Visibility to empowerment fostered using concept maps in the study of abstract biological concepts

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ABSTRACT

The concept mapping technique enables personal and collective autonomy, promoting the exercise of various cognitive skills, which favor creativity and logical thinking. Due to the importance of practices related to the construction of scientific texts, the objective of this article was to highlight products developed in the course of teaching and learning, using concept maps, as a way to signal evidence of empowerment in the study of little-known zoological taxa. The present investigation used the methodology of content analysis to examine the publications developed by students with the authors of this paper and associated researchers. Specifically, productions that used the conceptual integration tool to elucidate taxonomic, phylogenetic and ecological contents on neglected fauna groups were selected for analysis. The documents analyzed indicated that, by mobilizing the study of abstract concepts related to enigmatic invertebrates, with the elaboration of scientific writings disseminating biodiversity, an active participation of students is promoted. Experiences of this nature reflect evidence of empowerment in higher education, in addition to increasing the sense of belonging to biological diversity and its environmental interactions.

Keywords: Active learners, Enigmatic biodiversity, Scientific writing, Research in teaching.

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INTRODUCTION

Concept maps are graphical devices used to organize and build knowledge. Dr. Joseph D. Novak, author of this pedagogical innovation, points out that this type of graphic scheme was developed in the 1970s at Cornell University (Novak & Gowin, 1996; Novak & Cañas, 2007, 2008, 2010) and is constantly evolving (Novak & Cañas, 2006). From a personal and collective emancipatory perspective, the conceptual mapping technique, according to Novak (2002, 2013) and Ålhberg (2013), is a tool that promotes intellectual skills conducive to the empowerment of teachers and learners, by favoring teaching, learning and research. Moreira (2011) points out that Novak's (1977) humanistic approach to meaningful learning, grounding the positive and constructivist integration of thoughts, feelings, and actions, leads to human empowerment. In this context, those who acquire the ability to map concepts, based on the Theory of Meaningful Learning developed by Ausubel (2000), can achieve a promising way of thinking about a given subject.

In search of motivational elements in the process of acquiring knowledge, the teaching tools that add values that enhance the learner, according to Broom (2015), constitute alternatives for teachers to put in their pedagogical practices. As stated in Skene (2021), in recent years, empowerment has become a central theme in many fields of the social sciences, from human geography to business studies and in social movements for change. According to Calvès (2009), the notion of empowerment occupies a prominent place in the contemporary discourse of international institutions on the participation of the financially disadvantaged in development programs.

The idea of emancipation in the educational field had one of its first achievements in the social work led by Paulo Freire (Freire, 1972; Urbanowicz, 2020; Skene, 2021), and has been highlighted for being an empowering factor in the path of academic training, when referring to scientific writing. Several authors, such as Fahmi et al. (2020), Richards (2021), Jamil (2023), Nikkhah (2023), Permana et al. (2023) and Sari et al. (2023) highlight the ability to construct scientific texts, characterizing it as of great importance in the teaching and learning process, with potential to foster empowerment in the classroom.

Choosing concept maps as learning tools and research objects in the course of teaching abstract concepts of biology, Araújo-de-Almeida & Santos (2018, 2021), Araújo-de-Almeida et al. (2019a, b, 2020, 2021, 2022, 2023), Dias-da-Silva et al. (2019a, b, 2023) and Aciole et al. (2022, 2023, 2024) are examples of works that explain, at different times, data about the insertion of these visual instruments in the study of Phylogenetic Systematics, Zoology and Environmental Education. In these publications, the use of the conceptual mapping technique is also an element to promote the dissemination of important themes, but little discussed in the classroom, such as enigmatic invertebrates. The visual structuring of conceptualizations about these invertebrates, considered enigmatic in the sense of Blaxter et al. (2004) and Brusca et al. (2016, 2023), thus becomes pertinent;

since, their descriptions are complex and abstract. According to Brusca et al. (2023), invertebrates make up approximately 96% of the documented zoological diversity and, according to Eisenhauer et al. (2019), their representatives may be threatened or in the process of extinction.

A large number of invertebrate fauna, in addition to their intrinsic value, are essential in the maintenance of ecosystem functions and, therefore, for the conservation and balance of the environment (Wilson, 1987; Wilson & Peter, 1997; Santos, 2011; Tilman et al., 2014; Scudder, 2017; Brusca et al., 2023), however, Araújo-de-Almeida et al. (2011, 2020) state that little attention is paid to enigmatic invertebrates, especially when it comes to the teaching of zoology. Therefore, there is a call for a contextualized pedagogical content, with the need for strong appeals to environmental and social issues. Thus, concept maps have the opportunity to integrate knowledge about biodiversity with environmental education and promote public awareness, disseminating knowledge produced (Araújo-de-Almeida et al. 2023; Viana et al., 2023).

The use of visual instruments in communication about biodiversity contributes to the realization of what was recommended in article 13 of the Convention on Biological Diversity and in Component 6 of the National Biodiversity Policy (Decree No. 4,339/2002), which also deal with the dissemination of information on biological diversity, its conservation and sustainable use (see Brasil, 1998, Araújo-de-Almeida et al., 2023). In addition, the "ecologically balanced environment", according to the provisions of the *caput* of article 225 of the 1988 Constitution of the Federative Republic of Brazil (CRFB88), is considered by Milaré (2015) as a fundamental constitutional right and, according to Brasil (1988), its effectiveness implies, according to article 225 § 1º VI of the CRFB88, the promotion of "environmental education at all levels of education and public awareness for the preservation of the environment".

Recognizing the relevance of the exercise in the technique of conceptual mapping and the construction of scientific writings, contextualized with environmental problems, the objective of this article is to address a set of publications, with the participation of students, throughout the teaching process, using concept maps in the construction of knowledge, to evidence the empowerment in the study of abstract concepts related to little-known zoological taxa.

METHODOLOGY

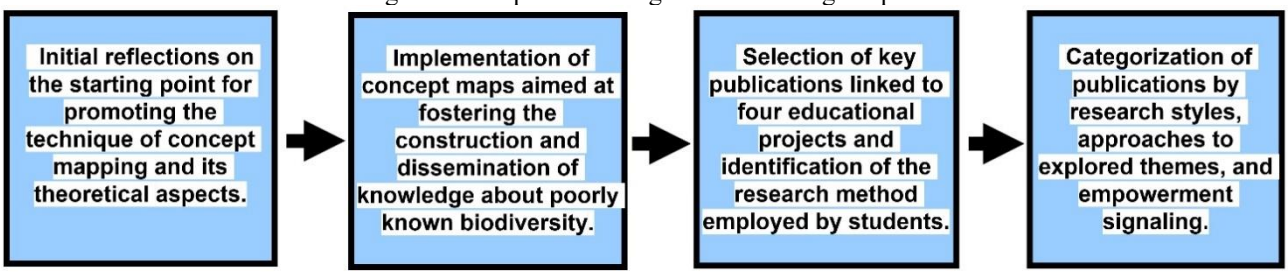
This work follows the qualitative research model, with the application of elements of content analysis systematized by Bardin (2013, 2016), to direct the bibliographic survey and elaboration of categories from a set of publications developed by students participating in teaching initiation projects. The writings collected used the concept maps in the exploration of abstract biological subjects. In 2016, the first publication record was released, addressing this graphic device, linked to the Laboratory of Research in Zoology Teaching (LaPEZ), Biosciences Center (CB), Federal

University of Rio Grande do Norte (UFRN), but, specifically, this research focuses on publications developed from 2019 onwards. The central idea was to emphasize the teaching projects registered with the Dean of Undergraduate Studies (Prograd) of UFRN. In this aspect, they involved the work of nine monitors linked to the teaching projects, in collaboration with four volunteer students engaged in learning the concept mapping technique and in the subsequent production of academic writings for publication in scientific vehicles.

As it is an investigation of the practice itself, this article is a space for reflection that documents an experience that began in 2015, thus encompassing, in this formative path, nine years of continuous interactions focused on scientific studies on little-known animals, using concept maps as the main methodological artifact. The reflections presented were inspired by Lyle (2018), Lira and Passeggi (2021), Passeggi (2021) and Suárez (2021). This study also constitutes an experience report regarding the positive actions carried out in the classroom, as outlined by Araújo-de-Almeida et al. (2019b).

By fostering the elaboration of contextualized concept maps through scientific writing while teaching, it was possible to build knowledge about animal biodiversity in several publications, contemplating different styles of texts. As seen in Aciole et al. (2023), these pedagogical materials have been used in the classroom and have also been the object of reflective analyses on the constructive path in general. To fulfill the objectives of the research, highlighting the importance of these teaching products for the empowerment of the students involved, the methodological path illustrated in Figure 1 summarizes the four topics that outlined the description of the process:

Figure 1 – Steps delineating the methodological path



Source: Authored by the authors.

As a starting point, it is important to reflect on the initiative of a graduate student, when she produced, together with the first author of this article, the first formal record involving the use of the concept maps and theoretical references adopted. Highlights of the works that address this path, in the initial phase, are also given to undergraduate students and related researchers, including the participation of a full professor at the Federal University of Paraíba (UFPB).

Regarding the construction of knowledge using the concept mapping technique, in order to achieve the elaboration of writings focused on learning and dissemination about enigmatic

biodiversity, the students associated with the projects received constant guidance from the authors of this writing. This training process took place both through individual and team care, mainly through courses and/or pedagogical workshops. The composition of projects by the students, to structure the scientific research, was of great importance in the initial phase. The planning stage was discussed in Araújo-de-Almeida and Santos (2021), where it is highlighted that the fulfillment of this requirement allows for more precise structuring of the contextualization of the text covering: Title, Introduction, Objectives, Methodology, Results, Discussion, and References. Developing a structuring of writing, in this aspect, is an exercise in scientific research, which, according to Scarpa (2016), involves stages and ways of reasoning and communicating that culminate in typical argumentative processes.

Throughout the process of advising students, guidelines for the construction of three research models were established. Among the types of writings fostered, experience reports, content analysis research and research focused on key concepts stand out. Pertinent to the training of the students, in this sense, instructions were made possible that would lead to the search, in a collective way, of the concepts that would answer the structuring focus question of the desired conceptual map. From then on, each student, as a team, had the opportunity to choose the most appropriate model for their specific interest, in order to prepare an unpublished and innovative scientific writing.

Regarding the selection of key works and identification of the writing style and the biological theme explored, all the productions developed by LaPEZ participants were verified, to investigate these publications, from the year 2019, when the action of the Teaching Projects began exploring content about little-known animal organisms using the conceptual mapping technique. The article by Aciole et al. (2023) was considered to be of great relevance, with regard to the initial bibliographic survey of the works of the present investigation; Thus, the analysis process intended in the research objective was facilitated. The criterion for selecting the respective texts, in the more detailed study, was the *status* of the publication, whether in a journal or book chapter. In this sense, works published in annals of events and those that were republished were excluded from the analysis. Continuing the path, in order to categorize the selected works and continue focusing on the opportunities for emancipation of the student, as the protagonist of the experience, the publications that occurred in the course of action in the teaching projects, contemplated one of the aspects of the research:

a) Elaboration of experience reports as scientific products, as emphasized by Suárez (2008) and Daltro and Faria (2019).
b) Content analysis research with thematic summarization of the published publications, following the content analysis developed by Bardin (2013, 2016).
c) Research focused on key concepts, as verified in Novak and Cañas (2008, 2010), by considering concept maps as a research tool.

RESULTS AND DISCUSSION

Before dealing with the experience with the elaboration of concept maps discussed in the scientific writings published by the students and which helped in the course of teaching about the little-known animal biodiversity, some previous evidences related to empowerment, in the investigative beginning of the conceptual mapping technique, are highlighted. After these initial observations, the rationale of the study regarding the publications linked to the teaching projects that were developed from 2019 onwards allows us to verify the visibility of the aggrandizement provided by the documented experiences.

THE STARTING POINT TOWARDS SCIENTIFIC PRODUCTIONS WITH CONCEPT MAPS ON BIODIVERSITY

The article by Monteiro and Araújo-de-Almeida (2016) signaled the beginning of the journey in relation to the experiences recorded in publications that indicated the use of the concept mapping technique exploring topics on biodiversity. This article, entitled "The environmental theme conveyed through concept maps", preceded a series of publications addressing this resource of conceptual integration in the teaching and research process. The theoretical frameworks on concept maps, including Novak and Cañas (2008), Moreira (2006, 2010) and Novak (2010) were explained in this publication. Regarding considerations about the environment, Ahlberg et al. (2001) and Chaiben et al. (2011) were cited as references in the approach to environmental education using such graphic devices.

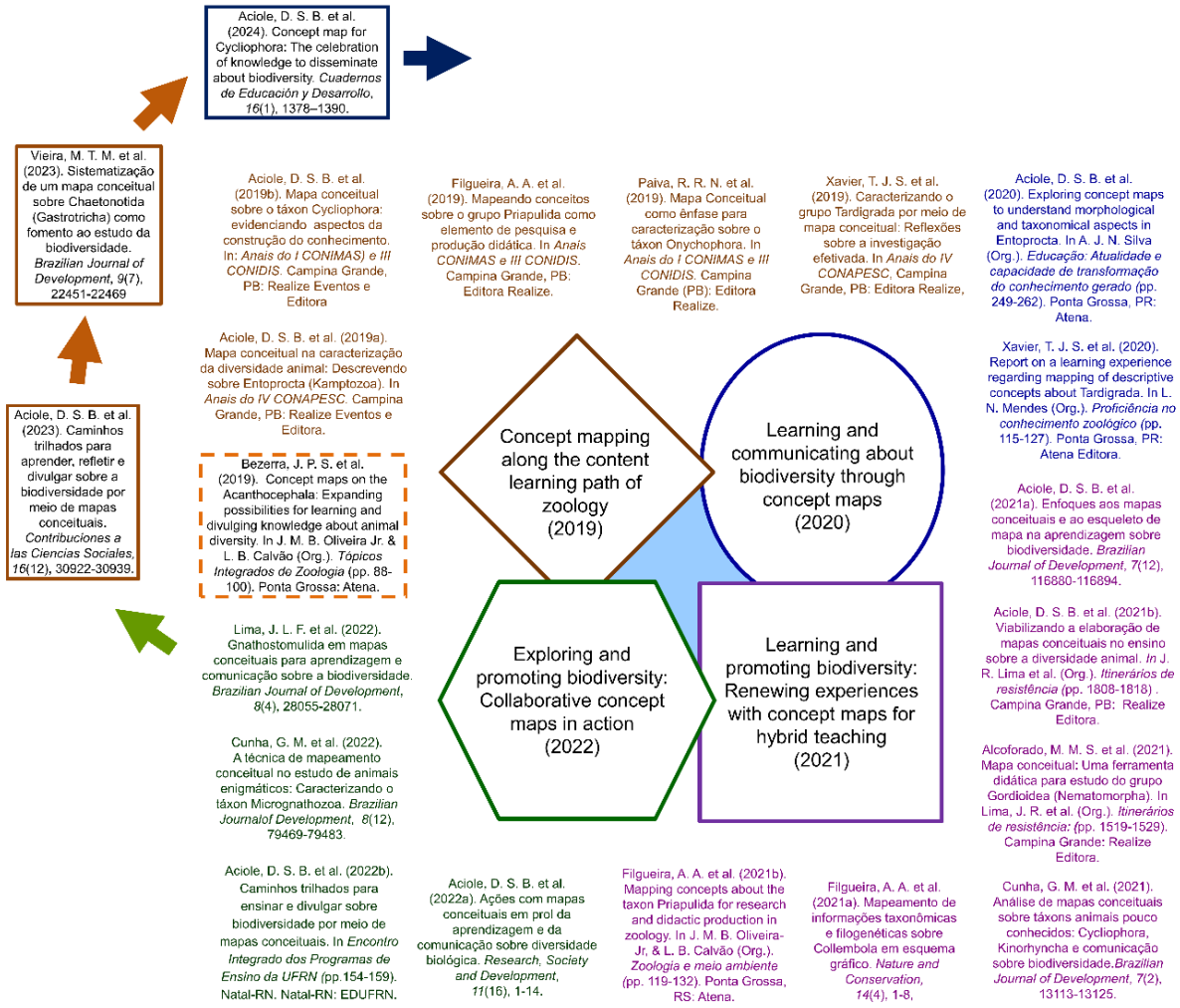
In anticipation of pedagogical experimentation, Araújo-de-Almeida and Santos (2018) address the first productions developed by students enrolled in the disciplines that address animal diversity in the undergraduate course in Biological Sciences at CB/UFRN. The experiments with concept *mapping tasks* developed in the classroom encompassed the study of the little-known diversity of invertebrates. Additionally, the works published by undergraduate (Bezerra et al., 2019) and graduate students (Dias-da-Silva et al., 2019a, b, 2023) are examples of the use of concept maps in the course of teaching invertebrate zoology. These publications highlighted several bibliographic sources that support the theoretical basis of concept maps, such as Moreira (1980, 2011), Novak and Gowin (1996), Novak and Cañas (2006, 2008, 2010), Hay et al. (2008), Kinchin (2011), Aguiar and Correia (2013), Ålhberg (2013), Cañas et al. (2015), and Correia et al. (2016), among other authors.

THE PUBLICATIONS COLLECTED AND THEIR CONNECTIONS TO THE TEACHING PROJECTS

Highlighting the teaching projects as organized in the scheme of Figure 2, for each year of operation, the following are the following: (a) "Conceptual mapping in the course of learning content

in zoology", conducted in 2019, resulting in five publications; (b) "Learning and communication on biodiversity through concept maps", developed in 2020, with two publications; (c) "Learning and dissemination about biodiversity: Renewing experiences with concept maps for blended learning", carried out in 2021, totaling six publications; and (d) "Knowing and Disseminating About Biodiversity: Collaborative Concept Maps in Action", concluded in 2022, with four publications.

Figure 2 – Illustrative scheme of the four teaching projects that promoted actions for the elaboration of writings addressing the concept maps about enigmatic taxa.



Fonte: Expanded from Aciole et al. (2023, p. 30929).

The various publications that took place over the four years of the teaching projects, chronologically circulating the different geometric figures, provide a panoramic view of this trajectory. The insertion of the book chapter on the taxon Acanthocephala, by Bezerra et al. (2019), highlighted in the rectangle with dashed borders, corresponds to a highlight of the publication that fostered the interest of students who applied for selection as teaching assistants in the project carried out in 2019. With the addition of publications of importance to the study, which occurred before and after the implementation of these projects, the total number of 21 publications surveyed was totaled, which were selected as a sample for analysis.

In view of the growing number of scientific writings generated in 2022, the articles arising from this demand, published in the years 2023 and 2024 were thus included in this analysis. Thus, in addition to this square of 18 publications, the writings of Aciole et al. (2023, 2024) and Vieira et al. (2023) are added, thus informing the continuity of the action. In the new cycle, which started in 2023, the titles of the publications are inserted in rectangles. The panorama in Figure 2, when adding the publications carried out from the year 2023 onwards, illustrates a spiral movement, whose direction of the arrows makes explicit the intention to create a new cycle.

PARTICIPATION OF STUDENTS IN PUBLICATIONS LINKED TO TEACHING PROJECTS

Although the students' productions associated with the teaching project carried out in 2019 were primarily published in annals of scientific events, they contributed to a comprehensive vision that was progressively enriched over four years of implementation of teaching actions. In fact, the improvement of the concept maps and the context of the information explored in the scientific articles continued throughout the classes in remote format (2020-2021) in the period of health restrictions resulting from the Covid-19 pandemic. In the year 2020, some of the writings presented in annals of scientific events were selected for review and expansion, culminating in publication as articles or book chapters, for example, Aciole et al. (2020) and Xavier et al. (2020). Continuing the process, the work made possible from 2021 onwards includes Aciole et al. (2021a, b, 2022, 2023, 2024), Alcoforado et al. (2021), Cunha et al. (2021, 2022), Filgueira et al. (2021a, b), Lima et al. (2022), and Vieira et al. (2023).

According to the exclusions of some writings in the final study sample, the 15 publications categorized into the three different typologies of scientific writings are in accordance with the students' choices and the scope of their skills around the research style adopted. Thus, three different types of documented productions are emphasized: (a) experience reports based on academic experiences; (b) content analysis research from produced documents; (c) research focused on key concepts as an exercise to clarify the contents. The concept maps, explained in Figures 3, 4, and 5, illustrate, respectively, a synthesis of the methodological process on each of these types of investigations.

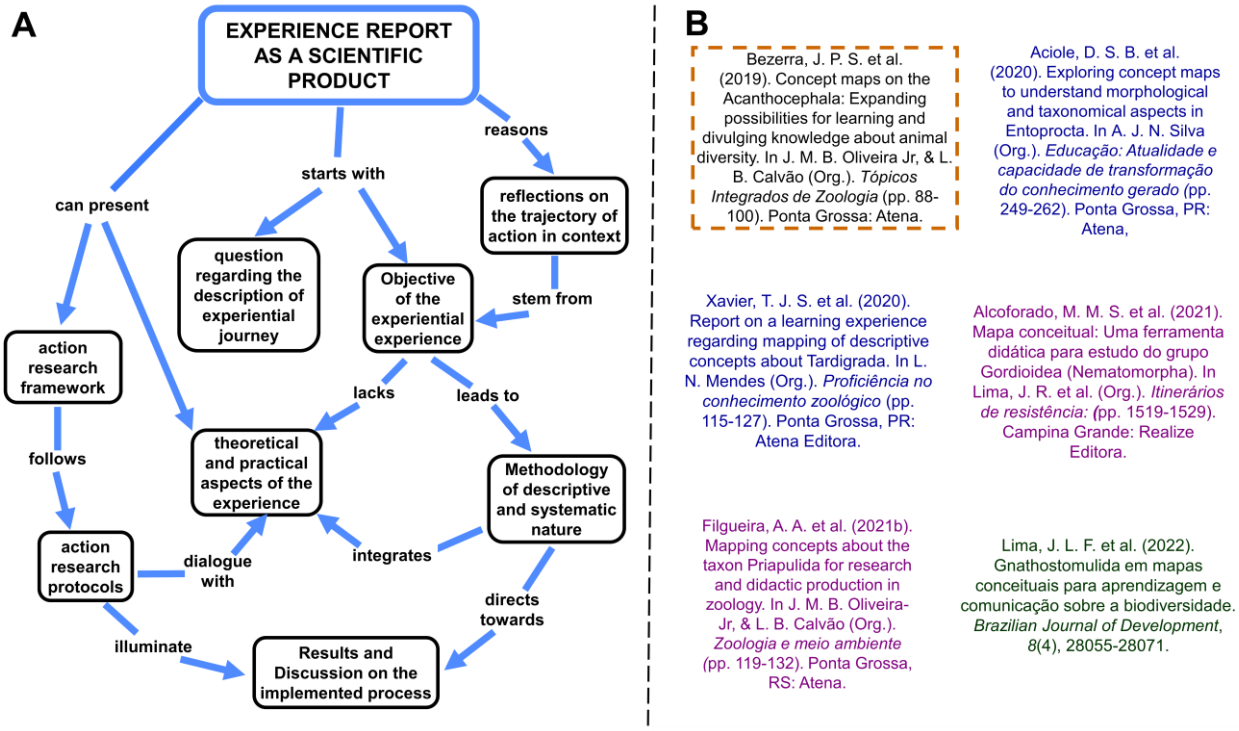
PRODUCTIONS BASED ON ACTIVITIES EXPERIENCED BY STUDENTS IN THE EXPERIENCE REPORT CATEGORY

Explaining the process of constructing the experience reports, Figure 3A presents a conceptual map that summarizes the main elements involved in this genre of writing, used to support the study of concept maps in the exploration of abstract biological contents. This scheme emphasizes this type of writing as a scientific product and serves as a basis for reflections on the knowledge

experienced through a mobilization of contextualized practice. The action is outlined from a specific investigative question and a clearly defined objective; It is also driven by an appropriate methodology that allows you to achieve the results and promote relevant discussions. When the research is developed collaboratively, it expands the possibilities of interactions between participants, while enabling, according to Yaacob et al. (2021), critical thinking through reflective learning. In addition, the conceptual map contained in this scheme highlights that this writing model can originate from an action research, which, according to Tripp (2005), is a modality of action research of great importance in a reflective practice.

As an experience of empowerment with the concept maps based on scientific writings, the students linked to the teaching projects experienced aspects of reflective writing about the path lived. In this style of writing, six works involving several students stand out. Represented in Figure 3B, the following belong to this list: Bezerra et al. (2019), in the study of the taxon Acanthocephala; Aciole et al. (2020), in the conceptual explorations on Entoprocta; Xavier et al. (2020), in their research on the Tardigrada lineage; Alcoforado et al. (2021), in the details about Gordioidea (Nematomorpha); Filgueira et al. (2021b), in the in-depth studies on the Priapulida taxon, and Lima et al. (2022) in the conceptual specifications related to the Gnathostomulida group.

Figure 3 – Concept map highlighting what an experience report is about and examples of related productions.



Source: Authored by the authors.

As it is a writing that can be constructed by apprentices in undergraduate courses, experience reports, as seen in Araújo-de-Almeida et al. (2019b), are very appropriate for a reflective evaluation. According to Kolb and Kolb (2018), reflexivity is present in the learning cycle proposed by David

Kolb (1984), which includes the related stages: experiencing, reflecting, thinking, and acting. The links with reflective practices, at the moment in which the experience report is constructed, show the existence of a reflection on action and another on action, defended by Schön (1987). By expanding the reflexive aspect of the experience report, it is possible to recover the steps of the trajectory, thus going through the cycle proposed by Gibbs (1988), which includes: description, perception, evaluation, analysis, conclusions, and action plan.

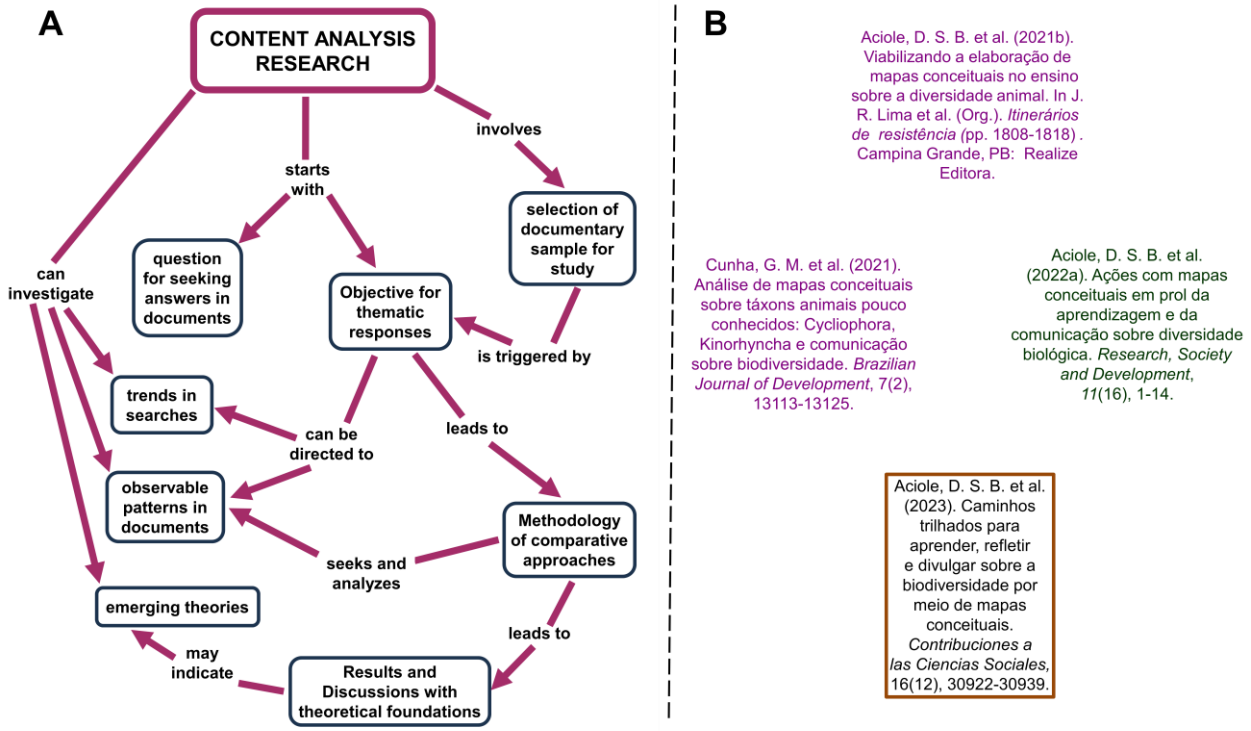
According to Daltro and Faria (2019), experience reports, as objects of analysis, are scientific narrative documents aligned with a postmodern approach. For Suárez (2008), when classroom practices and experiences are reflected, interpreted, reported and made public, they correspond to unique sources of research and pedagogical criticism that guide the revision of views on the academic world. In terms of empowerment in the formative process, according to Passeggi and Lira (2023), narrating an experience allows us to experience the three exercises of telling: reflecting, arguing, and reconstructing, in order to emancipate the subjects, in their historical temporality.

PRODUCTIONS DEVELOPED BY STUDENTS IN THE CONTENT ANALYSIS RESEARCH CATEGORY

The structuring of a concept map, highlighted in Figure 4A, evidences informative propositions about the research carried out, using the content analysis method, following Bardin (2013, 2016), and how it was thought and structured to support the student's writing. This research approach makes it possible to apprehend trends and new discoveries about researched content, which, according to Moraes (2003), may signal the emergence of a new theory. Being a structured and recognized research style in the investigation of a scientific problem, it recognizes a focal question linked to an objective leading to a corresponding methodology. According to Bardin (2013, 2016), the content analysis methodology contemplates the selection and investigation of a significant sample of the research problem so that the results and discussions appropriate to the formulated question can be reached.

In view of the advances in the construction of scientific works, the set of publications, added over the period, generated possibilities for carrying out various researches applying content analysis. Figure 4B includes the four studies published in this category: Aciole et al. (2021), in the explanations about the feasibility of developing concept maps in the study of animal diversity; Cunha et al. (2021), with a comparative analysis between two publications that explored morphological and phylogenetic characteristics related to the taxa Cycliophora and Kinorhyncha; Aciole et al. (2022, 2023) in the development of the state of the art regarding publications addressing neglected invertebrates that were deepened in the Laboratory of Research in Zoology Teaching.

Figure 4 – Illustration of a concept map explaining what a content analysis survey is about and examples of corresponding publications.



Source: Authored by the authors.

Content analysis is a method that allows the use of analytical and synthesis reasoning, including the study of speeches given and documented. Laurence Bardin's work, cited here in two versions (Bardin, 2013, 2016), in French and Portuguese, respectively, systematizes the reasoning about a methodological process of investigation that has been well applied in theoretical research and analysis of questionnaire responses. By discussing the content analysis technique as a research instrument on a theme developed in the authors' own practice, it is possible to visualize simplifications about the research process carried out. In addition, the analysis of the theme based on a sample of significant documents, for the study of a taxon, broadens the understanding of the problem (Araújo-de-Almeida et al., 2020).

STUDENT-LED PRODUCTIONS IN THE CATEGORY OF RESEARCH FOCUSED ON KEY CONCEPTS

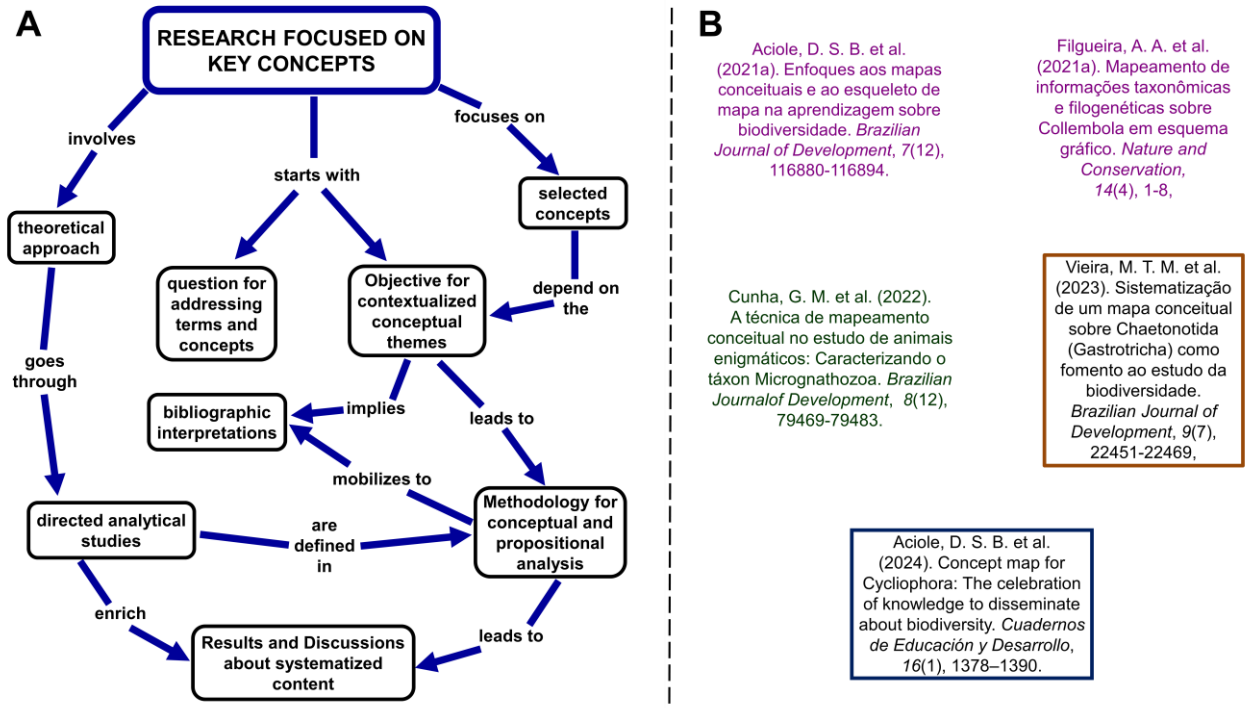
To ensure the rigor of an investigation, it is essential that the concepts are clearly defined and, in this sense, Wong et al. (2020) highlight the importance of clarifying scientific concepts and propose a theoretical scheme that defines these attributes. According to Memory (1990), Musheno and Lawson (1999), the comprehension of the terms of a content is necessary, deserving special attention before, during, and after the reading of a subject. In this conception, concept maps were used by Araújo-de-Almeida et al. (2019a) to illustrate interactions between the concepts used in

Phylogenetic Systematics, thus providing a more dynamic understanding of the various terminologies related to this subject.

As a model of scientific construction, to describe complex biological concepts related to the subject of study, a theoretical writing style focused on the exploration of concepts was adopted, as illustrated in Figure 5A. When applying the concept mapping technique in the systematization of knowledge, it is necessary to follow convincing scientific protocols that justify a scientific question to define the intended objective and guide the methodological path. Following these basic assumptions, the following rhetoric must be supported, like any scientific research, on theoretical foundations. Moreover, making use of maps in an investigation is, according to Wheeldon and Åhlberg (2012), another way of visualizing research and reflecting on the processes and decisions it requires.

With the support of a team skilled in the concept mapping technique, along with the demands of the classroom for published works involving concept maps on little-known animal diversity, some writings became necessary for conceptual studies. The visual schemes were contextualized as an object and research method and underwent a theoretical discussion, supporting an enlightening text. This made it possible to build didactic materials for teaching and disseminating biological diversity. Figure 5B shows, in this category, a total of five publications, in which the following participated: Aciole et al. (2021a), with the production of a skeletal concept map on Kamptozoa, in the previous triggering in order to add the necessary propositions to the focal question; Filgueira et al. (2021a), for the elaboration of a conceptual map on Collembola, which is of great importance in the study of the evolution of the Hexapoda; Cunha et al. (2022) and Vieira et al. (2022), for their illustrative description of the taxa Micrognathozoa and Chaetonotida (Gastrotricha), respectively. Citing Aciole et al. (2024), who went beyond teaching projects, with the proposition of a conceptual map containing morphological characters based on research on Cycliophora, for the celebration of biodiversity.

Figure 5 – Specification of a concept map illustrating what an investigation focused on concepts and examples of associated work is about.



Source: Authored by the authors.

It is worth noting that, from the perspective of developing good concept maps expressing propositional clarity in the scientific knowledge about animal diversity under study, the recommendations made by Novak and Cañas (2008, 2010), Aguiar and Correia (2013) and Cañas et al. (2015) were essential. And, as highlighted in Araújo-de-Almeida et al. (2019a, 2020), it is also necessary to structure the survey of concepts, based on specialized and conceptually validated bibliographies. In addition, the production of these visual schemes, in its constant evolution, benefited from the support of the *CmapTools software* developed at the Institute for Human and Machine Cognition (IHMC) (see Cañas et al., 2003). This *software* made the construction of concept maps more efficient, considering the search for semantic clarity in the propositions presented therein. This digital support, available free of charge and appropriate for making conceptual connections through linking words and arrows, reinforces the possibility of motivating learners with the use of the concept mapping technique (Dantas et al., 2021). The use of the *CmapTools* tool allows you to reduce the time spent on the elaboration of concept maps when compared to the laborious work required to manually make these graphic organizers.

FINAL THOUGHTS

The conclusions drawn from the various publications investigated and organized into three categories of scientific construction styles, namely, experience reports, content analysis and research focused on key concepts, show that the study of these enigmatic invertebrates provided opportunities

for students to take active roles in the investigation of these organisms. With the academic writings disseminated, the dissemination of general knowledge about biodiversity to a wider public was promoted, as well as technical information and important bibliographic references related to the mapped taxa, which often circulate only among specialists.

By noticing the advances in the experiences accumulated over nine years of academic production with the conceptual mapping tool, it is possible to affirm that this technique has been a relevant method in the production of academic content. The materialization of the works addressing phylogenetic, zoological and ecological concepts, makes visible the pedagogical empowerment and increases the sense of belonging in relation to the animal diversity little studied. Moreover, innovation in teaching, by fostering the publication of scientific writings, helps to build knowledge that returns to the classroom at a later time. Activities of this nature can also contribute to training and empowering both those who teach and those who learn.

Considering that conceptual mapping seeks to organize knowledge on any subject graphically, in a synthetic way, the acquisition of skills of this type becomes useful in the experience of intellectual empowerment, not only in teaching about animal diversity and related themes, but also in the exploration of diversified studies. In this way, the published publications, exploring different styles of writing, become examples to be considered in the methodological process of diverse academic research. In addition, with the possession of academic records, situated in space and time, there are valuable biographical subsidies to be revisited and that can be used to confront the past with the present and then evoke the voices that echo and transform the trajectories lived.

This study, addressing a set of experiences in addition to the contributions resulting from four teaching projects, reveals the renewal intentions that are being promoted through new constructions of projects and various publications, in the training of undergraduate students with a focus on environmental education (see Araújo-de-Almeida et al., 2023; Viana et al., 2023). Initiatives in this sense, to broaden the themes of the construction of concept maps beyond the study of enigmatic animals, include the prospect, in progress, of carrying out new research, revisiting other themes such as the fauna associated with various organisms, for example, the bivalve mollusks *Brachidonts* and bromeliads and psammophytes.

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We express our gratitude to the Dean of Undergraduate Studies of the Federal University of Rio Grande do Norte (UFRN), for the valuable financial support that subsidized students in the four teaching projects, where we explored the concept maps in the study of invertebrate biodiversity in the Undergraduate courses in Biological Sciences and Ecology. We are also grateful to the students who engaged in this trajectory in search of the construction of innovative and transformative

pedagogical knowledge. We emphasize our special thanks to the anonymous evaluators of the 9th International Conference on Conceptual Mapping, held in Malta in 2022, for their relevant contributions to the abridged version, in scholarly communication format, which was submitted and accepted for presentation at this event. The observations made by these evaluators motivated the updating and expansion of the ideas in this text. We also take this opportunity to offer a special tribute to Dr. Joseph Donald Novak (*In Memoriam*) for his contributions in the development and improvement of the concept mapping methodology.

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