | Post | 115 | 1 | 1,000 |
| | | Control | 19 | 0 | |
| | Water | Post | 115 | 1 | 0,264 |
| | | Control | 19 | 1 | |

*n* - number of observations. *p* - p-value (2-tailed). *Results were considered statistically significant for *p* <0,05.

**Appendix K –** Pre- vs- Post-test, and Experimental vs. Control groups analysis of notions mentioned by the participants in question C4.

| Question | Notion | Pre/Post | *n* | Absolute frequency | McNemar test *p* |
|---|---|---|---|---|---|
| C4 | Arthropods | Pre | 32 | 1 | 1,000 |
| | | Post | 48 | 1 | |
| | Cenozoic | Pre | 32 | 3 | 1,000 |
| | | Post | 48 | 3 | |
| | Changes (noun) | Pre | 32 | 5 | 1,000 |
| | | Post | 48 | 5 | |
| | Earth | Pre | 32 | 16 | 0,375 |
| | | Post | 48 | 13 | |
| | Emergence | Pre | 32 | 2 | 1,000 |
| | | Post | 48 | 2 | |
| | Era | Pre | 32 | 3 | 1,000 |
| | | Post | 48 | 4 | |
| | Extinction | Pre | 32 | 0 | 1,000 |
| | | Post | 48 | 1 | |
| | Geologic Time Scale | Pre | 32 | 3 | 0,500 |
| | | Post | 48 | 5 | |
| | History | Pre | 32 | 16 | 0,063 |
| | | Post | 48 | 11 | |
| | Human | Pre | 32 | 17 | 1,000 |
| | | Post | 48 | 16 | |
| | Human action | Pre | 32 | 10 | 0,687 |
| | | Post | 48 | 12 | |
| | Human impact | Pre | 32 | 3 | 1,000 |
| | | Post | 48 | 2 | |
| | Industrialism | Pre | 32 | 1 | 1,000 |
| | | Post | 48 | 1 | |
| | Insects | Pre | 32 | 1 | 1,000 |
| | | Post | 48 | 1 | |
| | Period (time) | Pre | 32 | 23 | 1,000 |
| | | Post | 48 | 23 | |
| | Predominance | Pre | 32 | 1 | 1,000 |
| | | Post | 48 | 1 | |
| | Presence | Pre | 32 | 0 | 0,500 |
| | | Post | 48 | 2 | |

| | | | | | |
|---|---|---|---|---|---|
| | Present (time) | Pre | 32 | 0 | 1,000 |
| | | Post | 48 | 1 | |
| | Recent | Pre | 32 | 9 | 0,625 |
| | | Post | 48 | 7 | |
| | Rocks | Pre | 32 | 1 | 1,000 |
| | | Post | 48 | 0 | |
| | Scientific Community | Pre | 32 | 1 | 1,000 |
| | | Post | 48 | 1 | |
| | Time Unit | Pre | 32 | 0 | 1,000 |
| | | Post | 48 | 1 | |
| | Traces (noun) | Pre | 32 | 1 | 1,000 |
| | | Post | 48 | 1 | |
| | Unofficial | Pre | 32 | 2 | 0,500 |
| | | Post | 48 | 4 | |

*n* - number of observations. *p* - p-value (2-tailed). *Results were considered statistically significant for *p* <0,05. Note: n=29 was considered by applying a test-by-test exclusion.

| **Question** | **Notion** | **Pre/ Control** | ***n*** | **Absolute frequency** | **Fisher's exact test** |
|---|---|---|---|---|---|
| | | | | | ***p*** |
| **C4** | Arthropods | Pre | 32 | 1 | 1,000 |
| | | Control | 10 | 0 | |
| | Cenozoic | Pre | 32 | 3 | 1,000 |
| | | Control | 10 | 1 | |
| | Changes (noun) | Pre | 32 | 5 | 0,315 |
| | | Control | 10 | 0 | |
| | Earth | Pre | 32 | 16 | 0,723 |
| | | Control | 10 | 4 | |
| | Emergence | Pre | 32 | 2 | 0,078 |
| | | Control | 10 | 3 | |
| | Era | Pre | 32 | 3 | 0,135 |
| | | Control | 10 | 3 | |
| | Geologic Time Scale | Pre | 32 | 3 | 0,135 |
| | | Control | 10 | 3 | |
| | History | Pre | 32 | 16 | 0,305 |
| | | Control | 10 | 3 | |
| | Hominids | Pre | 32 | 0 | 0,052 |
| | | Control | 10 | 2 | |

| | | | | | |
|---|---|---|---|---|---|
| | Human | Pre | 32 | 18 | 1,000 |
| | | Control | 10 | 6 | |
| | Human action | Pre | 32 | 11 | **0,041*** |
| | | Control | 10 | 0 | |
| | Human impact | Pre | 32 | 3 | 1,000 |
| | | Control | 10 | 0 | |
| | Industrialism | Pre | 32 | 1 | 1,000 |
| | | Control | 10 | 0 | |
| | Insects | Pre | 32 | 1 | 1,000 |
| | | Control | 10 | 0 | |
| | Period (time) | Pre | 32 | 23 | 0,697 |
| | | Control | 10 | 6 | |
| | Predominance | Pre | 32 | 1 | 0,424 |
| | | Control | 10 | 1 | |
| | Presence | Pre | 32 | 0 | 0,238 |
| | | Control | 10 | 1 | |
| | Recent | Pre | 32 | 9 | 0,404 |
| | | Control | 10 | 1 | |
| | Rocks | Pre | 32 | 1 | 1,000 |
| | | Control | 10 | 0 | |
| | Scientific Community | Pre | 32 | 1 | 1,000 |
| | | Control | 10 | 0 | |
| | Time Unit | Pre | 32 | 0 | 0,052 |
| | | Control | 10 | 2 | |
| | Traces (noun) | Pre | 32 | 1 | 1,000 |
| | | Control | 10 | 0 | |
| | Unofficial | Pre | 32 | 2 | 1,000 |
| | | Control | 10 | 0 | |

*n* - number of observations. *p* - p-value (2-tailed). *Results were considered statistically significant for *p* <0,05.

| Question | Notion | Post/Control | *n* | Absolute frequency | Fisher's exact test *p* |
|---|---|---|---|---|---|
| C4 | Arthropods | Post | 48 | 1 | 1,000 |
| | | Control | 10 | 0 | |
| | Cenozoic | Post | 48 | 6 | 1,000 |
| | | Control | 10 | 1 | |
| | Changes (noun) | Post | 48 | 6 | 0,577 |
| | | Control | 10 | 0 | |
| | Earth | Post | 48 | 17 | 1,000 |
| | | Control | 10 | 4 | |
| | Emergence | Post | 48 | 2 | **0,032*** |
| | | Control | 10 | 3 | |
| | Environment | Post | 48 | 1 | 1,000 |
| | | Control | 10 | 0 | |
| | Epoch | Post | 48 | 1 | 1,000 |
| | | Control | 10 | 0 | |
| | Era | Post | 48 | 12 | 0,708 |
| | | Control | 10 | 3 | |
| | Exctinction | Post | 48 | 2 | 1,000 |
| | | Control | 10 | 0 | |
| | Geologic Time Scale | Post | 48 | 11 | 0,691 |
| | | Control | 10 | 3 | |
| | History | Post | 48 | 19 | 0,727 |
| | | Control | 10 | 3 | |
| | Hominids | Post | 48 | 0 | **0,027*** |
| | | Control | 10 | 2 | |
| | Human | Post | 48 | 20 | 0,319 |
| | | Control | 10 | 6 | |
| | Human action | Post | 48 | 14 | 0,098 |
| | | Control | 10 | 0 | |
| | Human impact | Post | 48 | 2 | 1,000 |
| | | Control | 10 | 0 | |
| | Industrialism | Post | 48 | 1 | 1,000 |
| | | Control | 10 | 0 | |
| | Insects | Post | 48 | 1 | 1,000 |
| | | Control | 10 | 0 | |
| | Living Beings | Post | 48 | 1 | 1,000 |
| | | Control | 10 | 0 | |

| | | | | | |
|---|---|---|---|---|---|
| | Period (time) | Post | 48 | 31 | 1,000 |
| | | Control | 10 | 6 | |
| | Predominance | Post | 48 | 1 | 0,318 |
| | | Control | 10 | 1 | |
| | Presence | Post | 48 | 2 | 0,439 |
| | | Control | 10 | 1 | |
| | Present (time) | Post | 48 | 1 | 1,000 |
| | | Control | 10 | 0 | |
| | Recent | Post | 48 | 12 | 0,429 |
| | | Control | 10 | 1 | |
| | Scientific Community | Post | 48 | 2 | 1,000 |
| | | Control | 10 | 0 | |
| | Time Unit | Post | 48 | 2 | 0,134 |
| | | Control | 10 | 2 | |
| | Traces (noun) | Post | 48 | 1 | 1,000 |
| | | Control | 10 | 0 | |
| | Unofficial | Post | 48 | 6 | 0,577 |
| | | Control | 10 | 0 | |

*n* - number of observations. *p* - p-value (2-tailed). *Results were considered statistically significant for *p* <0,05.

**Appendix L -** Pre- vs. Post-test, and Experimental vs. Control group results of question C5.

| Question | Pre/Post | Descriptive statistics | | | McNemar test |
|---|---|---|---|---|---|
| | | ***n*** | ***M*** | ***SD*** | ***p*** |
| **C5a)** | Pre | 107 | 0,89 | 0,317 | 0,227 |
| | Post | 107 | 0,93 | 0,248 | |
| **C5b)** | Pre | 115 | 0,95 | 0,223 | 0,500 |
| | Post | 115 | 0,97 | 0,160 | |
| **C5c)** | Pre | 112 | 0,95 | 0,226 | 1,000 |
| | Post | 112 | 0,96 | 0,207 | |
| **C5d)** | Pre | 114 | 1,00 | 0,000 | N.A. |
| | Post | 114 | 1,00 | 0,000 | |
| **C5e)** | Pre | 114 | 0,97 | 0,161 | 1,000 |
| | Post | 114 | 0,98 | 0,132 | |

*n* - number of observations. *M* - Mean. *SD* - Standard deviation. *p* - p-value (2-tailed). None of the results were considered statistically significant for p <0,05. N.A. The McNemar Test for C5d was not performed because both variables are not dichotomous. Every participant who answered selected *Agree*.

| Question | Pre/Post/Control | Descriptive statistics | | | Fisher's exact test |
|---|---|---|---|---|---|
| | | ***n*** | ***M*** | ***SD*** | ***p*** |
| **C5a)** | Pre | 107 | 0,89 | 0,317 | 0,222 |
| | Control | 16 | 0,75 | 0,447 | |
| | Post | 115 | 0,93 | 0,256 | **0,041*** |
| | Control | 16 | 0,75 | 0,447 | |
| **C5b)** | Pre | 115 | 0,95 | 0,223 | 1,000 |
| | Control | 18 | 1,00 | 0,000 | |
| | Post | 115 | 0,97 | 0,160 | 1,000 |
| | Control | 18 | 1,00 | 0,000 | |
| **C5c)** | Pre | 112 | 0,95 | 0,226 | 1,000 |
| | Control | 19 | 0,95 | 0,229 | |
| | Post | 112 | 0,96 | 0,207 | 1,000 |
| | Control | 19 | 0,95 | 0,229 | |
| **C5d)** | Pre | 114 | 1,00 | 0,000 | N.A. |
| | Control | 19 | 1,00 | 0,000 | |
| | Post | 115 | 1,00 | 0,000 | N.A. |
| | Control | 19 | 1,00 | 0,000 | |

| | | | | | |
|---|---|---|---|---|---|
| **C5e)** | Pre | 114 | 0,97 | 0,161 | 0,126 |
| | Control | 17 | 0,88 | 0,332 | |
| | Post | 116 | 0,98 | 0,131 | 0,079 |
| | Control | 17 | 0,88 | 0,332 | |

*n* - number of observations. *M* - Mean. *SD* - Standard deviation. *p* - p-value (2-tailed). *Results were considered statistically significant for p <0,05. N.A. The McNemar Test for C5d was not performed because both variables are not dichotomous. Every participant who answered selected *Agree*.

**Appendix M –** Pre- vs- Post-test, and Experimental vs. Control groups analysis of notions mentioned by the participants in question A2.

| Question | Notion | Pre/Post | *n* | Absolute frequency | McNemar test *p* |
|---|---|---|---|---|---|
| A2 | Adaptation | Pre | 106 | 0 | 1,000 |
| | | Post | 110 | 1 | |
| | Advantage (ecology) | Pre | 106 | 0 | 1,000 |
| | | Post | 110 | 1 | |
| | Aesthetics | Pre | 106 | 0 | 1,000 |
| | | Post | 110 | 1 | |
| | Analogy | Pre | 106 | 0 | 0,250 |
| | | Post | 110 | 3 | |
| | Anatomy | Pre | 106 | 1 | 1,000 |
| | | Post | 110 | 0 | |
| | Ancestor | Pre | 106 | 0 | 0,250 |
| | | Post | 110 | 3 | |
| | Animals | Pre | 106 | 9 | **<0,001*** |
| | | Post | 110 | 37 | |
| | Antlers | Pre | 106 | 0 | 0,500 |
| | | Post | 110 | 2 | |
| | Aquatic mammal | Pre | 106 | 0 | 0,500 |
| | | Post | 110 | 2 | |
| | Bee | Pre | 106 | 0 | 0,250 |
| | | Post | 110 | 3 | |
| | Biodiversity | Pre | 106 | 38 | **<0,001*** |
| | | Post | 110 | 9 | |
| | Biology | Pre | 106 | 1 | 1,000 |
| | | Post | 110 | 2 | |
| | Biosphere | Pre | 106 | 1 | 1,000 |
| | | Post | 110 | 0 | |
| | Bird | Pre | 106 | 0 | 0,250 |
| | | Post | 110 | 3 | |
| | Body size | Pre | 106 | 0 | **0,002*** |
| | | Post | 110 | 10 | |
| | Bone structure | Pre | 106 | 0 | 1,000 |
| | | Post | 110 | 1 | |
| | Chicken | Pre | 106 | 0 | 1,000 |
| | | Post | 110 | 1 | |

| | | | | | |
|---|---|---|---|---|---|
| | Colour | Pre | 106 | 0 | 1,000 |
| | | Post | 110 | 1 | |
| | Deer | Pre | 106 | 0 | 0,500 |
| | | Post | 110 | 2 | |
| | Dinosaurs | Pre | 106 | 0 | 1,000 |
| | | Post | 110 | 1 | |
| | Disadvantage (ecology) | Pre | 106 | 0 | 1,000 |
| | | Post | 110 | 1 | |
| | Diversity | Pre | 106 | 53 | 0,127 |
| | | Post | 110 | 42 | |
| | Ears | Pre | 106 | 0 | 1,000 |
| | | Post | 110 | 1 | |
| | Earth | Pre | 106 | 0 | 0,581 |
| | | Post | 110 | 5 | |
| | Economy | Pre | 106 | 0 | 0,500 |
| | | Post | 110 | 2 | |
| | Ecosystem | Pre | 106 | 0 | 1,000 |
| | | Post | 110 | 1 | |
| | Eggs | Pre | 106 | 0 | **<0,001*** |
| | | Post | 110 | 18 | |
| | Environment | Pre | 106 | 2 | 1,000 |
| | | Post | 110 | 1 | |
| | Environmental changes | Pre | 106 | 0 | 1,000 |
| | | Post | 110 | 2 | |
| | Ethics | Pre | 106 | 0 | 0,250 |
| | | Post | 110 | 3 | |
| | Evidences | Pre | 106 | 13 | **0,002*** |
| | | Post | 110 | 1 | |
| | Evolution | Pre | 106 | 5 | 0,774 |
| | | Post | 110 | 7 | |
| | Extinction | Pre | 106 | 5 | 0,063 |
| | | Post | 110 | 0 | |
| | Eyes | Pre | 106 | 0 | 0,500 |
| | | Post | 110 | 2 | |
| | Eyesight | Pre | 106 | 0 | **<0,001*** |
| | | Post | 110 | 40 | |
| | Female | Pre | 106 | 0 | 0,500 |
| | | Post | 110 | 2 | |
| | Fish | Pre | 106 | 0 | 1,000 |
| | | Post | 110 | 1 | |
| | Fossil | Pre | 106 | 7 | **0,016*** |
| | | Post | 110 | 0 | |

| | | | | | |
|---|---|---|---|---|---|
| | Fungi | Pre | 106 | 1 | 1,000 |
| | | Post | 110 | 0 | |
| | Future | Pre | 106 | 1 | 1,000 |
| | | Post | 110 | 0 | |
| | General Knowledge | Pre | 106 | 2 | 0,500 |
| | | Post | 110 | 0 | |
| | Genetics | Pre | 106 | 0 | 0,500 |
| | | Post | 110 | 2 | |
| | Genetic variability | Pre | 106 | 0 | 0,500 |
| | | Post | 110 | 2 | |
| | Geology | Pre | 106 | 1 | 1,000 |
| | | Post | 110 | 0 | |
| | Heartbeat | Pre | 106 | 0 | **<0,001*** |
| | | Post | 110 | 16 | |
| | Hiroshima | Pre | 106 | 0 | 0,250 |
| | | Post | 110 | 3 | |
| | History | Pre | 106 | 1 | 1,000 |
| | | Post | 110 | 1 | |
| | Homology | Pre | 106 | 0 | 0,063 |
| | | Post | 110 | 5 | |
| | Horns | Pre | 106 | 0 | 0,500 |
| | | Post | 110 | 2 | |
| | Human | Pre | 106 | 3 | 0,625 |
| | | Post | 110 | 1 | |
| | Human impact | Pre | 106 | 3 | 0,625 |
| | | Post | 110 | 1 | |
| | Hummingbird | Pre | 106 | 0 | 0,500 |
| | | Post | 110 | 2 | |
| | Interdigital webbing | Pre | 106 | 0 | 1,000 |
| | | Post | 110 | 1 | |
| | Intraspecific diversity | Pre | 106 | 0 | 0,250 |
| | | Post | 110 | 3 | |
| | Kingdom (biology) | Pre | 106 | 1 | 1,000 |
| | | Post | 110 | 0 | |
| | Knowledge | Pre | 106 | 27 | **0,002*** |
| | | Post | 110 | 9 | |
| | Leaves (plant) | Pre | 106 | 0 | 0,250 |
| | | Post | 110 | 3 | |
| | Lifestyle | Pre | 106 | 1 | 1,000 |
| | | Post | 110 | 0 | |
| | Living beings | Pre | 106 | 31 | **0,043*** |
| | | Post | 110 | 18 | |

| | | | | | |
|---|---|---|---|---|---|
| | Maize | Pre | 106 | 0 | 0,500 |
| | | Post | 110 | 2 | |
| | Male | Pre | 106 | 0 | 0,250 |
| | | Post | 110 | 3 | |
| | Mammal | Pre | 106 | 0 | **0,008*** |
| | | Post | 110 | 8 | |
| | Mammoth | Pre | 106 | 0 | 1,000 |
| | | Post | 110 | 1 | |
| | Mexico | Pre | 106 | 0 | 1,000 |
| | | Post | 110 | 1 | |
| | Mimicry | Pre | 106 | 0 | 1,000 |
| | | Post | 110 | 1 | |
| | Native biodiversity | Pre | 106 | 1 | 1,000 |
| | | Post | 110 | 0 | |
| | Natural selection | Pre | 106 | 0 | 0,500 |
| | | Post | 110 | 2 | |
| | Nature | Pre | 106 | 1 | 1,000 |
| | | Post | 110 | 0 | |
| | Organ | Pre | 106 | 0 | 0,500 |
| | | Post | 110 | 2 | |
| | Origin | Pre | 106 | 1 | 1,000 |
| | | Post | 110 | 0 | |
| | Ostrich | Pre | 106 | 0 | 1,000 |
| | | Post | 110 | 1 | |
| | Owl | Pre | 106 | 0 | 1,000 |
| | | Post | 110 | 1 | |
| | Ox | Pre | 106 | 0 | 1,000 |
| | | Post | 110 | 1 | |
| | Past (time) | Pre | 106 | 3 | 0,625 |
| | | Post | 110 | 1 | |
| | Photographs | Pre | 106 | 3 | 0,250 |
| | | Post | 110 | 0 | |
| | Phylogeny | Pre | 106 | 1 | 1,000 |
| | | Post | 110 | 0 | |
| | Plants | Pre | 106 | 9 | 0,109 |
| | | Post | 110 | 3 | |
| | Portugal | Pre | 106 | 1 | 0,625 |
| | | Post | 110 | 3 | |
| | Predator | Pre | 106 | 0 | 1,000 |
| | | Post | 110 | 1 | |
| | Present (time) | Pre | 106 | 1 | 1,000 |
| | | Post | 110 | 0 | |

| | | | | | |
|---|---|---|---|---|---|
| | Preservation | Pre | 106 | 14 | 0,077 |
| | | Post | 110 | 6 | |
| | Prey | Pre | 106 | 0 | 1,000 |
| | | Post | 110 | 1 | |
| | Rabbit | Pre | 106 | 0 | 1,000 |
| | | Post | 110 | 1 | |
| | Reproduction | Pre | 106 | 0 | 0,250 |
| | | Post | 110 | 3 | |
| | Research | Pre | 106 | 1 | 1,000 |
| | | Post | 110 | 0 | |
| | Rhino | Pre | 106 | 0 | 1,000 |
| | | Post | 110 | 1 | |
| | Rocks | Pre | 106 | 1 | 1,000 |
| | | Post | 110 | 0 | |
| | Salamander | Pre | 106 | 0 | 0,250 |
| | | Post | 110 | 3 | |
| | Science | Pre | 106 | 0 | 1,000 |
| | | Post | 110 | 1 | |
| | Scientific instruments | Pre | 106 | 1 | 1,000 |
| | | Post | 110 | 0 | |
| | Scientists | Pre | 106 | 1 | 1,000 |
| | | Post | 110 | 0 | |
| | Sculptures | Pre | 106 | 1 | 1,000 |
| | | Post | 110 | 0 | |
| | Seeds | Pre | 106 | 1 | 1,000 |
| | | Post | 110 | 0 | |
| | Sexual selection | Pre | 106 | 0 | 0,250 |
| | | Post | 110 | 3 | |
| | Shape | Pre | 106 | 0 | 0,250 |
| | | Post | 110 | 3 | |
| | Similarities | Pre | 106 | 0 | 0,500 |
| | | Post | 110 | 2 | |
| | Skull | Pre | 106 | 0 | 1,000 |
| | | Post | 110 | 1 | |
| | Snail | Pre | 106 | 0 | 0,250 |
| | | Post | 110 | 3 | |
| | Snake | Pre | 106 | 0 | 0,500 |
| | | Post | 110 | 2 | |
| | Species | Pre | 106 | 46 | **0,002*** |
| | | Post | 110 | 25 | |
| | Survival | Pre | 106 | 0 | 0,500 |
| | | Post | 110 | 2 | |

| | | | | | |
|---|---|---|---|---|---|
| | Taxidermy | Pre | 106 | 0 | 1,000 |
| | | Post | 110 | 1 | |
| | Terrestrial animals | Pre | 106 | 0 | 0,500 |
| | | Post | 110 | 2 | |
| | Toad | Pre | 106 | 0 | 1,000 |
| | | Post | 110 | 1 | |
| | Trait | Pre | 106 | 2 | 0,687 |
| | | Post | 110 | 4 | |
| | Tree | Pre | 106 | 0 | 1,000 |
| | | Post | 110 | 1 | |
| | Vestigial structure | Pre | 106 | 0 | 1,000 |
| | | Post | 110 | 1 | |
| | Whale | Pre | 106 | 0 | 0,063 |
| | | Post | 110 | 5 | |
| | Wolf | Pre | 106 | 0 | 0,500 |
| | | Post | 110 | 2 | |

*n* - number of observations. *p* - p-value (2-tailed). *Results were considered statistically significant for *p* <0,05. Note: n=105 was considered in each group by applying a test-by-test exclusion.

| **Question** | **Notion** | **Pre/Post/Control** | ***n*** | **Absolute frequency** | **Fisher's exact test** |
|---|---|---|---|---|---|
| | | | | | ***p*** |
| | Anatomy | Pre | 106 | 1 | 1,000 |
| | | Control | 19 | 0 | |
| | Animals | Pre | 106 | 9 | 0,674 |
| | | Control | 19 | 2 | |
| | Biodiversity | Pre | 106 | 38 | 0,614 |
| | | Control | 19 | 8 | |
| | Biology | Pre | 106 | 1 | 1,000 |
| | | Control | 19 | 0 | |
| | Biosphere | Pre | 106 | 1 | 1,000 |
| | | Control | 19 | 0 | |
| | Discoveries | Pre | 106 | 0 | 0,152 |
| | | Control | 19 | 1 | |
| | Diversity | Pre | 106 | 54 | 0,140 |

| | | | | | |
|---|---|---|---|---|---|
| | | Control | 19 | 6 | |
| | Earth | Pre | 106 | 8 | 0,648 |
| | | Control | 19 | 2 | |
| | Environment | Pre | 106 | 2 | 1,000 |
| | | Control | 19 | 0 | |
| | Evidences | Pre | 106 | 13 | 0,215 |
| | | Control | 19 | 0 | |
| | Evolution | Pre | 106 | 5 | 0,288 |
| | | Control | 19 | 2 | |
| | Extinction | Pre | 106 | 5 | 0,102 |
| | | Control | 19 | 3 | |
| | Fossil | Pre | 106 | 7 | 1,000 |
| | | Control | 19 | 1 | |
| | Fungi | Pre | 106 | 1 | 1,000 |
| | | Control | 19 | 0 | |
| | Future | Pre | 106 | 1 | 1,000 |
| | | Control | 19 | 0 | |
| | General Knowledge | Pre | 106 | 2 | 1,000 |
| | | Control | 19 | 0 | |
| | Geology | Pre | 106 | 1 | 1,000 |
| | | Control | 19 | 0 | |
| | Habitat | Pre | 106 | 0 | 0,152 |
| | | Control | 19 | 1 | |
| | History | Pre | 106 | 1 | 0,282 |
| | | Control | 19 | 1 | |
| | Human | Pre | 106 | 3 | 0,165 |
| | | Control | 19 | 2 | |
| | Human impact | Pre | 106 | 3 | 0,487 |
| | | Control | 19 | 1 | |
| | Kingdom (biology) | Pre | 106 | 1 | 1,000 |
| | | Control | 19 | 0 | |
| | Knowledge | Pre | 106 | 28 | 0,072 |
| | | Control | 19 | 1 | |
| | Lifestyle | Pre | 106 | 1 | 1,000 |
| | | Control | 19 | 0 | |
| | Living beings | Pre | 106 | 32 | 0,596 |
| | | Control | 19 | 7 | |
| | Native biodiversity | Pre | 106 | 1 | 1,000 |
| | | Control | 19 | 0 | |
| | Nature | Pre | 106 | 1 | 0,282 |
| | | Control | 19 | 1 | |
| | Origin | Pre | 106 | 1 | 1,000 |

| | | | | | |
|---|---|---|---|---|---|
| | | Control | 19 | 0 | |
| | Paintings | Pre | 106 | 0 | 0,152 |
| | | Control | 19 | 1 | |
| | Past (time) | Pre | 106 | 3 | 1,000 |
| | | Control | 19 | 0 | |
| | Photographs | Pre | 106 | 3 | 0,165 |
| | | Control | 19 | 2 | |
| | Phylogeny | Pre | 106 | 1 | 1,000 |
| | | Control | 19 | 0 | |
| | Plants | Pre | 106 | 9 | 0,674 |
| | | Control | 19 | 2 | |
| | Portugal | Pre | 106 | 1 | 1,000 |
| | | Control | 19 | 0 | |
| | Posters | Pre | 106 | 0 | 0,152 |
| | | Control | 19 | 1 | |
| | Present (time) | Pre | 106 | 1 | 1,000 |
| | | Control | 19 | 0 | |
| | Preservation | Pre | 106 | 14 | 0,475 |
| | | Control | 19 | 4 | |
| | Research | Pre | 106 | 1 | **0,011*** |
| | | Control | 19 | 3 | |
| | Rocks | Pre | 106 | 1 | 1,000 |
| | | Control | 19 | 0 | |
| | Scientific instruments | Pre | 106 | 1 | 1,000 |
| | | Control | 19 | 0 | |
| | Scientists | Pre | 106 | 1 | 0,282 |
| | | Control | 19 | 1 | |
| | Sculptures | Pre | 106 | 1 | 1,000 |
| | | Control | 19 | 0 | |
| | Seeds | Pre | 106 | 1 | 1,000 |
| | | Control | 19 | 0 | |
| | Species | Pre | 106 | 47 | 0,206 |
| | | Control | 19 | 5 | |
| | Trait | Pre | 106 | 2 | 1,000 |
| | | Control | 19 | 0 | |
| | Zoo | Pre | 106 | 0 | 0,152 |
| | | Control | 19 | 1 | |

*n* - number of observations. *p* - p-value (2-tailed). *Results were considered statistically significant for *p* <0,05.

| Question | Notion | Pre/Post/Control | *n* | Absolute frequency | McNemar test *p* |
|---|---|---|---|---|---|
| A2 | Adaptation | Post | 110 | 1 | 1,000 |
| | | Control | 19 | 0 | |
| | Advantage (ecology) | Post | 110 | 1 | 1,000 |
| | | Control | 19 | 0 | |
| | Aesthetics | Post | 110 | 1 | 1,000 |
| | | Control | 19 | 0 | |
| | Analogy | Post | 110 | 3 | 1,000 |
| | | Control | 19 | 0 | |
| | Ancestor | Post | 110 | 3 | 1,000 |
| | | Control | 19 | 0 | |
| | Animals | Post | 110 | 37 | 0,057 |
| | | Control | 19 | 2 | |
| | Antlers | Post | 110 | 2 | 1,000 |
| | | Control | 19 | 0 | |
| | Aquatic mammal | Post | 110 | 2 | 1,000 |
| | | Control | 19 | 0 | |
| | Bee | Post | 110 | 3 | 1,000 |
| | | Control | 19 | 0 | |
| | Biodiversity | Post | 110 | 11 | **0,001*** |
| | | Control | 19 | 8 | |
| | Biology | Post | 110 | 2 | 1,000 |
| | | Control | 19 | 0 | |
| | Bird | Post | 110 | 3 | 1,000 |
| | | Control | 19 | 0 | |
| | Body size | Post | 110 | 10 | 0,356 |
| | | Control | 19 | 0 | |
| | Bone structure | Post | 110 | 1 | 1,000 |
| | | Control | 19 | 0 | |
| | Chicken | Post | 110 | 1 | 1,000 |
| | | Control | 19 | 0 | |
| | Colour | Post | 110 | 1 | 1,000 |
| | | Control | 19 | 0 | |
| | Deer | Post | 110 | 2 | 1,000 |
| | | Control | 19 | 0 | |
| | Dinosaurs | Post | 110 | 1 | 1,000 |
| | | Control | 19 | 0 | |
| | Disadvantage (ecology) | Post | 110 | 1 | 1,000 |
| | | Control | 19 | 0 | |

| | | | | | |
|---|---|---|---|---|---|
| | Discoveries | Post | 110 | 0 | 0,147 |
| | | Control | 19 | 1 | |
| | Diversity | Post | 110 | 45 | 0,612 |
| | | Control | 19 | 6 | |
| | Ears | Post | 110 | 1 | 1,000 |
| | | Control | 19 | 0 | |
| | Earth | Post | 110 | 6 | 0,335 |
| | | Control | 19 | 2 | |
| | Economy | Post | 110 | 2 | 1,000 |
| | | Control | 19 | 0 | |
| | Ecosystem | Post | 110 | 1 | 1,000 |
| | | Control | 19 | 0 | |
| | Eggs | Post | 110 | 18 | 0,073 |
| | | Control | 19 | 0 | |
| | Environment | Post | 110 | 1 | 1,000 |
| | | Control | 19 | 0 | |
| | Environmental changes | Post | 110 | 1 | 1,000 |
| | | Control | 19 | 0 | |
| | Ethics | Post | 110 | 3 | 1,000 |
| | | Control | 19 | 0 | |
| | Evidences | Post | 110 | 1 | 1,000 |
| | | Control | 19 | 0 | |
| | Evolution | Post | 110 | 8 | 0,641 |
| | | Control | 19 | 2 | |
| | Extinction | Post | 110 | 0 | **0,003*** |
| | | Control | 19 | 3 | |
| | Eyes | Post | 110 | 2 | 1,000 |
| | | Control | 19 | 0 | |
| | Eyesight | Post | 110 | 42 | **<0,001*** |
| | | Control | 19 | 0 | |
| | Female | Post | 110 | 2 | 1,000 |
| | | Control | 19 | 0 | |
| | Fish | Post | 110 | 1 | 1,000 |
| | | Control | 19 | 0 | |
| | Fossil | Post | 110 | 0 | 0,147 |
| | | Control | 19 | 1 | |
| | Genetics | Post | 110 | 2 | 1,000 |
| | | Control | 19 | 0 | |
| | Genetic variability | Post | 110 | 2 | 1,000 |
| | | Control | 19 | 0 | |
| | Habitat | Post | 110 | 0 | 0,147 |
| | | Control | 19 | 1 | |

| | | | | | |
|---|---|---|---|---|---|
| | Heartbeat | Post | 110 | 17 | 0,075 |
| | | Control | 19 | 0 | |
| | Hiroshima | Post | 110 | 3 | 1,000 |
| | | Control | 19 | 0 | |
| | History | Post | 110 | 1 | 0,274 |
| | | Control | 19 | 1 | |
| | Homology | Post | 110 | 5 | 1,000 |
| | | Control | 19 | 0 | |
| | Horns | Post | 110 | 2 | 1,000 |
| | | Control | 19 | 0 | |
| | Human | Post | 110 | 3 | 0,157 |
| | | Control | 19 | 2 | |
| | Human impact | Post | 110 | 2 | 0,382 |
| | | Control | 19 | 1 | |
| | Hummingbird | Post | 110 | 2 | 1,000 |
| | | Control | 19 | 0 | |
| | Interdigital webbing | Post | 110 | 1 | 1,000 |
| | | Control | 19 | 0 | |
| | Intraspecific diversity | Post | 110 | 3 | 1,000 |
| | | Control | 19 | 0 | |
| | Knowledge | Post | 110 | 9 | 1,000 |
| | | Control | 19 | 1 | |
| | Leaves (plant) | Post | 110 | 3 | 1,000 |
| | | Control | 19 | 0 | |
| | Living beings | Post | 110 | 19 | 0,064 |
| | | Control | 19 | 7 | |
| | Maize | Post | 110 | 2 | 1,000 |
| | | Control | 19 | 0 | |
| | Male | Post | 110 | 3 | 1,000 |
| | | Control | 19 | 0 | |
| | Mammal | Post | 110 | 8 | 0,603 |
| | | Control | 19 | 0 | |
| | Mammoth | Post | 110 | 1 | 1,000 |
| | | Control | 19 | 0 | |
| | Mexico | Post | 110 | 1 | 1,000 |
| | | Control | 19 | 0 | |
| | Mimicry | Post | 110 | 1 | 1,000 |
| | | Control | 19 | 0 | |
| | Natural selection | Post | 110 | 2 | 1,000 |
| | | Control | 19 | 0 | |
| | Nature | Post | 110 | 0 | 0,147 |
| | | Control | 19 | 1 | |

| | | | | | |
|---|---|---|---|---|---|
| | Organ | Post | 110 | 2 | 1,000 |
| | | Control | 19 | 0 | |
| | Ostrich | Post | 110 | 1 | 1,000 |
| | | Control | 19 | 0 | |
| | Owl | Post | 110 | 1 | 1,000 |
| | | Control | 19 | 0 | |
| | Ox | Post | 110 | 1 | 1,000 |
| | | Control | 19 | 0 | |
| | Paintings | Post | 110 | 0 | 0,147 |
| | | Control | 19 | 1 | |
| | Past (time) | Post | 110 | 1 | 1,000 |
| | | Control | 19 | 0 | |
| | Photographs | Post | 110 | 0 | **0,021*** |
| | | Control | 19 | 2 | |
| | Plants | Post | 110 | 3 | 0,157 |
| | | Control | 19 | 2 | |
| | Portugal | Post | 110 | 3 | 1,000 |
| | | Control | 19 | 0 | |
| | Posters | Post | 110 | 0 | 0,147 |
| | | Control | 19 | 1 | |
| | Predator | Post | 110 | 1 | 1,000 |
| | | Control | 19 | 0 | |
| | Preservation | Post | 110 | 6 | **0,040*** |
| | | Control | 19 | 4 | |
| | Prey | Post | 110 | 1 | 1,000 |
| | | Control | 19 | 0 | |
| | Rabbit | Post | 110 | 1 | 1,000 |
| | | Control | 19 | 0 | |
| | Reproduction | Post | 110 | 3 | 1,000 |
| | | Control | 19 | 0 | |
| | Research | Post | 110 | 0 | **0,003*** |
| | | Control | 19 | 3 | |
| | Rhino | Post | 110 | 1 | 1,000 |
| | | Control | 19 | 0 | |
| | Salamander | Post | 110 | 3 | 1,000 |
| | | Control | 19 | 0 | |
| | Science | Post | 110 | 1 | 1,000 |
| | | Control | 19 | 0 | |
| | Scientists | Post | 110 | 0 | 0,147 |
| | | Control | 19 | 1 | |
| | Sexual selection | Post | 110 | 3 | 1,000 |
| | | Control | 19 | 0 | |

| | | | | | |
|---|---|---|---|---|---|
| | Shape | Post | 110 | 3 | 1,000 |
| | | Control | 19 | 0 | |
| | Similarities | Post | 110 | 2 | 1,000 |
| | | Control | 19 | 0 | |
| | Skull | Post | 110 | 1 | 1,000 |
| | | Control | 19 | 0 | |
| | Snail | Post | 110 | 3 | 1,000 |
| | | Control | 19 | 0 | |
| | Snake | Post | 110 | 2 | 1,000 |
| | | Control | 19 | 0 | |
| | Species | Post | 110 | 27 | 1,000 |
| | | Control | 19 | 5 | |
| | Survival | Post | 110 | 2 | 1,000 |
| | | Control | 19 | 0 | |
| | Taxidermy | Post | 110 | 2 | 1,000 |
| | | Control | 19 | 0 | |
| | Terrestrial animals | Post | 110 | 2 | 1,000 |
| | | Control | 19 | 0 | |
| | Toad | Post | 110 | 1 | 1,000 |
| | | Control | 19 | 0 | |
| | Trait | Post | 110 | 4 | 1,000 |
| | | Control | 19 | 0 | |
| | Tree | Post | 110 | 1 | 1,000 |
| | | Control | 19 | 0 | |
| | Vestigial structure | Post | 110 | 1 | 1,000 |
| | | Control | 19 | 0 | |
| | Whale | Post | 110 | 6 | 0,591 |
| | | Control | 19 | 0 | |
| | Wolf | Post | 110 | 2 | 1,000 |
| | | Control | 19 | 0 | |

*n* - number of observations. *p* - p-value (2-tailed). *Results were considered statistically significant for *p* <0,05.

**Appendix N –** Gender comparisons of the questionnaire items C1, C2, C3, C4, C5 and A1.

| Q | Pre/ Post/ Cont. | G | Descriptive statistics | | | | Independent-samples *t*-test | | | Effect size | Mann-Whitney U test | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | *n* | *M* | *SD* | *Md n* | *t* | *df* | *p* | Cohen's *d* | *U* | *z* | *p* |
| **C1** | Pre | f | 67 | 2,81 | 0,500 | 3 | -1,480 | 107,70 [a] | 0,142 | 0,257 | 1468 | -1,082 | 0,279 |
| | | m | 47 | 2,91 | 0,282 | 3 | | | | | | | |
| | Post | f | 67 | 2,94 | 0,239 | 3 | 0,812 | 112 | 0,419 | 0,154 | 1533 | -0,546 | 0,585 |
| | | m | 47 | 2,89 | 0,375 | 3 | | | | | | | |
| | Cont. | f | 9 | 2,78 | 0,441 | 3 | -0,112 | 17 | 0,912 | 0,052 | 44 | -0,115 | 0,908 |
| | | m | 10 | 2,80 | 0,422 | 3 | | | | | | | |
| **C2** | Pre | f | 64 | 6,00 | 2,078 | 6 | 0,128 | 108,44 [a] | 0,904 | 0,023 | 1440 | -0,406 | 0,685 |
| | | m | 47 | 5,96 | 1,414 | 6 | | | | | | | |
| | Post | f | 67 | 6,18 | 2,110 | 6 | -0,237 | 110,39 [a] | 0,813 | 0,043 | 1510 | -0,194 | 0,846 |
| | | m | 46 | 6,26 | 1,555 | 6 | | | | | | | |
| | Cont. | f | 9 | 6,22 | 1,202 | 6 | 0,032 | 17 | 0,975 | 0,015 | 42 | -0,286 | 0,775 |
| | | m | 10 | 6,20 | 1,751 | 6 | | | | | | | |
| **C3** | Pre | f | 67 | 1,45 | 0,702 | 1 | -0,365 | 111 | 0,716 | 0,070 | 1535 | -0,043 | 0,966 |
| | | m | 46 | 1,50 | 0,810 | 1 | | | | | | | |
| | Post | f | 67 | 1,82 | 0,886 | 2 | 0,195 | 112 | 0,845 | 0,037 | 1531 | -0,279 | 0,780 |
| | | m | 47 | 1,79 | 0,931 | 1 | | | | | | | |
| | Cont. | f | 9 | 1,89 | 0,782 | 2 | 0,470 | 17 | 0,644 | 0,216 | 38 | -0,616 | 0,538 |
| | | m | 10 | 1,70 | 0,949 | 1 | | | | | | | |
| **C4** | Pre | f | 21 | 3,62 | 3,170 | 2 | -2,351 | 28,18[a] | **0,026 *** | 0,770 | 68 | -1,921 | **0,055 *** |
| | | m | 11 | 5,82 | 2,089 | 6 | | | | | | | |
| | Post | f | 28 | 3,79 | 2,833 | 2 | -2,168 | 46 | **0,035 *** | 0,635 | 173 | -2,306 | **0,021 *** |
| | | m | 20 | 5,40 | 2,062 | 5 | | | | | | | |
| | Cont. | f | 6 | 3,17 | 2,563 | 3 | 0,335 | 8 | 0,746 | 0,217 | 10 | -0,543 | 0,587 |
| | | m | 4 | 2,50 | 3,786 | 1 | | | | | | | |
| **C5a)** | Pre | f | 62 | 0,89 | 0,319 | 1 | 0,053 | 103 | 0,958 | 0,011 | 1329 | -0,053 | 0,958 |
| | | m | 43 | 0,88 | 0,324 | 1 | | | | | | | |
| | Post | f | 66 | 0,94 | 0,240 | 1 | 0,497 | 111 | 0,620 | 0,095 | 1513 | -0,498 | 0,618 |
| | | m | 47 | 0,91 | 0,282 | 1 | | | | | | | |
| | Cont. | f | 6 | 0,83 | 0,408 | 1 | 0,564 | 14 | 0,582 | 0,291 | 26 | -0,577 | 0,564 |
| | | m | 10 | 0,70 | 0,483 | 1 | | | | | | | |
| **C5b)** | Pre | f | 67 | 0,96 | 0,208 | 1 | 0,445 | 112 | 0,657 | 0,085 | 1545 | -0,446 | 0,655 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | m | 47 | 0,94 | 0,247 | 1 | | | | | | | |
| | Post | f | 67 | 0,99 | 0,122 | 1 | 0,923 | 111 | 0,358 | 0,177 | 1497 | -0,923 | 0,356 |
| | | m | 46 | 0,96 | 0,206 | 1 | | | | | | | |
| | Cont. | f | 8 | 1,00 | 0,000 | 1 | N.A. | N.A. | N.A. | N.A. | 40 | 0,000 | 1,000 |
| | | m | 10 | 1,00 | 0,000 | 1 | | | | | | | |
| **C5c)** | Pre | f | 63 | 0,97 | 0,177 | 1 | 1,141 | 72,29[a] | 0,258 | 0,234 | 1402 | -1,214 | 0,225 |
| | | m | 47 | 0,91 | 0,282 | 1 | | | | | | | |
| | Post | f | 65 | 0,95 | 0,211 | 1 | -0,042 | 108 | 0,967 | 0,008 | 1460 | -0,042 | 0,966 |
| | | m | 45 | 0,96 | 0,208 | 1 | | | | | | | |
| | Cont. | f | 9 | 1,00 | 0,000 | 1 | 1,000 | 9,00[a] | 0,343 | 0,435 | 41 | -0,949 | 0,343 |
| | | m | 10 | 0,90 | 0,316 | 1 | | | | | | | |
| **C5d)** | Pre | f | 66 | 1,00 | 0,000 | 1 | N.A. | N.A. | N.A. | N.A. | 1518 | 0,000 | 1,000 |
| | | m | 46 | 1,00 | 0,000 | 1 | | | | | | | |
| | Post | f | 66 | 1,00 | 0,000 | 1 | N.A. | N.A. | N.A. | N.A. | 1551 | 0,000 | 1,000 |
| | | m | 47 | 1,00 | 0,000 | 1 | | | | | | | |
| | Cont. | f | 9 | 1,00 | 0,000 | 1 | N.A. | N.A. | N.A. | N.A. | 45 | 0,000 | 1,000 |
| | | m | 10 | 1,00 | 0,000 | 1 | | | | | | | |
| **C5e)** | Pre | f | 65 | 0,95 | 0,211 | 1 | -1,760 | 64,00[a] | 0,083 | 0,286 | 1457 | -1,486 | 0,137 |
| | | m | 47 | 1,00 | 0,000 | 1 | | | | | | | |
| | Post | f | 67 | 0,97 | 0,171 | 1 | -1,425 | 66,00[a] | 0,159 | 0,227 | 1528 | -1,190 | 0,234 |
| | | m | 47 | 1,00 | 0,000 | 1 | | | | | | | |
| | Cont. | f | 8 | 0,88 | 0,354 | 1 | -0,083 | 15 | 0,935 | 0,041 | 36 | -0,086 | 0,931 |
| | | m | 9 | 0,89 | 0,333 | 1 | | | | | | | |
| **A1a)** | Pre | f | 67 | 5,00 | 0,000 | 5 | 1,000 | 46,00[a] | 0,323 | 0,228 | 1541 | -1,194 | 0,232 |
| | | m | 47 | 4,98 | 0,146 | 5 | | | | | | | |
| | Post | f | 67 | 4,97 | 0,171 | 5 | -0,279 | 112 | 0,781 | 0,053 | 1561 | -0,280 | 0,779 |
| | | m | 47 | 4,98 | 0,146 | 5 | | | | | | | |
| | Cont. | f | 9 | 4,89 | 0,333 | 5 | 0,565 | 17 | 0,579 | 0,260 | 45 | 0,000 | 1,000 |
| | | m | 10 | 4,70 | 0,949 | 5 | | | | | | | |
| **A1b)** | Pre | f | 67 | 3,85 | 0,857 | 4 | 2,142 | 85,11[a] | **0,035 *** | 0,424 | 1210 | -2,070 | **0,038 *** |
| | | m | 46 | 3,46 | 1,026 | 4 | | | | | | | |
| | Post | f | 66 | 3,88 | 0,832 | 4 | -0,342 | 111 | 0,733 | 0,065 | 1472 | -0,493 | 0,622 |
| | | m | 47 | 3,94 | 0,942 | 4 | | | | | | | |
| | Cont. | f | 9 | 4,11 | 1,167 | 5 | 2,294 | 17 | **0,035 *** | 1,054 | 21 | -2,039 | **0,041 *** |
| | | m | 10 | 3,00 | 0,943 | 3 | | | | | | | |
| **A1c)** | Pre | f | 67 | 3,91 | 0,981 | 4 | 0,600 | 108 | 0,550 | 0,117 | 1357 | -0,547 | 0,584 |
| | | m | 43 | 3,79 | 1,081 | 4 | | | | | | | |
| | Post | f | 67 | 4,21 | 0,930 | 4 | 0,583 | 111 | 0,561 | 0,112 | 1397 | -0,909 | 0,363 |
| | | m | 46 | 4,11 | 0,849 | 4 | | | | | | | |
| | Cont. | f | 9 | 4,67 | 0,500 | 5 | 1,636 | 15 | 0,123 | 0,795 | 23 | -1,443 | 0,149 |
| | | m | 8 | 3,88 | 1,356 | 4 | | | | | | | |
| **A1d)** | Pre | f | 67 | 4,37 | 0,735 | 4 | -0,434 | 111 | 0,665 | 0,083 | 1454 | -0,573 | 0,567 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | m | 46 | 4,43 | 0,750 | 5 | | | | | | | |
| | Post | f | 67 | 4,43 | 0,743 | 5 | -0,427 | 112 | 0,670 | 0,081 | 1540 | -0,229 | 0,819 |
| | | m | 47 | 4,49 | 0,621 | 5 | | | | | | | |
| | Cont. | f | 9 | 3,89 | 0,928 | 4 | 0,909 | 17 | 0,376 | 0,418 | 37 | -0,775 | 0,438 |
| | | m | 10 | 3,40 | 1,350 | 4 | | | | | | | |
| **A1e)** | Pre | f | 67 | 4,45 | 0,858 | 5 | -0,881 | 112 | 0,380 | 0,168 | 1521 | -0,358 | 0,721 |
| | | m | 47 | 4,57 | 0,580 | 5 | | | | | | | |
| | Post | f | 67 | 4,46 | 0,841 | 5 | -1,075 | 112 | 0,285 | 0,205 | 1442 | -0,899 | 0,369 |
| | | m | 47 | 4,62 | 0,610 | 5 | | | | | | | |
| | Cont. | f | 9 | 4,11 | 1,054 | 4 | 0,021 | 17 | 0,983 | 0,010 | 45 | -0,044 | 0,965 |
| | | m | 10 | 4,10 | 1,197 | 4 | | | | | | | |
| **A1f)** | Pre | f | 63 | 4,56 | 0,929 | 5 | 0,491 | 104 | 0,625 | 0,097 | 1266 | -0,701 | 0,483 |
| | | m | 43 | 4,47 | 0,935 | 5 | | | | | | | |
| | Post | f | 67 | 4,64 | 0,690 | 5 | 0,532 | 111 | 0,596 | 0,102 | 1501 | -0,298 | 0,766 |
| | | m | 46 | 4,57 | 0,834 | 5 | | | | | | | |
| | Cont. | f | 8 | 4,50 | 0,535 | 5 | -1,333 | 16 | 0,201 | 0,632 | 28 | -1,304 | 0,192 |
| | | m | 10 | 4,80 | 0,422 | 5 | | | | | | | |
| **A1g)** | Pre | f | 67 | 4,55 | 0,784 | 5 | -0,985 | 112 | 0,327 | 0,187 | 1477 | -0,687 | 0,492 |
| | | m | 47 | 4,68 | 0,515 | 5 | | | | | | | |
| | Post | f | 67 | 4,82 | 0,424 | 5 | 1,810 | 82,86[a] | 0,074 | 0,361 | 1294 | -1,979 | **0,048 *** |
| | | m | 46 | 4,65 | 0,526 | 5 | | | | | | | |
| | Cont. | f | 8 | 4,88 | 0,354 | 5 | 1,337 | 15,71[a] | 0,200 | 0,608 | 29 | -1,258 | 0,208 |
| | | m | 10 | 4,60 | 0,516 | 5 | | | | | | | |
| **A1h)** | Pre | f | 67 | 4,82 | 0,716 | 5 | -0,653 | 112 | 0,515 | 0,124 | 1553 | -0,242 | 0,809 |
| | | m | 47 | 4,89 | 0,312 | 5 | | | | | | | |
| | Post | f | 67 | 4,91 | 0,288 | 5 | 0,959 | 65,46[a] | 0,341 | 0,201 | 1512 | -0,682 | 0,495 |
| | | m | 47 | 4,83 | 0,524 | 5 | | | | | | | |
| | Cont. | f | 8 | 5,00 | 0,000 | 5 | 0,889 | 16 | 0,387 | 0,422 | 36 | -0,894 | 0,371 |
| | | m | 10 | 4,90 | 0,316 | 5 | | | | | | | |
| **A1i)** | Pre | f | 67 | 4,90 | 0,431 | 5 | 1,095 | 112 | 0,276 | 0,208 | 1395 | -1,817 | 0,069 |
| | | m | 47 | 4,81 | 0,398 | 5 | | | | | | | |
| | Post | f | 67 | 4,88 | 0,327 | 5 | 1,547 | 81,77[a] | 0,126 | 0,308 | 1394 | -1,610 | 0,107 |
| | | m | 47 | 4,77 | 0,428 | 5 | | | | | | | |
| | Cont. | f | 9 | 4,78 | 0,441 | 5 | 0,654 | 17 | 0,522 | 0,300 | 41 | -0,477 | 0,633 |
| | | m | 10 | 4,60 | 0,699 | 5 | | | | | | | |
| **A1j)** | Pre | f | 67 | 4,82 | 0,386 | 5 | 2,528 | 62,05[a] | **0,014 *** | 0,536 | 1236 | -2,548 | **0,011 *** |
| | | m | 47 | 4,51 | 0,777 | 5 | | | | | | | |
| | Post | f | 67 | 4,76 | 0,495 | 5 | 0,621 | 112 | 0,536 | 0,118 | 1474 | -0,783 | 0,434 |
| | | m | 47 | 4,70 | 0,507 | 5 | | | | | | | |
| | Cont. | f | 9 | 4,67 | 0,500 | 5 | 0,236 | 17 | 0,816 | 0,109 | 45 | 0,000 | 1,000 |
| | | m | 10 | 4,60 | 0,699 | 5 | | | | | | | |
| **A1k)** | Pre | f | 63 | 4,17 | 0,925 | 4 | -1,518 | 106 | 0,132 | 0,296 | 1241 | -1,212 | 0,225 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | m | 45 | 4,42 | 0,690 | 5 | | | | | | | |
| | Post | f | 63 | 4,29 | 0,851 | 4 | -1,082 | 108 | 0,282 | 0,208 | 1371 | -0,739 | 0,460 |
| | | m | 47 | 4,45 | 0,653 | 5 | | | | | | | |
| | Cont. | f | 7 | 4,29 | 0,488 | 4 | 0,648 | 13 | 0,528 | 0,335 | 26 | -0,321 | 0,748 |
| | | m | 8 | 4,00 | 1,069 | 4 | | | | | | | |
| **A1l)** | Pre | f | 61 | 4,52 | 0,595 | 5 | 1,459 | 63,47[a] | 0,149 | 0,315 | 1195 | -0,876 | 0,381 |
| | | m | 43 | 4,28 | 0,984 | 5 | | | | | | | |
| | Post | f | 62 | 4,55 | 0,803 | 5 | 0,921 | 106 | 0,359 | 0,179 | 1212 | -1,535 | 0,125 |
| | | m | 46 | 4,41 | 0,686 | 5 | | | | | | | |
| | Cont. | f | 6 | 4,83 | 0,408 | 5 | 0,155 | 14 | 0,879 | 0,080 | 29 | -0,160 | 0,873 |
| | | m | 10 | 4,80 | 0,422 | 5 | | | | | | | |

Q – Question. Cont. – Control. G – Gender. f – Female. m – Male. *n* - number of observations. *M* - Mean. *SD* - Standard deviation. *Mdn* - Median. *t*- t-value. *df* - degrees of freedom. *U* - Mann-Whitney U value. *z* - z-value. *p* - p-value (2-tailed). *Results were considered statistically significant for $p < 0,05$. [a]Levene's Test for Equality of Variances shows that equal variances are not assumed. N.A. Independent-samples T-Test for C5b (Control) and C5d was not performed because both variables are not dichotomous. Every participant who answered selected *Agree*.

**Appendix O –** District comparisons of the questionnaire items C1, C2, C3, C4, C5 and A1

| Q | Pre Post | D | Descriptive statistics | | | | Independent-samples *t*-test | | | Effect size | Mann-Whitney U test | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | *n* | *M* | *SD* | *Md n* | *t* | *df* | *p* | Cohen's *d* | *U* | *z* | *p* |
| **C1** | Pre | A | 47 | 2,68 | 0,594 | 3 | -3,061 | 53,57[a] | **0,003*** | 0,674 | 1274 | -3,362 | **0,001*** |
| | | B | 69 | 2,96 | 0,205 | 3 | | | | | | | |
| | Post | A | 47 | 2,83 | 0,433 | 3 | -2,401 | 50,87[a] | **0,020*** | 0,536 | 1403 | -2,799 | **0,005*** |
| | | B | 69 | 2,99 | 0,120 | 3 | | | | | | | |
| **C2** | Pre | A | 44 | 6,82 | 1,944 | 6 | 4,221 | 111 | **<0,001*** | 0,814 | 878 | -4,022 | **<0,001*** |
| | | B | 69 | 5,45 | 1,491 | 6 | | | | | | | |
| | Post | A | 46 | 7,04 | 1,920 | 8 | 4,227 | 113 | **<0,001*** | 0,805 | 904 | -4,115 | **<0,001*** |
| | | B | 69 | 5,62 | 1,655 | 6 | | | | | | | |
| **C3** | Pre | A | 46 | 1,83 | 0,851 | 2 | 4,308 | 68,99[a] | **<0,001*** | 0,894 | 956 | -4,407 | **<0,001*** |
| | | B | 69 | 1,22 | 0,539 | 1 | | | | | | | |
| | Post | A | 47 | 2,32 | 0,837 | 3 | 5,918 | 114 | **<0,001*** | 1,119 | 777 | -5,250 | **<0,001*** |
| | | B | 69 | 1,43 | 0,757 | 1 | | | | | | | |
| **C4** | Pre | A | 23 | 5,22 | 2,844 | 6 | 2,804 | 30 | **0,009*** | 1,102 | 41 | -2,670 | **0,008*** |
| | | B | 9 | 2,22 | 2,333 | 2 | | | | | | | |
| | Post | A | 33 | 5,15 | 2,729 | 6 | 2,902 | 46 | **0,006*** | 0,904 | 141 | -2,441 | **0,015*** |
| | | B | 15 | 2,93 | 1,668 | 4 | | | | | | | |
| **C5a)** | Pre | A | 43 | 0,95 | 0,213 | 1 | 1,956 | 103,20[a] | 0,053 | 0,350 | 1225 | -1,755 | 0,079 |
| | | B | 64 | 0,84 | 0,366 | 1 | | | | | | | |
| | Post | A | 47 | 0,94 | 0,247 | 1 | 0,199 | 113 | 0,842 | 0,038 | 1583 | -0,200 | 0,841 |
| | | B | 68 | 0,93 | 0,263 | 1 | | | | | | | |
| **C5b)** | Pre | A | 47 | 0,96 | 0,204 | 1 | 0,383 | 113 | 0,703 | 0,073 | 1572 | -0,384 | 0,701 |
| | | B | 68 | 0,94 | 0,237 | 1 | | | | | | | |
| | Post | A | 47 | 0,96 | 0,204 | 1 | -0,916 | 113 | 0,361 | 0,174 | 1554 | -0,917 | 0,359 |
| | | B | 68 | 0,99 | 0,121 | 1 | | | | | | | |
| **C5c)** | Pre | A | 45 | 0,93 | 0,252 | 1 | -0,500 | 110 | 0,618 | 0,096 | 1475 | -0,502 | 0,616 |
| | | B | 67 | 0,96 | 0,208 | 1 | | | | | | | |
| | Post | A | 43 | 0,98 | 0,152 | 1 | 0,899 | 110 | 0,561 | 0,174 | 1442 | -0,899 | 0,368 |
| | | B | 68 | 0,94 | 0,208 | 1 | | | | | | | |
| **C5d)** | Pre | A | 47 | 1,00 | 0,000 | 1 | N.A. | N.A. | N.A. | N.A. | 1575 | 0,000 | 1,000 |
| | | B | 67 | 1,00 | 0,000 | 1 | | | | | | | |
| | Post | A | 47 | 1,00 | 0,000 | 1 | N.A. | N.A. | N.A. | N.A. | 1587 | 0,000 | 1,000 |
| | | B | 69 | 1,00 | 0,000 | 1 | | | | | | | |
| **C5e)** | Pre | A | 47 | 0,98 | 0,146 | 1 | 0,279 | 112 | 0,781 | 0,053 | 1561 | -0,280 | 0,779 |
| | | B | 67 | 0,97 | 0,171 | 1 | | | | | | | |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Post | A | 47 | 0,98 | 0,146 | 1 | -0,273 | 114 | 0,785 | 0,052 | 1611 | -0,274 | 0,784 |
| | | B | 69 | 0,99 | 0,120 | 1 | | | | | | | |
| **A1a)** | Pre | A | 47 | 5,00 | 0,000 | 5 | 0,824 | 114 | 0,412 | 0,156 | 1598 | -0,825 | 0,409 |
| | | B | 69 | 4,99 | 0,120 | 5 | | | | | | | |
| | Post | A | 47 | 4,98 | 0,146 | 5 | 0,255 | 114 | 0,799 | 0,048 | 1609 | -0,256 | 0,798 |
| | | B | 69 | 4,97 | 0,169 | 5 | | | | | | | |
| **A1b)** | Pre | A | 46 | 3,70 | 1,030 | 4 | -0,080 | 113 | 0,936 | -0,015 | 1556 | -0,192 | 0,848 |
| | | B | 69 | 3,71 | 0,893 | 4 | | | | | | | |
| | Post | A | 47 | 3,66 | 1,027 | 4 | -2,483 | 75,47[a] | **0,015*** | 0,503 | 1224 | -2,268 | **0,023*** |
| | | B | 68 | 4,09 | 0,707 | 4 | | | | | | | |
| **A1c)** | Pre | A | 45 | 4,27 | 0,915 | 4 | 3,592 | 110 | **<0,001*** | 0,692 | 908 | -3,775 | **<0,001*** |
| | | B | 67 | 3,60 | 1,001 | 4 | | | | | | | |
| | Post | A | 46 | 4,41 | 0,909 | 5 | 2,298 | 113 | **0,023*** | 0,437 | 1123 | -2,859 | **0,004*** |
| | | B | 69 | 4,03 | 0,857 | 4 | | | | | | | |
| **A1d)** | Pre | A | 47 | 4,47 | 0,654 | 5 | 0,932 | 113 | 0,353 | 0,177 | 1482 | -0,738 | 0,460 |
| | | B | 68 | 4,34 | 0,784 | 4 | | | | | | | |
| | Post | A | 47 | 4,45 | 0,583 | 4 | -0,240 | 114 | 0,811 | 0,045 | 1496 | -0,803 | 0,422 |
| | | B | 69 | 4,48 | 0,759 | 5 | | | | | | | |
| **A1e)** | Pre | A | 47 | 4,57 | 0,500 | 5 | 1,084 | 110,80[a] | 0,281 | 0,186 | 1607 | -0,094 | 0,925 |
| | | B | 69 | 4,43 | 0,882 | 5 | | | | | | | |
| | Post | A | 47 | 4,49 | 0,718 | 5 | -0,532 | 114 | 0,595 | 0,101 | 1457 | -1,094 | 0,274 |
| | | B | 69 | 4,57 | 0,776 | 5 | | | | | | | |
| **A1f)** | Pre | A | 44 | 4,55 | 0,975 | 5 | 0,164 | 106 | 0,869 | 0,032 | 1335 | -0,569 | 0,569 |
| | | B | 64 | 4,52 | 0,891 | 5 | | | | | | | |
| | Post | A | 46 | 4,46 | 0,959 | 5 | -1,723 | 64,07[a] | 0,090 | 0,364 | 1366 | -1,600 | 0,110 |
| | | B | 69 | 4,72 | 0,539 | 5 | | | | | | | |
| **A1g)** | Pre | A | 47 | 4,64 | 0,705 | 5 | 0,562 | 114 | 0,575 | 0,106 | 1493 | -0,872 | 0,383 |
| | | B | 69 | 4,57 | 0,675 | 5 | | | | | | | |
| | Post | A | 46 | 4,76 | 0,480 | 5 | 0,240 | 113 | 0,811 | 0,046 | 1545 | -0,330 | 0,742 |
| | | B | 69 | 4,74 | 0,474 | 5 | | | | | | | |
| **A1h)** | Pre | A | 47 | 4,96 | 0,204 | 5 | 1,896 | 83,07[a] | 0,061 | 0,304 | 1477 | -1,600 | 0,110 |
| | | B | 69 | 4,78 | 0,725 | 5 | | | | | | | |
| | Post | A | 47 | 4,89 | 0,477 | 5 | 0,317 | 114 | 0,751 | 0,060 | 1518 | -1,103 | 0,270 |
| | | B | 69 | 4,87 | 0,339 | 5 | | | | | | | |
| **A1i)** | Pre | A | 47 | 4,89 | 0,477 | 5 | 0,674 | 114 | 0,501 | 0,128 | 1472 | -1,489 | 0,136 |
| | | B | 69 | 4,84 | 0,369 | 5 | | | | | | | |
| | Post | A | 47 | 4,89 | 0,312 | 5 | 1,642 | 112,88[a] | 0,103 | 0,294 | 1442 | -1,547 | 0,122 |
| | | B | 69 | 4,78 | 0,415 | 5 | | | | | | | |
| **A1j)** | Pre | A | 47 | 4,77 | 0,476 | 5 | 1,015 | 114 | 0,312 | 0,192 | 1496 | -0,927 | 0,354 |
| | | B | 69 | 4,65 | 0,660 | 5 | | | | | | | |
| | Post | A | 47 | 4,79 | 0,463 | 5 | 0,821 | 114 | 0,413 | 0,155 | 1509 | -0,861 | 0,389 |
| | | B | 69 | 4,71 | 0,517 | 5 | | | | | | | |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **A1k)** | Pre | A | 46 | 4,28 | 0,834 | 4 | 0,008 | 108 | 0,993 | 0,002 | 1467 | -0,033 | 0,973 |
| | | B | 64 | 4,28 | 0,845 | 4 | | | | | | | |
| | Post | A | 46 | 4,24 | 0,874 | 4 | -1,360 | 110 | 0,177 | 0,261 | 1357 | -1,060 | 0,289 |
| | | B | 66 | 4,44 | 0,682 | 5 | | | | | | | |
| **A1l)** | Pre | A | 44 | 4,57 | 0,625 | 5 | 1,675 | 103 | 0,097 | 0,331 | 1130 | -1,559 | 0,119 |
| | | B | 61 | 4,31 | 0,867 | 4 | | | | | | | |
| | Post | A | 45 | 4,49 | 0,661 | 5 | 0,082 | 108 | 0,935 | 0,016 | 1425 | -0,266 | 0,791 |
| | | B | 65 | 4,48 | 0,812 | 5 | | | | | | | |

Q – Question. D – District. A – Aveiro. B - Braga. *n* - number of observations. *M* - Mean. *SD* - Standard deviation. *Mdn* - Median. *t*- t-value. *df* - degrees of freedom. *U* - Mann-Whitney U value. *z* - z-value. *p* - p-value (2-tailed). *Results were considered statistically significant for *p* <0,05. [a]Levene's Test for Equality of Variances shows that equal variances are not assumed. N.A. Independent-samples T-Test for C5d was not performed because both variables are not dichotomous. Every participant who answered selected *Agree*.

**Appendix P –** Frequency of visit comparisons of the questionnaire items C1, C2, C3, C4, C5 and A1.

| Q | Pre Post | FT | Descriptive statistics | | | | Independent-samples *t*-test | | | Effect size | Mann-Whitney U test | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | *n* | *M* | *SD* | *Md n* | *t* | *df* | *p* | Cohen's *d* | *U* | *z* | *p* |
| **C1** | Pre | Y | 109 | 2,84 | 0,434 | 3 | -0,078 | 114 | 0,938 | 0,030 | 378 | -0,080 | 0,936 |
| | | N | 7 | 2,86 | 0,378 | 3 | | | | | | | |
| | Post | Y | 109 | 2,92 | 0,308 | 3 | -0,706 | 114 | 0,402 | 0,275 | 354 | -0,739 | 0,460 |
| | | N | 7 | 3,00 | 0,000 | 3 | | | | | | | |
| **C2** | Pre | Y | 106 | 6,04 | 1,745 | 6 | 1,276 | 111 | 0,205 | 0,498 | 304 | -0,857 | 0,391 |
| | | N | 7 | 5,14 | 2,545 | 6 | | | | | | | |
| | Post | Y | 108 | 6,20 | 1,873 | 6 | 0,275 | 113 | 0,784 | 0,107 | 341 | -0,456 | 0,648 |
| | | N | 7 | 6,00 | 2,309 | 6 | | | | | | | |
| **C3** | Pre | Y | 108 | 1,48 | 0,755 | 1 | 2,113 | 9,47[a] | 0,062 | 0,458 | 301 | -1,102 | 0,270 |
| | | N | 7 | 1,14 | 0,378 | 1 | | | | | | | |
| | Post | Y | 109 | 1,77 | 0,889 | 3 | -1,062 | 114 | 2,91 | 0,414 | 306 | -0,968 | 0,333 |
| | | N | 7 | 2,14 | 1,069 | 1 | | | | | | | |
| **C4** | Pre | Y | 31 | 4,48 | 2,987 | 4 | 1,148 | 30 | 0,260 | 1,166 | 6 | -1,104 | 0,270 |
| | | N | 1 | 1,00 | 0,000 | 1 | | | | | | | |
| | Post | Y | 44 | 4,50 | 2,655 | 4 | 0,359 | 46 | 0,721 | 0,188 | 79 | -0,346 | 0,729 |
| | | N | 4 | 4,00 | 2,828 | 3 | | | | | | | |
| **C5a)** | Pre | Y | 100 | 0,88 | 0,327 | 1 | -3,674 | 99,00[a] | **<0,001*** | 0,378 | 308 | -0,968 | 0,333 |
| | | N | 7 | 1,00 | 0,000 | 1 | | | | | | | |
| | Post | Y | 108 | 0,94 | 0,230 | 1 | 1,239 | 6,17[a] | 0,260 | 0,919 | 291 | -2,309 | **0,021*** |
| | | N | 7 | 0,71 | 0,488 | 1 | | | | | | | |
| **C5b)** | Pre | Y | 108 | 0,94 | 0,230 | 1 | -0,636 | 113 | 0,526 | 0,248 | 357 | -0,638 | 0,524 |
| | | N | 7 | 1,00 | 0,000 | 1 | | | | | | | |
| | Post | Y | 108 | 0,97 | 0,165 | 1 | -0,443 | 113 | 0,658 | 0,173 | 368 | -0,445 | 0,656 |
| | | N | 7 | 1,00 | 0,000 | 1 | | | | | | | |
| **C5c)** | Pre | Y | 105 | 0,94 | 0,233 | 1 | -0,645 | 110 | 0,520 | 0,252 | 347 | -0,647 | 0,518 |
| | | N | 7 | 1,00 | 0,000 | 1 | | | | | | | |
| | Post | Y | 105 | 0,96 | 0,192 | 1 | 0,727 | 6,21[a] | 0,494 | 0,507 | 329 | -1,294 | 0,196 |
| | | N | 7 | 0,86 | 0,378 | 1 | | | | | | | |
| **C5d)** | Pre | Y | 107 | 1,00 | 0,000 | 1 | N.A. | N.A. | N.A. | N.A. | 375 | 0,000 | 1,000 |
| | | N | 7 | 1,00 | 0,000 | 1 | | | | | | | |
| | Post | Y | 108 | 1,00 | 0,000 | 1 | N.A. | N.A. | N.A. | N.A. | 378 | 0,000 | 1,000 |
| | | N | 7 | 1,00 | 0,000 | 1 | | | | | | | |
| **C5e)** | Pre | Y | 107 | 0,97 | 0,166 | 1 | -0,445 | 112 | 0,657 | 0,174 | 364 | -0,447 | 0,655 |
| | | N | 7 | 1,00 | 0,000 | 1 | | | | | | | |
| | Post | Y | 109 | 0,98 | 0,135 | 1 | -0,359 | 114 | 0,721 | 0,140 | 375 | -0,360 | 0,719 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | N | 7 | 1,00 | 0,000 | 1 | | | | | | | |
| **A1a)** | Pre | Y | 109 | 4,99 | 0,096 | 5 | -0,252 | 114 | 0,801 | 0,098 | 378 | -0,253 | 0,800 |
| | | N | 7 | 5,00 | 0,000 | 5 | | | | | | | |
| | Post | Y | 109 | 4,97 | 0,164 | 5 | -0,441 | 114 | 0,660 | 0,172 | 371 | -0,443 | 0,658 |
| | | N | 7 | 5,00 | 0,000 | 5 | | | | | | | |
| **A1b)** | Pre | Y | 108 | 3,66 | 0,949 | 4 | -2,123 | 113 | **0,036*** | 0,828 | 199 | -2,238 | **0,025*** |
| | | N | 7 | 4,43 | 0,535 | 4 | | | | | | | |
| | Post | Y | 108 | 3,88 | 0,883 | 4 | -1,621 | 113 | 0,108 | 0,632 | 248 | -1,619 | 0,106 |
| | | N | 7 | 4,43 | 0,535 | 4 | | | | | | | |
| **A1c)** | Pre | Y | 105 | 3,90 | 1,028 | 4 | 1,177 | 110 | 0,242 | 0,459 | 250 | -1,505 | 0,132 |
| | | N | 7 | 3,43 | 0,787 | 4 | | | | | | | |
| | Post | Y | 108 | 4,18 | 0,895 | 4 | -0,314 | 113 | 0,754 | 0,122 | 349 | -0,372 | 0,710 |
| | | N | 7 | 4,29 | 0,951 | 5 | | | | | | | |
| **A1d)** | Pre | Y | 108 | 4,38 | 0,707 | 4 | -0,668 | 113 | 0,505 | 0,261 | 263 | -1,512 | 0,131 |
| | | N | 7 | 4,57 | 1,134 | 5 | | | | | | | |
| | Post | Y | 109 | 4,48 | 0,618 | 5 | 0,337 | 6,13[a] | 0,748 | 0,276 | 335 | -0,613 | 0,540 |
| | | N | 7 | 4,29 | 1,496 | 5 | | | | | | | |
| **A1e)** | Pre | Y | 109 | 4,50 | 0,689 | 5 | 0,227 | 114 | 0,821 | 0,089 | 298 | -1,119 | 0,263 |
| | | N | 7 | 4,43 | 1,512 | 5 | | | | | | | |
| | Post | Y | 109 | 4,59 | 0,596 | 5 | 1,218 | 6,08[a] | 0,268 | 1,205 | 322 | -0,820 | 0,412 |
| | | N | 7 | 3,71 | 1,890 | 5 | | | | | | | |
| **A1f)** | Pre | Y | 101 | 4,54 | 0,878 | 5 | 0,717 | 106 | 0,475 | 0,280 | 351 | -0,046 | 0,963 |
| | | N | 7 | 4,29 | 1,496 | 5 | | | | | | | |
| | Post | Y | 108 | 4,64 | 0,676 | 5 | 0,621 | 6,16[a] | 0,557 | 0,475 | 366 | -0,178 | 0,859 |
| | | N | 7 | 4,29 | 1,496 | 5 | | | | | | | |
| **A1g)** | Pre | Y | 109 | 4,58 | 0,698 | 5 | -1,046 | 114 | 0,298 | 0,408 | 298 | -1,169 | 0,243 |
| | | N | 7 | 4,86 | 0,378 | 5 | | | | | | | |
| | Post | Y | 108 | 4,73 | 0,485 | 5 | -5,749 | 107,00[a] | **<0,001*** | 0,568 | 284 | -1,502 | 0,133 |
| | | N | 7 | 5,00 | 0,000 | 5 | | | | | | | |
| **A1h)** | Pre | Y | 109 | 4,84 | 0,596 | 5 | -0,690 | 114 | 0,492 | 0,269 | 343 | -0,879 | 0,379 |
| | | N | 7 | 5,00 | 0,000 | 5 | | | | | | | |
| | Post | Y | 109 | 4,87 | 0,411 | 5 | -0,824 | 114 | 0,411 | 0,321 | 340 | -0,923 | 0,356 |
| | | N | 7 | 5,00 | 0,000 | 5 | | | | | | | |
| **A1i)** | Pre | Y | 109 | 4,85 | 0,427 | 5 | -0,907 | 114 | 0,366 | 0,354 | 333 | -1,006 | 0,314 |
| | | N | 7 | 5,00 | 0,000 | 5 | | | | | | | |
| | Post | Y | 109 | 4,82 | 0,389 | 5 | -4,926 | 108,00[a] | **<0,001*** | 0,485 | 312 | -1,240 | 0,215 |
| | | N | 7 | 5,00 | 0,000 | 5 | | | | | | | |
| **A1j)** | Pre | Y | 109 | 4,69 | 0,604 | 5 | -0,730 | 114 | 0,467 | 0,285 | 333 | -0,738 | 0,460 |
| | | N | 7 | 4,86 | 0,378 | 5 | | | | | | | |
| | Post | Y | 109 | 4,73 | 0,503 | 5 | -0,636 | 114 | 0,526 | 0,248 | 344 | -0,600 | 0,549 |
| | | N | 7 | 4,86 | 0,378 | 5 | | | | | | | |
| **A1k)** | Pre | Y | 103 | 4,28 | 0,845 | 4 | -0,013 | 108 | 0,990 | 0,005 | 347 | -0,182 | 0,856 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | N | 7 | 4,29 | 0,756 | 4 | | | | | | | |
| | Post | Y | 106 | 4,33 | 0,777 | 4 | -1,568 | 110 | 0,120 | 0,658 | 198 | -1,726 | 0,084 |
| | | N | 6 | 4,83 | 0,408 | 5 | | | | | | | |
| **A1l)** | Pre | Y | 98 | 4,40 | 0,796 | 5 | -1,035 | 103 | 0,303 | 0,405 | 271 | -1,055 | 0,292 |
| | | N | 7 | 4,71 | 0,488 | 5 | | | | | | | |
| | Post | Y | 103 | 4,50 | 0,684 | 5 | 0,368 | 6,17[a] | 0,725 | 0,278 | 326 | -0,486 | 0,627 |
| | | N | 7 | 4,29 | 1,496 | 5 | | | | | | | |

Q – Question. FT – First time?. Y – Yes. N - No. *n* - number of observations. *M* - Mean. *SD* - Standard deviation. *Mdn* - Median. *t*- t-value. *df* - degrees of freedom. *U* - Mann-Whitney U value. *z* - z-value. *p* - p-value (2-tailed). *Results were considered statistically significant for *p* <0,05. [a]Levene's Test for Equality of Variances shows that equal variances are not assumed. N.A. Independent-samples T-Test for C5d was not performed because both variables are not dichotomous. Every participant who answered selected *Agree*.