EPISTEMOLOGY OF THE ENVIRONMENT FOR BIODIVERSITY CONSERVATION: VALIDATION OF A DIAGNOSTIC INSTRUMENT

EPISTEMOLOGIA DO AMBIENTE PARA A CONSERVAÇÃO DA BIODIVERSIDADE: VALIDAÇÃO DE UM INSTRUMENTO DIAGNÓSTICO

EPISTEMOLOGÍA DEL MEDIO AMBIENTE PARA LA CONSERVACIÓN DE LA BIODIVERSIDAD: VALIDACIÓN DE UN INSTRUMENTO DE DIAGNÓSTICO

Thais Adrianne Silva REINALDO [1]
e-mail: thais.adrianne@unesp.br
Luene Pessoa VICENTE [2]
e-mail: luene.vicente@usp.br
Anaís Freitas SILVEIRA [3]
e-mail: anaissilveira@hotmail.com
Ariadne Dall'aqua AYRES [4]
e-mail: ariadneayres5@gmail.com
Fernanda da Rocha BRANDO [5]
e-mail: ferbrando@ffclrp.usp.br
Ana Maria de Andrade CALDEIRA [6]
e-mail: ana.caldeira@unesp.br

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[1] São Paulo State University (UNESP), Bauru – SP – Brazil. PhD student in the Postgraduate Program in Science Education at the Faculty of Sciences.
[2] University of São Paulo (USP), Ribeirão Preto – SP – Brazil. PhD student in the Postgraduate Program in Comparative Biology at the Faculty of Philosophy, Sciences and Letters.
[3] University of São Paulo (USP), Ribeirão Preto – SP – Brazil. Master's student in the Postgraduate Program in Comparative Biology at the Faculty of Philosophy, Sciences and Letters.
[4] University of São Paulo (USP), Ribeirão Preto – SP – Brazil. PhD student in the Postgraduate Program in Comparative Biology at the Faculty of Philosophy, Sciences and Letters.
[5] University of São Paulo (USP), Ribeirão Preto – SP – Brazil. Associate Professor in the Department of Biology at the Faculty of Philosophy, Sciences and Letters.
[6] São Paulo State University (UNESP), Bauru – SP – Brazil. Volunteer Retired Professor at the Education Department of the Faculty of Sciences. 1 to 6 Environmental Diagnosis Network – UNESP and USP Agreement – Research Group in Epistemology of Biology (GPEB, FC-UNESP) and Laboratory of Epistemology and Didactics of Biology (LEDiB , FFCLRP-USP).

ABSTRACT: The relationship between climate and biodiversity is complex and requires research that, through environmental, social and economic crises, guide decision-making for the conservation of biodiversity that is environmentally and socially appropriate and viable. In this sense, it is imperative to point out ways, mainly through Environmental Education, adapted to the conceptions and values about biodiversity protection found in society, in order to provide responses as fast and efficient as the environmental crises demand. Therefore, this article aimed to present the validation and potential of a diagnostic instrument that helps to understand this range of values and ideas. The instrument, built based on Likert scaling, was semantically and statistically validated and resulted in three potential axes of analysis: anthropic, biological and geosystemic. These axes can be analyzed according to the context of application, articulate issues involved in the complexity of environmental factors and guide decision-making in the environmental area.

KEYWORDS: Environmental education. Environmental conception. Quantitative analysis. Basic education.

RESUMO*: A relação entre clima e biodiversidade é complexa e necessita de pesquisas que, mediante às crises ambientais, sociais e econômicas, guiem tomadas de decisão para a conservação da biodiversidade, ambiental e socialmente adequadas e viáveis. Neste sentido, é imperativo apontar caminhos, principalmente por meio da Educação Ambiental, adaptados às concepções e valores sobre proteção da biodiversidade encontrados na sociedade, de modo a fornecer respostas tão rápidas e eficientes quanto as crises ambientais demandam. Sendo assim, este artigo objetivou apresentar a validação e as potencialidades de um instrumento diagnóstico que auxilie a compreensão desta gama de valores e ideias. O instrumento, construído com base no escalonamento Likert, foi validado semântica e estatisticamente e resultou em três eixos de análise potenciais: antrópico, biológico e geossistêmico. Eixos esses que podem ser analisados conforme contexto de aplicação, articulam questões envolvidas na complexidade de fatores ambientais e orientam tomadas de decisão na área ambiental.*

PALAVRAS-CHAVE*: Educação Ambiental. Concepção ambiental. Análise Quantitativa. Educação Básica.*

RESUMEN*: La relación entre clima y biodiversidad es compleja y requiere de investigaciones que, ante las crisis ambientales, sociales y económicas, orienten la toma de decisiones para la conservación de la biodiversidad, ambiental y socialmente apropiada y viable. En este sentido, resulta imperativo señalar vías, principalmente a través de la Educación Ambiental, adaptadas a las concepciones y valores sobre la protección de la biodiversidad que se encuentran en la sociedad, para dar respuestas tan rápidas y eficientes como las crisis ambientales exigen. Por ello, este artículo tuvo como objetivo presentar la validación y el potencial de un instrumento de diagnóstico que ayude a comprender este abanico de valores e ideas. El instrumento, construido con base en la escala Likert, fue validado semántica y estadísticamente y resultó en tres potenciales ejes de análisis: antrópico, biológico y geosistémico. Estos ejes pueden ser analizados según el contexto de aplicación, articular cuestiones involucradas en la complejidad de los factores ambientales y orientar la toma de decisiones en el área ambiental.*

PALABRAS CLAVE*: Educación ambiental. Concepción ambiental. Análisis cuantitativo. Educación básica.*

Introduction

Complex problems, such as the ongoing climate crisis, require solutions that take multiple approaches into consideration, so working with an interdisciplinary science such as Environmental Education can better guide practical actions resulting from the scientific knowledge generated. Philippi *et al*. (2013) defend how interdisciplinarity naturally presents the possibility of exploring and crossing frontiers of knowledge to "interconnect knowledge and expand technical-scientific cooperation" (p. 522, our translation), allowing new approaches to emerge from shared knowledge.

Understanding Environmental Education as a training field for citizens, giving new meaning to environmental issues in different contexts, allows the proposition of a new arena of debate for the climate and biodiversity crises (Jacobi, 2003; Roos; Becker, 2012). Accessing the different epistemologies of the environment is fundamental to designing the current environmental scenario and guiding action towards mitigating the climate and biodiversity crises.

One way to gather data that translates this is through the application of diagnostic instruments. Capable of raising conceptions and perceptions of different social actors, diagnostic instruments can provide more support for the interpretation of complex environmental problems, as well as being allies in decision-making, combating global crises and structuring environmental policies.

In this sense, this article aims to present the validation and applicability processes of a diagnostic instrument, of quantitative analysis, which seeks to understand how society, specifically Basic Education students, teachers in initial training and institutionalized environmental social agents understand and give meaning to the concepts of restoration, preservation and conservation of biodiversity in a given location and its effects on the climate.

In order to capture perceptions and conceptions involving environmental concepts, this diagnostic instrument explores the potential for collecting data from different social actors, incorporating structuring elements from different areas of research. A quantitative study allows for a comprehensive survey, based on broad and/or diversified samples, for general and specific analyses. In the educational sphere, this characteristic becomes a differentiator, due to the complexity and breadth of processes, contexts and teaching systems, for the search for common aspects, considering their social role for the development of skills for responsible and participatory social action.

Thus, bringing aspects of its construction and the articulating concepts mobilized for this, the proposal of this instrument aims to address socio-environmental issues focused on the climate and biodiversity crises, in addition to presenting the obstacles that different perceptions, conceptions, and interpretations of the selected environmental concepts may entail within the scope of decision making.

Elements for building an epistemology of the environment

The intricacies of the interaction between climate and biodiversity are complex to access and understand. Such complexity permeates both the scientific and social fields, to the same extent that it reverberates in the ways of doing science and being a society. The great social awakening about the human impact on environmental crises occurred in the West throughout the second half of the 20th century, expressed by works such as Carson's Silent Spring (1962), by documents and treaties, such as the Report "Our Common Future" (United Nations, 1987) and the 1992 Convention on Biological Diversity (Brazil, 2000a), and by events, such as the Stockholm Conference in 1972, which are still the basis for the practice of environmental protection today. The debates caused by this awakening, which brought together actors from different regions of the world, gave rise to supranational organizations focused on monitoring issues related to the protection of biodiversity.

Currently, the Intergovernmental Panel on Climate Change (IPCC), created in 1988, and the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES), created in 2012, have the important role of organizing scientific work that aims to address the complexity of climate and biodiverse issues, as well as assisting States, companies and civil society in decision-making moments (Balvanera *et al.*, 2022; Scott *et al.*, 2023).

In an initiative to strengthen dialogue between social actors involved in mitigation and solution strategies for the climate crisis and the biodiversity crisis, in 2020 the first event organized by the IPCC and IPBES was held, in which the need for studies connecting the spheres of biodiversity and climate. At this event, issues were discussed about the impacts of climate change on the adaptation of species, the resilience and maintenance of ecosystems and the importance of these actions aimed at mitigating the impacts of climate change on the loss of biodiversity, biomass and ecosystem services, resulting in the first joint publication between these institutions, which recognizes the need for more collaborations in work in these areas (Pörtner *et al*, 2021; Mahecha *et al.*, 2022).

Another example of the assistance of these organizations in decision-making are the recent reports published by the IPCC, which indicate the improbability of the goal defined by the Paris Agreement, of maintaining the increase in the global average temperature at 1.5°C, being achieved if our pattern of behavior and consumption as a society is not changed, (Kock; Buchs; Lee, 2023), and the uncertainty of meeting the "conservation and sustainability goals outlined for 2030 [...], unless there is a drastic transformation in factors economic, social, political and technological" (Miranda; Bezerra, 2022, p. 24, our translation), which manifests the need for deeper changes in the way society and public policies act.

Such changes are necessary because the context in which the climate crisis and the biodiversity crisis are revealed and emerge, as stated above, is complex to understand. When individuals think about the climate crisis and the biodiversity crisis, they think about iconic examples, such as the melting of glaciers and the extinction of the polar bear. This global ideology, however, neglects more imperceptible changes. A survey carried out by Mahecha *et al.* (2022) on biodiversity loss and climate extremes, presents studies that explain the subtle, but intertwined interaction between climate and biodiversity. Among these, a study carried out in Germany indicated that throughout the 20th century the genetic diversity of some plants was affected by the decrease in vegetation cover, also causing changes in nutrient absorption, heat resistance or survival against pathogenic attacks. Such degradation transforms the resilience capacity of environments to the climate crisis, due, for example, to the reduction in the capacity to absorb carbon, water and regulate temperature, which affects the lives of other beings that make up the network of ecosystem services. Another study analyzing the effects of two consecutive droughts in Leipzig, Germany, in 2018 and 2019, indicated that tree growth decreased and the proliferation of pathogens increased; This sequence of droughts increased the tree death rate. And another research presented by Mahecha and collaborators highlights the influence of stress on the ability of plants to remove ozone from the atmosphere.

Such studies presented by the aforementioned authors indicate that the relationship between decision-making about what to do with land use, the climate crisis and the biodiversity crisis is not obvious, and actions are often taken in accordance with what Balvanera *et al.* (2022) identified as "single-curve learning". This type of appropriation of a problem and its possibilities for resolution refers to a way of thinking that focuses more on solving a specific problem and not its causes in itself, to the detriment, for example, of the principles of prevention and precaution. In environmental situations, this model of action is very close to the values that the individual, group or institution has regarding the factors that make up a given situation.

When thinking specifically about the impact of the value attributed to something on decisions made individually or collectively, it is necessary to think that this is a word that has a range of meanings, as well as its ramifications, and can reflect opinions and judgments about the importance of something in given context and situation. “The ways in which values are conceptualized and linked to specific decisions and actions vary greatly across academic disciplines, as informed by different worldviews” (Balvanera *et al.*, 2022, p. 6). Its ramifications also indicate different practices; while valuing means “evaluating the quality or representativeness of something” (Michaelis, 2021), valuing means “attributing due value or recognition”, or “making something or someone stand out, highlighting” (Michaelis, 2021). These are complex terms that guide, unconsciously or not, all the decision-making we have in society.

This epistemological problem is also discussed by Enrique Leff:

> Environmental epistemology transcends a permanent exercise of reflection, theorization and action that constructs and transforms reality, that brings together different disciplines and brings different worldviews into play... Environmental complexity not only integrates different epistemologies, rationalities, imaginaries and languages that converge, but is constructed through the reflection of thought on reality (Leff, 2007, p. 17, our translation).

Recognizing the importance of values and worldviews in the transition from single-curve learning to “double-curve learning”, which considers not only solving a problem already caused, but rather understanding the values, objectives, decisions, practices and institutions associates who allowed something to become a problem, Balvanera *et al.* (2022) propose a strategic path. First, it is necessary *to know* the values of nature that base decision-making at different levels. Second, it is necessary *to allow* different values to aggregate decision-making processes, so that they are appropriate to the context involved. Third, it is necessary to institutionally *change the formulation of regulations, in accordance with the diversity of values.* Finally, the strategy of *building* new values, beliefs and paradigms, in order to direct them towards more sustainable ideas. In other words, from diagnostic assessment (knowledge) to Environmental Education (build), it is possible to cause an effective change in the values that interfere in decision-making in environmental protection.

In research carried out with students from different educational levels, results indicated a feeling of separation from the subject in relation to nature, disregarding relevant aspects due to a fragmented perspective, for example genetic diversity and the human being as part of the environment, and this directly interferes in their level of understanding about conservation

(Miani, 2017; Miranda; Bezerra, 2022). Considering the training of teachers in the area of Natural Sciences and promoter of projects in Environmental Education, it is understood that Science Teaching has a fundamental role in the formation of an individual who is able to respond to environmental, social, and economic needs, which it will certainly come into contact with, being of special importance in a context of global ecological crisis such as the one the planet is currently facing (Borges; Oliveira; Müller, 2022; Miranda; Bezerra, 2022). The Science and Biology teacher works directly with the social transformation strategies mentioned above, since teaching towards environmental protection is an integral part of Environmental Education and "the lack of these skills on the part of the population, associated with a lack of interest in nature, it leads to a lack of responsibilities and care, generating serious problems, such as climate change, water, soil and air pollution and the loss of biodiversity" (Borges; Oliveira; Müller, 2022, p. 2, our translation).

Therefore, epistemological obstacles need to be overcome in the learning process, in order to facilitate the historical-scientific development of conceptual evolution, supported by the mental construction of representative signs. Thus, during schooling, the thinking skills typical of the production of scientific knowledge need to be developed so that they can be associated with the scientific name and, in this way, enable reflection on scientific knowledge in its various aspects.

Articulating elements in the construction of a diagnostic instrument for environmental concepts

Through understanding what was explained, a group of researchers organized in an Environmental Epistemology Diagnostic Network (RDA) proposed the construction of a diagnostic instrument on a valuation scale, whose intention was to organize the interpretations of different audiences about environmental concepts that can reflect on environmental decision-making. Interviews and questionnaires are being widely incorporated as collection instruments in environmental research due to the understanding that objective questions and statements are capable of obtaining answers that can be interpreted and analyzed both quantitatively and qualitatively (Montero, 1997, Seixas, 2005).

When it comes to trying to access the interpretations of different actors on the same subject, one of the most used tools is the questionnaire, since this instrument allows the standardization of the response format, favors application in different settings, such as in person or remotely, favoring this flexibility of application to reach a greater number of people than that offered by other tools (Marconi; Lakatos, 2003). In general, the construction of a questionnaire carries with it certain epistemological responsibilities on the part of the researcher, such as, for example, the clear definition of what is intended to be answered and who the target audience of the research will be (Melo; Bianchi, 2015).

In order to access data that allows describing facts and phenomena, multi-item measurement scale instruments, that is, with more than one factor in the evaluation process, are often chosen. Among this range of instruments are the “Likert-type” scales (Dalmoro; Vieira, 2013), whose use is quite widespread in social, political, economic and biological sciences (Willits; Theodori; Luloff, 2016). This tool consists of a series of statements prepared on a specific topic, called assertions, which are the focus of analysis on the respondents' attitudes, which should indicate their personal degree of agreement or disagreement with the statements presented (Willits; Theodori; Luloff, 2016).

In Psychometrics, the branch of Psychology that deals with mental measurements (Tovar, 2007), attitudes are the representation of the interaction between cognitive assessment, such as thoughts, beliefs and personal judgments, and affective assessment, which can also be taken as the emotional response regarding an object, which may be a place, a social group, an action, an idea or a person (Gifford; Sussman, 2012, Prislin; Crano, 2008). The attitude measurement represents whether the respondent has a favorable or unfavorable evaluation in relation to the measured object and can indicate a behavioral intention, that is, the action planned by a person in relation to a subject (Prislin; Crano, 2008).

In this way, by measuring attitude in “Likert-type” questionnaires, it is possible to understand the tendency of perceptions and judgments of different social actors, having as the object of study, for example, the “environment”, which, as discussed in a study developed by Martins *et al*. (2015), has different interpretations depending on the cultural context, geographic location and space in which the term is used.

Considering the construction processes of a diagnostic instrument, Balvanera *et al.* (2022) state that to understand the values, valuation and appreciation that an individual attributes to something, it is necessary to understand what this something means. The instrument discussed in this article was created based on environmental concepts whose conception and public perception of the relationship between the biodiversity and climate crises can be interpreted from different perspectives.

As part of identifying the worldviews that society presents in relation to environmental protection, the concepts of restoration, conservation and preservation of biodiversity were selected. Such concepts combine scientific knowledge, practices and values about the environment and can be investigated at various levels, namely: Basic Education students, teachers in initial training and institutionalized environmental social agents, managers of conservation units, representing a large part of the society.

However, one of the challenges of proposing a single diagnostic instrument to different social actors is adjusting the assertions in terms of semantic understanding and complexity. It is necessary that all respondents are able to understand what is being proposed in the statement, but the amount of content required in each statement must also be balanced so that the questionnaire does not become unattractive or superficial for respondents more accustomed to the topic.

In view of this, an in-depth study of the meanings and uses of each concept was carried out, indicating definitions and references used. To do this, we sought to understand the etymological, normative and scientific uses of these concepts. In this context, the scientific and normative definitions of each concept that were used in the construction of the diagnostic instrument are presented below.

The concepts "conservation", "preservation" and "restoration"

A review of Brazilian environmental legislation as well as articles by researchers dedicated to this issue indicate that there are different meanings and understandings for the same concept. Table 1, below, presents a set of terms and their definitions that served as the basis for a survey of the main concepts that support the environmental issue and that were used to construct the research instrument.

Table 1 - Etymological, normative and scientific definitions of the terms restoration, conservation and preservation.

Restoration	
Etymological	Restoration: Repair of something that is damaged or in poor condition; restoration. Restoration of vigor after a period of stress or illness; restoration. Return to a previous state in politics, economics, etc., which had been shaken for a certain period, whether by the recovery of independence or the reestablishment of the power of a regime (Michaelis, 2021).
Normative	Law 9,985/2000 – National System of Conservation Units XIV - restoration: restitution of an ecosystem or a degraded wild population as close as possible to its original condition (Brazil, 2000b).
Scientific	Ecological restoration: the objective is to achieve a community that can be maintained over the long term, with a priority focus on conserving biodiversity (Ser, 2004). Assisted process that aims to recover aspects of the ecological structure and functions characteristic of the altered ecosystem. Restoring is promoting the sustainability of ecological processes that guarantee the self-maintenance of biodiversity (species diversity and genetic variability), defined based on a prior diagnosis based on the context where population processes occur (the landscape), to establish an action plan" (Nery *et al*., 2013).
Conservation	
Etymological	Conservation [Ecology]: Planned management of a country's natural resources to prevent harmful exploitation, destruction, or neglect, enabling preservation and renewal (Michaelis, 2021).
Normative	Law 9,985/2000 – National System of Conservation Units II - nature conservation : the management of human use of nature, comprising the preservation, maintenance, sustainable use, restoration and recovery of the natural environment, so that it can produce the greatest benefit, on a sustainable basis, to current generations, maintaining its potential to satisfy the needs and aspirations of future generations, and ensuring the survival of living beings in general (Brazil, 2000b).
Scientific	Set of practices aimed at protecting biological diversity. It aims to maintain genetic diversity, ecological processes and essential vital systems, as well as the perennial use of species and ecosystems (Ganem; Drummond, 2011). It includes a combination of actions that range from the absolute preservation of stable biotic communities to the management of ecosystems modified by humans (Ganem; Drummond, 2011).
Preservation	
Etymological	Environmental preservation [Ecology]: conservation or maintenance of the natural environment as it appears, without change or extraction of resources, environmental protection (Michaelis, 2021).
Normative	Law 9,985/2000 – National System of Conservation Units V - Preservation: set of methods, procedures and policies aimed at the long-term protection of species, habitats and ecosystems, in addition to the maintenance of ecological processes, preventing the simplification of natural systems (Brazil, 2000b).
Scientific	Preservationism, "integral protection of remnants of natural environments". (Adapted from Brito; Brito; Souza, 2015). Preservation of the wild world, "maintenance of currently uninhabited or sparsely inhabited natural landscapes" (Free translation by Sarkar, 1999).

Source: Prepared by the authors.

Development

Theoretical-methodological assumptions

The validation and applicability processes of a diagnostic instrument for environmental conceptions, the objective of this article, have as their theoretical-methodological foundation quantitative research linked to Scientific Education. According to Sampieri, Collado and Lucio (2013, p. 30), the quantitative research approach "uses data collection to test hypotheses, relying on numerical measurement and statistical analysis to establish patterns".

Quantitative research can have different scopes, among which is the correlational scope study, used in this study, whose purpose is "to understand the relationship or degree of association that exists between two or more concepts, categories or variables in a specific context", the which indicate a partial explanation, since "the fact of knowing that two concepts or variables are related contributes to having some explanatory information", as explained in Sampieri, Collado and Lucio (2013, p. 107, our translation)

For Baptista and Campos (2007), the correlational research design can be of two types: one that compares changes in intensity in different variables and another that verifies the change in intensity in groups in relation to a defined variable. The diagnostic instrument presented in this article allows for both types of correlational studies.

Quantitative research related to Scientific Education seeks to find patterns in social situations in order to promote the teaching and learning of Natural Sciences. However, according to Fischer, Boone and Neumann (2006), one of the biggest problems in research in Scientific Education is classifying the different types of cognition. Thus, for the development and validation of a study with instructional quality, it is necessary to consider three aspects, namely: i) selection of representative constructs, the variables (theoretical models); ii) formulation of hypothetical correlations (structural models); and, iii) proposition of indicators suitable for operationalization (measurement models).

To this end, the planning and development of the study requires a theoretical model based on relevant work, rigorous sampling and the development of an instrument that, in turn, involves its pilot application, an adequate research design, current psychometrics, as well as data collection and rigorous interpretation of data (Fischer; Boone; Neumann, 2006).

The authors, Fischer, Boone and Neumann (2006), also explain four criteria for reliability of data and results in research in the area of Scientific Education: objectivity, reliability, validity and significance.

The *objectivity* criterion demands the reduction or elimination of any external influences in the research, which requires rigor in the standardization of actions, psychometric tests, statistical analysis and interpretation.

The *reliability criterion* refers to measurement errors that can be of three types: random errors, such as variation in the subject's attention; errors in data capture, transcription and analysis; and, systematic errors, of social desire. Analysis of data reliability can occur in two ways: through peer consultation, considering experts' agreement on an interpretation, and through statistical calculation. In the latter, the Cronbach 's alpha index (or coefficient α) is measured from the sample data obtained through the pilot application of a defined instrument for data collection (questionnaire) in the research, in order to verify the consistency of this instrument. To be satisfactory, the alpha value must be equal to or greater than 0.7, as a lower value indicates little correlation between the items and with the instrument's base theory. This index can be improved by adding more items to the instrument or by removing items that reduce it, a criterion that was used in the statistical analysis of the instrument proposed here.

The *validation* criterion verifies whether the instrument effectively measures what it proposes to measure and can be verified in four ways: i) content validation; ii) construct validation; iii) concurrent validation; and, iv) prognostic validation. In this research, in the instrument development stage, content validation was used to evaluate the semantic agreement of measurement and theoretical bases of the instrument, considering all the aspects involved and which will be dimensioned.

And the *significance criterion* refers to the reliability of the results obtained by data reduction processes in the case of larger samples. This criterion was used in the statistical analysis of the instrument.

Therefore, in this research, these assumptions and criteria were adopted, explained throughout the article.

The diagnostic instrument

The data collection instrument described is an evaluative scale that allows quantitative analysis through a questionnaire organized based on the Likert Scale.

This scale, widely used in quantitative and qualitative research, is based on and named after its creator, Likert (1932). This checks whether the respondent agrees or disagrees with the statement. This agreement is later transformed into numerical patterns and this brings, based on statistical analyses, important results for research.

According to Babbie (2005, p. 232, our translation), this scale corresponds to a more systematic and refined measurement method for constructing indices, since "in the construction of scales, response patterns between several items are weighted, while in construction of indices, individual responses are weighted and the independent scores are added together".

This assessment instrument is composed of statements designed to identify trends in the understanding of the terms restoration, preservation and conservation of biodiversity in the economic, social, cultural and ecological dimensions in different strata of society. These trends will serve as a diagnosis for a subsequent qualitative analysis of the data in order to build elements for an epistemology of the environment for teaching purposes, to be published in other publications.

For each statement there is the option to select the answer: completely agree, partially agree, totally disagree and partially disagree. It was decided to omit the neutral response point. This omission, according to Pasquali (1999), does not affect the consistency of the evaluation scale.

The assertions were developed and defined jointly by the pairs involved in the research, in periodic meetings, through construction, proposition and spelling, syntactic and semantic analysis. After an extensive elaboration process, a set of statements was defined, a total of 35, to be validated as an instrument and evaluation scale for the proposed objective.

Instrument validation

The validation (approval) process of the diagnostic instrument comprised two stages: semantic and statistical.

For the semantic validation of the instrument, which corresponds to the content validation reliability criterion proposed by Fischer, Boone and Neumann (2006), reviews were requested from judges in areas related to the theme and target audience of the research, two of whom were specialists in Education Environmental and a manager in an environmental protection agency. These judges analyzed, among other topics, the clarity of the language, the relevance of the statements, their theoretical relevance and relationship with the research objectives, the dimension to be evaluated and the answers indicated as a template.

This stage of the instrument validation process is fundamental for the construction of a data collection instrument since "[...] it is important that the language used in the instrument is close to the language of the respondents, thus avoiding misunderstandings" (Silva *et al*., 2012, p. 498, our translation).

Based on the reviewers' opinions, the set of statements was analyzed again, with some of them rewritten and others excluded, resulting in 25 statements selected to compose the pre-pilot application instrument.

Continuing the validation process, in order to achieve the reliability of the instrument and evaluate its internal consistency, reliability was checked, a stage of statistical validation, according to the criteria proposed by Fischer, Boone and Neumann (2006).

To this end, pilot tests were carried out with 10% of the N population, among the intended target audience. For each test, the statistical results were analyzed, and the permanence and need for improvement of each statement were discussed and reassessed. In the fourth application of the pilot version to a sample, a reliability index higher than the minimum acceptable was obtained using the Cronbach's alpha coefficient, which corresponds to 0.7. To carry out the reliability analysis, the statistical program *Statistical Packet for Social Sciences* (SPSS ®), version 25, obtaining $\alpha = 0.783$. Specifically, the sample for this latest pilot covered 32 Basic Education students, individuals with a profile similar to one of the groups of participants included in the research. The validated instrument contains 21 statements, listed in Table 2, in sequence.

Table 2 - Evaluation scale composed of 21 statements about the concepts of conservation, preservation and restoration of biodiversity. On a gray background, the expected response is identified, considered a value of 4 when transformed into a numerical pattern

Analyze the statements and select your degree of agreement with the sentence as a response.					
1	The terms "biodiversity conservation" and "biodiversity preservation" are synonymous.	I totally agree	Partially agree	Partially Disagree	Totally Disagree
2	The only way to preserve a natural environment is to prevent the permanent presence of traditional populations.	I totally agree	Partially agree	Partially Disagree	Totally Disagree
3	To achieve ecological restoration it is necessary to return the degraded environment to its exact original state.	I totally agree	Partially agree	Partially Disagree	Totally Disagree
4	Any action aimed at conserving biodiversity excludes the sustainable use of the environment by humans.	I totally agree	Partially agree	Partially Disagree	Totally Disagree
5	Environmental preservation presupposes the absence of decision-making on the part of human beings.	I totally agree	Partially agree	Partially Disagree	Totally Disagree
6	The conservation of a biome does not depend on public policies.	I totally agree	Partially agree	Partially Disagree	Totally Disagree
7	Biodiversity conservation includes practices for maintaining ecological processes.	I totally agree	Partially agree	Partially Disagree	Totally Disagree
8	For the preservation of biodiversity to be established, the region must be uninhabited by humans.	I totally agree	Partially agree	Partially Disagree	Totally Disagree
9	Actions aimed at preserving biodiversity aim to maintain the natural environment without extracting resources by humans.	I totally agree	Partially agree	Partially Disagree	Totally Disagree
10	Ethnoconservation and biodiversity conservation are synonymous.	I totally agree	Partially agree	Partially Disagree	Totally Disagree
11	The conservation of biological diversity requires the maintenance of ecosystem diversity, species diversity and genetic diversity.	I totally agree	Partially agree	Partially Disagree	Totally Disagree
12	Biodiversity conservation processes are independent of the consequences of climate change.	I totally agree	Partially agree	Partially Disagree	Totally Disagree
13	An area with biodiversity preservation can be used sustainably.	I totally agree	Partially agree	Partially Disagree	Totally Disagree
14	Biodiversity conservation only occurs in uninhabited territories.	I totally agree	Partially agree	Partially Disagree	Totally Disagree

15	It is important to previously carry out a survey of native species of the flora of the region to be restored.	I totally agree	Partially agree	Partially Disagree	Totally Disagree
16	The deterioration of the environment due to changes in temperature, humidity, salinity and pH is irrelevant to the conservation of biodiversity.	I totally agree	Partially agree	Partially Disagree	Totally Disagree
17	Actions to conserve biodiversity prevent human beings from directly using the natural resources of a region.	I totally agree	Partially agree	Partially Disagree	Totally Disagree
18	In discussions about biodiversity conservation, it is essential to consider cultural diversity.	I totally agree	Partially agree	Partially Disagree	Totally Disagree
19	Traditional populations make it impossible to conserve biodiversity.	I totally agree	Partially agree	Partially Disagree	Totally Disagree
20	The preservation of biodiversity aims to protect species, habitats, ecosystems and ecological processes in the long term.	I totally agree	Partially agree	Partially Disagree	Totally Disagree
21	The ecological restoration of a degraded ecosystem includes the restitution of ecological processes.	I totally agree	Partially agree	Partially Disagree	Totally Disagree

Source: Prepared by the authors.

Olkin (KMO) and Bartlett Test were carried out. These tests allow checking the quality of correlations between variables and correspond to the significance reliability criterion proposed by Fischer, Boone and Neumann (2006). Values equal to or greater than 0.5 for the KMO test and a significance value of less than 0.05 for the Bartlett test indicate a good correlation. These tests were carried out using the SPSS ® statistical program, version 25, using the correlation matrix in factor analysis. Satisfactory indices were obtained for both tests, shown in Figure 1, which allowed the continuation of the validation process by factor analysis.

Figure 1 – Values obtained in the KMO and Bartlett tests

Teste de KMO e Bartlett

Medida Kaiser-Meyer-Olkin de adequação de amostragem.		,785
Teste de esfericidade de Bartlett	Aprox. Qui-quadrado	648,648
	gl	210
	Sig.	,000

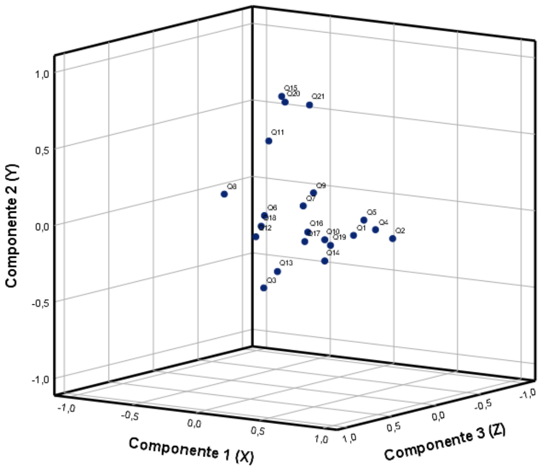
Source: Research data, extracted from the SPSS ® statistical program.

Finally, to analyze the structure of the diagnostic instrument, the statistical method for factor analysis called Principal Component Analysis (PCA) was used, which seeks to reduce a greater number of variables, based on the relevance and relationships between these variables, into components main (Lebart; Morineau; Fénelon, 1977). In factor analysis, the values represent the factor loadings, that is, the correlation of each variable with each component, with the variable belonging to the component in which it has the highest absolute value.

Thus, through PCA it was possible to condense a greater number of statements into a smaller number of components, making it possible to extract conceptual guidelines from the set of variables and, thus, identify subgroups of statements according to the cognitive skills involved.

The PCA was also carried out using the statistical program SPSS ®, version 25, based on dimension reduction by factor. In this PCA, three main components were obtained, as can be seen in Figure 2, which corresponds to the resulting rotated space component graph.

Figure 2 - Graph of the main components of the set of assertions



Source: Research data, extracted from the SPSS ® statistical program.

This result is consistent with the content validation adopted, in which all different aspects of the construct must be represented in the instruments, therefore, with three elements validated, a three-dimensional model must be considered (Fischer; Boone; Neumann, 2006). And, in this study, the elaboration of the assertions was based on three concepts (restoration, preservation and conservation of biodiversity), using three sources of definitions (etymological, normative and scientific).

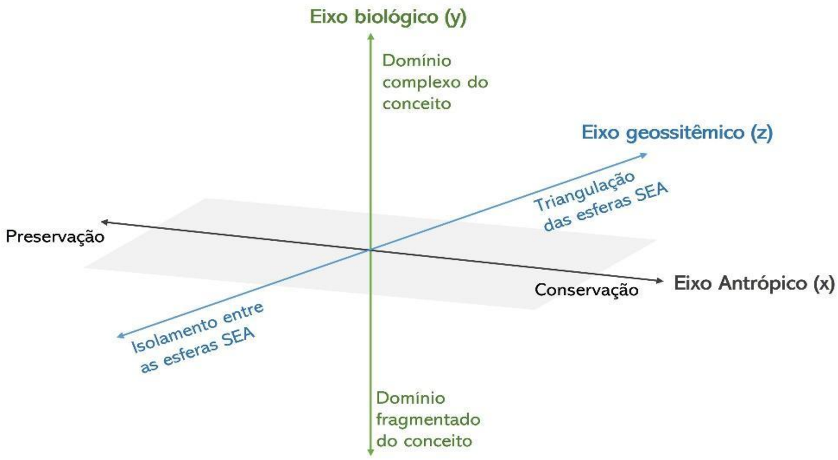
Considering the coordinates of the assertions in relation to the three axes (Figure 2), it is possible to verify the relationship of the assertions with the three components and, consequently, which assertions characterize each component, based on the highest value on an axis of each assertion. In this way, it was identified that statements 1, 2, 4, 5, 8, 10, 14, 17 and 19 have greater representation in Component 1 (x). Assertions 11, 13, 15, 20 and 21 show a greater relationship with Component 2 (y). And statements 3, 6, 9, 12, 16 and 18 present higher values in Component 3 (z). The conceptual interpretation of these analysis components is presented below.

Analysis components

According to Balvanera *et al*. (2022), when thinking about the typology of concepts involving environmental issues, it is possible to discern four dimensions: i) *indicator*, which encompasses questions such as "which measures can be used to evaluate or classify values?", having the biophysical dimension as guiding axes, economic and sociocultural, for example; ii) *specific values*, associated with the question "why do we consider nature and its contributions important to people?", with axes such as instrumental value, intrinsic value and relational value; iii) *broad values*, with the question "what type of values guide the way we interact with nature and the way we attribute value to it?", with axes such as the duty of protection, desire for harmonious relationships or prioritization of economic growth; and iv) *world views*, which considers axes that answer questions similar to "how does our understanding of the world influence the way we articulate the values attributed to nature?", with guiding axes such as human-centered views, nature-centered views and visions relationally-centered.

Considering the purpose of developing and applying the assessment diagnostic instrument and the context of application within the training of individuals capable of making effective decisions aimed at environmental protection, it is possible to interpret the axes of the component graph according to the perspective of the world view. The proximity of the statements plotted in the components graph indicates proximity or distance between the following guiding axes: anthropic, biological and geosystemic, as shown in Figure 3 and its details presented below.

Figure 3 - Guiding axes obtained from the main components



Source: Prepared by the authors.

Anthropogenic axis

The anthropic axis (x) mainly considers the action or role of human beings in relation to the environment. This axis has two world views as endpoints. At one extreme, a vision that does not identify the possibility of human management and/or human presence in environmental protection actions. At the other extreme, a vision that identifies possibilities for human coexistence in actions aimed at environmental protection. According to the concepts mentioned above and previously detailed, the extreme that represents the impossibility of human coexistence in environmental protection actions can be read according to perspectives closer to preservationism and the vision of untouched nature. The other extreme can be related to worldviews and decision-making that are more similar to the concept of conservation, since it integrates the social and economic sphere into environmental complexity.

An example of this axis is statement no. 8: "For the preservation of biodiversity to be established, the region must be uninhabited by human beings". The statement can be read by the sample in proximity to the axis of removal of human presence from environmental protection actions, as addressed by Law 9,985/2000 (Brazil, 2000b), which, despite not explicitly bringing issues of human habitation in the definition of the term, states in Article 7, in its §1, that the "basic objective of Integral Protection Units is to preserve nature, with only the indirect use of its natural resources being permitted, with the exception of the cases provided for in this Law", and some of these models of Conservation Units provide for expropriation. However, it is possible to read the statement according to the approach between human presence and environmental protection. According to Sarkar (1999), a scientific reference, preservation is defined as the "maintenance of natural landscapes that are currently uninhabited or sparsely inhabited", indicating the possibility of human presence in preserved areas.

Through this assertion, the response polarities indicate the approximation of the sample's worldview regarding the proximity between the concept of biodiversity preservation in environmental management and the human presence in preserved spaces, with the possibility of discussing aspects of cultural and cultural biodiversity about the importance of traditional populations in protecting biodiversity in all its complexity.

Biological axis

The biological axis (y) considers the ecological and ecosystem processes that shape nature as we perceive it; indicates the natural processes that are possible to map and understand, such as the concepts highlighted in the prepared instrument. It brings at its opposite extremes the understanding of the sample regarding the definitions of relevant concepts in moments of decision-making aimed at protecting biodiversity.

An example of an assertion is no. 11, which reads as follows: "The conservation of biological diversity requires the maintenance of ecosystem diversity, species diversity and genetic diversity". This assertion is mainly based on the scientific definition put forward by the IUCN (1984), according to Ganem and Drumond (2011, p. 31), detailing that:

> biodiversity conservation is the set of practices aimed at protecting biological diversity. It aims to maintain genetic diversity, ecological processes and essential vital systems, as well as the perennial use of species and ecosystems (IUCN, 1984). It includes a combination of actions ranging from the absolute preservation of stable biotic communities to the management of ecosystems modified by humans (Ganem; Drummond, 2011, p. 31, our translation).

Furthermore, it brings aspects identified in Law No. 9,985/00 to the definition of biological diversity, characterized as "the variability of living organisms of all origins, comprising, among others, terrestrial, marine and other aquatic ecosystems and ecological complexes of which they are part; also comprising diversity within species, between species and ecosystems" (Brasil, 2000b, our translation).

According to the interpretation of the positioning of the response on the axis, it is possible to evaluate the sample's perception regarding the complexity of the concept of conservation and, mainly, regarding the definition of biological diversity, since to agree or not with such an assertion it is necessary to mobilization of knowledge about types of biological diversity.

Geosystemic axis

The geosystemic axis (z) encompasses the analysis of assertions according to the perception of biogeographic space and political-social actions. The assertions corresponding to this axis mobilize world views that connect the impact of biogeographic space on public policies and vice versa, bringing at their poles views that associate the social, economic and environmental spheres (SEA spheres) and views that treat them separately each of these spheres, without interconnections. This axis considers the fit between systems and their "interactions", as Drouin (1993) puts it.

Statement no. 6 is an example involving the geosystemic axis, with the wording "The conservation of a biome is independent of public policies". It is based equally on both normative and scientific aspects, since the term conservation, both by Law nº 9.985/00 (Brazil, 2000b) and by authors such as Ganem and Drummond (2011), includes practices carried out by human beings such as focus on protecting biological diversity. The assertion also considers that other groups can carry out nature conservation without being directly related to public policies; however, when dealing with biomes as a whole, the intervention of government-level entities is considered necessary. It is also based on what Iucn (2013) stated when talking about conservation:

> Conservation often happens as a result of conscious and purposeful management efforts, but it can also be the unintended result of other intentions. It is also a dynamic phenomenon, varying over time in response to changes in internal and external circumstances. Why and how conservation occurs depends heavily on human worldviews and values, knowledge and skills, policies and practices, which combine in a variety of "human institutions" (Iucn, 2013, p. 13, our translation).

Through the geosystemic axis, it is possible to evaluate your sample regarding the perception of the connection between public policies and environmental conservation processes, in addition to evaluating the fluidity of the association between biological complexity and managerial complexity that make up terrestrial and marine biomes. It deals with topics related to decision making and, when compared to the answers given to other statements, can indicate the theoretical distance of the answer to the concept of environmental conservation adopted in the theoretical foundation.

Applicability and potential of the instrument: the case of climate change

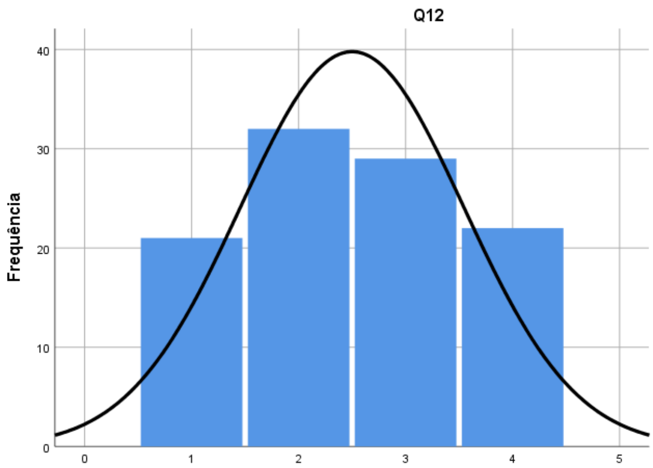
To explain the analysis of descriptive statistical data, referring to the responses in each statement, such as the frequencies of concordant and discordant responses and measures of central tendency, such as mean and mode (Bruni, 2009), assertion 12 is suggested as an example: "Biodiversity conservation processes are independent of the consequences of climate change." This assertion aims to identify the concept of interdependence between biodiversity conservation and the implications of climate change. In this case, "processes" cover biological, ecological and physical-chemical processes, in addition to planning and actions involved in biodiversity conservation, with a scientific theoretical foundation.

According to Ganem and Drummond (2011), biodiversity conservation corresponds to the "set of practices aimed at protecting biological diversity", this being biological diversity at all levels of organization (genetics, species and ecosystems)" according to Sarkar (1999). In this way, the effects of climate change cannot be disregarded, as they interfere at different levels of organization, even if in a different way and intensity at each level and, thus, biodiversity conservation processes have a dependent relationship with climate change.

Therefore, this assertion fits into the geosystemic axis. The discordant responses (totally disagree and partially disagree) to this statement demonstrate a deeper understanding of the triangulation of the SEA spheres and, therefore, the concordant responses (partially agree and completely agree) demonstrate a partial perception of the relationships of the SEA spheres or the isolation of SEA spheres, respectively.

In order to exemplify the descriptive statistical data relating to this assertion, the measurement is presented considering a sample composed of 104 Basic Education students, both from the public and private education networks. The frequency of responses given to statement 12 is represented in the histogram, Figure 4, below.

Figure 4 – Histogram of responses to statement 12



Source: Research data, extracted from the SPSS ® statistical program.

As can be seen in Figure 4, the frequency distribution is almost symmetrical, since the center of the distribution (the range of classes with the highest frequency density) is practically in the middle of the histogram, evidenced by the bars following the curve normal (line), whose maximum point is equivalent to the average frequency, in this case 2.5.

The frequency measured for each answer option was: 20.2% for completely agree (class 1); 30.8 for partially agree (class 2); 27.9 for partially disagree (class 3); and 21.2 for totally disagree (class 4). Therefore, it appears that 49.1% of the subjects understand in some way the relationships between climate change and the processes involved in biodiversity conservation.

However, mode, that is, the value (class) that occurred most frequently, was 2, which corresponds to the answer I partially agree, highlighting a reduced understanding of the triangulation of SEA spheres based on the proposed assertion. This mistaken conception can be an epistemological obstacle, as it limits subjects' reflection and decision-making when faced with environmental and climate issues.

Final remarks

From the materialization of a diagnostic instrument, capable of collecting data relating to the perceptions, conceptions and interpretations given by different social actors, the aim is to understand a new rationality and epistemology for the study and debate of socio-environmental issues.

The use of this format of environmental diagnostic instrument is likely to add important environmental concepts for resolving complex problems involved in global crises, at the same time as collecting the environmental conceptions and perceptions of social actors. Knowing society and how society thinks and makes its decisions is, therefore, fundamental for proposing strategies to combat and mitigate these crises.

The diagnostic instrument presented in this article, according to the validation steps previously described, met the reliability criteria and, therefore, can be applied to collect data on samples from different contexts. To this end, we suggest the analysis process using PCA, as described, which will enable the verification of the sample trend regarding the conception of ecological and ecosystemic processes, as well as the perception of anthropic action in the environment and the geosystemic relationships involved, based on the main components of the instrument's set of assertions and the guiding axes obtained from these main components, according to the examples presented in the previous topics. Furthermore, it is suggested to analyze descriptive statistical data relating to the responses to each statement, such as the frequencies of concordant and discordant responses and measures of central tendency, such as mean and mode. Such analysis may allow for greater detail and comparison across different groups of subjects.

Regarding potential uses, the instrument appears to be suitable for use as a diagnosis of perception on concepts relevant to the protection of biodiversity, and can be used to guide the development of training courses, Environmental Education classes and other activities aimed at favoring the complex rigor of interaction between the social, economic and environmental spheres in decision-making.

By accessing diverse environmental concepts and perceptions, it is also possible to elucidate how the individual's decision-making will be based. This point is fundamental with regard to global crises, such as climate and biodiversity, since the diversity of views of social actors stimulates awareness and environmental awareness based on ecological, cultural, social, economic, and political aspects.

The contribution of data from the diagnostic instrument to Environmental Education resides exactly in this space, as it accesses information concerning reality and that enables decision-making to help mitigate global crises. Environmental Education is, therefore, welcome and encouraged to incorporate this type of diagnostic instrument, as it can encourage social participation in global and interdisciplinary socio-environmental discussions.

REFERENCES

BABBIE, E. **Métodos de pesquisas de Survey**. 3. reimpr. Tradução de Guilherme Cezarino. Belo Horizonte: Editora UFMG, 2005.

BALVANERA, P.; PASCUAL, U.; CHRISTIE, M.; BAPTISTE, B. Chapter 1: The role of the values of nature and valuation for addressing the biodiversity crisis and navigating towards more just and sustainable futures. *In*: BALVANERA, P.; PASCUAL, U.; CHRISTIE, M.; BAPTISTE, B. (ed.). **Methodological Assessment Report on the Diverse Values and Valuation of Nature of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services**. IPBES secretariat, Bonn, Germany, 2022. p. 1-35.

BAPTISTA, M. N.; CAMPOS, D. C. **Metodologias de Pesquisa em Ciências**: análises quantitativa e qualitativa. Rio de Janeiro: LTC, 2007.

BORGES, W. B.; OLIVEIRA, A. D.; MÜLLER, E. S. Percepção da biodiversidade: qual a contribuição da educação básica? **Research, Society And Development**, [*S. l.*], v. 11, n. 13, p. 1-15, 10 out. 2022.

BRASIL. Ministério do Meio Ambiente. **Convenção sobre Diversidade Biológica**. Série Biodiversidade n. 1. Brasília, DF, 2000a.

BRASIL. **Lei n. 9.985, de 18 de julho de 2000**. Regulamenta o art. 225, § 1º, incisos I, II, III, e VI da Constituição Federal, institui o Sistema Nacional de Unidades de Conservação da Natureza e dá outras providências. Brasília, DF, 2000b.

BRUNI, A. L. **SPSS aplicado à pesquisa acadêmica**. São Paulo: Atlas, 2009.

BRITO, B. L.; BRITO, D. M. C.; SOUZA, E. A. Pressupostos teóricos de proteção da natureza. **Planeta Amazônia: Revista Internacional de Direito Ambiental e Políticas Públicas**, Macapá, n. 7, p. 141-147, 2015.

CARSON, R. **Silent spring**. Edição 2002. Nova Iorque: Houghton Mifflin Company. 1962.

DALMORO, M.; VIEIRA, K. M. Dilemas na construção de escalas Tipo Likert: o número de itens e a disposição influenciam nos resultados? **Revista Gestão Organizacional**, [*S. l.*], v. 6, n. 3, p. 161-174, 2013.

DROUIN, J. M. Comunidades e sistemas. *In*: DROUIN, J. M. **Reinventar a natureza**: a ecologia e sua história. Lisboa: Instituto Piaget, 1993. p. 73-90.

FISCHER, H. E.; BOONE, W. J.; NEUMANN, K. Quantitative Research Designs and Approaches. *In*: ABELL, S. K.; LEDERMAN, N. G. **Handbook of research on science education,** 2006. p. 18-53.

GANEM, R. S.; DRUMMOND, J. A. Biologia da conservação: as bases científicas da proteção da biodiversidade. *In*: GANEM, R. S. **Conservação da biodiversidade**: legislação e políticas públicas. 2. ed. Brasília, DF: Edições Câmara, Série Memória e Análise de Leis, 2011. p. 11-46.

GIFFORD, R.; SUSSMAN, R. Environmental attitudes. *In*: CLAYTON, S. D. (ed.). **The Oxford handbook of environmental and conservation psychology**. Oxford University Press, 2012. p. 65-80.

INTERNATIONAL UNION FOR CONSERVATION OF NATURE (IUCN). **Governance of Protected Areas**: From understanding to action. Gland: IUCN, 2013.

JACOBI, P. Educação Ambiental, Cidadania e Sustentabilidade. **Cadernos de Pesquisa**, [*S. l.*], v. 118, p. 189–206, 2003.

KOCH, M.; BUCHS, M.; LEE, J. Towards a New Generation of Social Policy: commonalities between sustainable welfare and the IPCC. **Politiche Sociali**, [*S. l.*], n. 1, p. 27-42, 2023.

LEBART, L.; MORINEAU, A.; FÉNELON, J. P. **Traitement des Données Statistiques; Méthodes et Programmes**. 2. ed. Paris: Dunod. 1977.

LEFF, E. **Epistemologia Ambiental**. São Paulo: Editora Cortez, 2007.

LIKERT, R. A technique for the measurement of attitudes. **Archives of Psychology**, [*S. l.*], v. 22, n. 140, 1932.

MAHECHA, M. D.; BASTOS, A.; BOHN, F. J.; EISENHAUER, N.; FEILHAUER, H.; HARTMANN, H.; HICKLER, T.; KALESSE-LOS, H.; MIGLIAVACCA, M.; OTTO, F. E. L.; PENG, J.; QUAAS, J.; TEGEN, I.; WEIGELT, A.; WENDISCH, M.; WIRTH, C. Biodiversity loss and climate extremes — study the feedbacks. **Nature**, [*S. l.*], v. 612, n. 7938, p. 30-32, 29 nov. 2022.

MARCONI, M. A; LAKATOS, E. M. **Fundamentos da Metodologia Científica**. São Paulo: Editora Atlas, 2003.

MARTINS, G. A.; BENAVIDES, M. L. A.; RAMALHO, D. G.; BRANDO, F. R. Uma proposta didática para disciplina de Educação Ambiental no Ensino Superior, a partir de concepções prévias sobre meio ambiente. **Tecné, Episteme y Didaxis: TED**, [*S. l.*], v. 38, p. 57-74, 2015.

MELO, W. V. de; BIANCHI, C. dos S. Discutindo estratégias para a construção de questionários como ferramenta de pesquisa. **Revista Brasileira de Ensino de Ciência & Tecnologia**, [*S. l.*], v. 8, n. 3, p. 43-59, 2015.

MIANI, C. S. **Um estudo sobre a conservação da biodiversidade com futuros professores de biologia**. 2017. 149 f. Tese (Doutorado em Educação para a Ciência) – Universidade Estadual Paulista, Faculdade de Ciências, Bauru, SP, 2017.

MICHAELIS. **Dicionário Brasileiro da Língua Portuguesa**. Editora Melhoramentos, 2021. Disponível em: https://michaelis.uol.com.br/moderno-portugues/. Acesso em: 04 jan. 2021.

MIRANDA, G. P.; BEZERRA, E. P. Litorália. **Interacções**, [*S. l.*], v. 18, n. 63, p. 23-46, 28 dez. 2022.

MONTERO, M. B. Técnicas de Investigación. La indagación cualitativa y sus usos más comunes en Investigación Social. *In*: **Planificación, Organización y Evaluación de Proyectos Sociales**. Escuela de animación de la Comunidad de Madrid. Madrid: Consejería de Educación y Cultura, 1997.

NAÇÕES UNIDAS. **Our Common Future**. Oslo, Noruega, 1987.

NERY, E. R. A.; SARAIVA, C. S.; CRUZ, L. M. S.; SOUZA, M. M. O. R.; GOMES, F. S.; EL-HANI, C. N.; MARIANO-NETO, E. O conceito de restauração. **Revista Caititu**, [*S. l.*], n. 1, p. 43-56, 2013.

PASQUALI, L. Escalas psicométricas. *In:* PASQUALI, L. **Instrumentos psicológicos**: manual prático de elaboração. [*S. l.: s. n.*], 1999. p. 105-126.

PHILIPPI, A.; SOBRAL, M.; FERNANDES, V.; ALBERTO, C. Desenvolvimento sustentável, interdisciplinaridade e Ciências Ambientais. **Revista Brasileira de Pós-Graduação**, [*S. l.*], v. 10, p. 509-533, 2013.

PÖRTNER, H. O.; SCHOLES, R. J.; AGARD, J.; ARCHER, E.; ARNETH, A.; BAI, X.; BARNES, D.; BURROWS, M.; CHAN, L.; CHEUNG, W. L.; DIAMOND, S.; DONATTI, C.; DUARTE, C.; EISENHAUER, N.; FODEN, W.; GASALLA, M. A.; HANDA, C.; HICKLER, T.; HOEGH-GULDBERG, O.; ICHII, K.; JACOB, U.; INSAROV, G.; KIESSLING, W.; LEADLEY, P.; LEEMANS, R.; LEVIN, L.; LIM, M.; MAHARAJ, S.; MANAGI, S.; MARQUET, P. A.; MCELWEE, P.; MIDGLEY, G.; OBERDORFF, T.; OBURA, D.; OSMAN, E.; PANDIT, R.; PASCUAL, U.; PIRES, A. P. F.; POPP, A.; REYES-GARCÍA, V.; SANKARAN, M.; SETTELE, J.; SHIN, Y. J.; SINTAYEHU, D. W.; SMITH, P.; STEINER, N.; STRASSBURG, B.; SUKUMAR, R.; TRISOS, C.; VAL, A. L.; WU, J.; ALDRIAN, E.; PARMESAN, C.; PICHS-MADRUGA, R.; ROBERTS, D. C.; ROGERS, A. D.; DÍAZ, S.; FISCHER, M.; HASHIMOTO, S.; LAVOREL, S.; WU, N.; NGO, H. T. **Scientific outcome of the IPBES-IPCC co-sponsored workshop on biodiversity and climate change**. Bonn, Germany: IPBES secretariat, 2021.

PRISLIN, R.; CRANO, W. D. Attitudes and Attitude Change: the Fourth Peak. *In*: CRANO, W. D.; PRISLIN, R. (ed.). **Attitudes and Attitude change**. New York, Psychology Press: Taylor & Francis Group, 2008. p. 3-15.

ROOS, A.; BECKER, E. L. S. Educação Ambiental e Sustentabilidade. **Revista Eletrônica em Gestão, Educação e Tecnologia Ambiental**, [*S. l.*], v. 5, p. 857-866, 2012.

SAMPIERI, R. H.; COLLADO, C. F.; LUCIO, M. P. B. **Metodologia de Pesquisa**. 5. ed. Porto Alegre: Penso, 2013.

SARKAR, S. Wilderness preservation and biodiversity conservation-keeping divergent goals distinct. **BioScience**, [*S. l.*], v. 49, n. 5, p. 405-412, 1999.

SCOTT, D.; HALL, C. M.; RUSHTON, B.; GÖSSLING, S. A review of the IPCC Sixth Assessment and implications for tourism development and sectoral climate action. **Journal Of Sustainable Tourism**, [*S. l.*], p. 1-18, 29 mar. 2023.

SEIXAS, C. S. Abordagens e técnicas de pesquisa participativa em gestão de recursos naturais. *In*: VIEIRA, P. F.; BERKES, F.; SEIXAS, C. S. (org.). **Gestão Integrada e Participativa de Recursos Naturais**. Florianópolis: APED Editora, 2005.

SER (Society for Ecological Restoration). **SER International Primer on Ecological Restoration**. Society for Ecological Restoration International Science & Policy Working Group, Washington DC. 2004.

SILVA, P. R.; ARAÚJO, E. S. N. S.; CALDEIRA, A. M. A.; CARVALHO, G. S. Construção e validação de questionário para análise de concepções bioéticas. **Revista Bioética**, [*S. l.*], v. 20, n. 3, p. 490-501, 2012.

TOVAR, J. Psicometría: tests psicométricos, confiabilidad y validez. **Psicología: Tópicos de actualidad**, [*S. l.*], v. 8, p. 85-108, 2007.

WILLITS, F. K.; THEODORI, G. L.; LULOFF, A. E. Another look at Likert scale. **Journal of Rural Social Sciences**, [*S. l.*], v. 31, p. 126–139, 2016.

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Availability of data and material: The data and materials used in the work are available for public access, with the exception of the application data described in the section "Applicability and potential of the instrument: the case of climate change", which are part of the postgraduate research of one of the authors.

Author contributions: Thais Adrianne Silva Reinaldo, Luene Pessoa Vicente, Anaís Freitas Silveira and Ariadne Dall'acqua Ayres participated in the conception of the instrument, from its first elaboration to validation, pilot applications, reformulations, final application and data analysis and interpretation . The authors contributed to the writing of this article. Fernanda da Rocha Brando co-supervised the construction and validation of the instrument as well as the analysis and interpretation of the data. Ana Maria de Andrade Caldeira conceived the project, coordinated the research group, guided the discussions on the elaboration, validation and application of the instrument, as well as the analysis and interpretation of the data. The authors helped with the final writing of this article.

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