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ARTICLE

GUIDELINES FOR PLANNING SCIENCE TEACHING BASED ON THE THEORY OF CONCEPTUAL PROFILES

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ABSTRACT:

Conceptual profile is a model that characterizes the heterogeneity of conceptual thinking in the meaning of scientific concepts, assuming the coexistence, in individuals, of two or more ways of meaning the same concept, when it is mobilized in different contexts. This research started from the following question: which guidelines can support the planning of science teaching based on the theory of conceptual profiles? In order to do so, we used a theoretical-bibliographic study, in which we analyzed a set of theses and dissertations that developed science teaching interventions supported by the theory. This analysis allowed us to enunciate theoretical-methodological guidelines for the planning of teaching supported by the theory of conceptual profiles.

Keywords:
Theory of conceptual profiles; Pedagogical planning; Science teaching.

LINEAMIENTOS PARA LA PLANIFICACIÓN DE LA ENSEÑANZA DE LAS CIENCIAS A PARTIR DE LA TEORÍA DE LOS PERFILES CONCEPTUALES

RESUMEN:

El perfil conceptual es un modelo que caracteriza la heterogeneidad del pensamiento conceptual en la significación de los conceptos científicos, asumiendo la coexistencia, en los individuos, de dos o más formas de significar un mismo concepto, cuando se lo moviliza en contextos diferentes. Esta investigación partió de la siguiente pregunta: ¿qué lineamientos pueden sustentar la planificación de la enseñanza de las ciencias a partir de la teoría de los perfiles conceptuales? Para ello, utilizamos un estudio teórico-bibliográfico a partir del cual analizamos un conjunto de tesis de maestría y de doctorado que desarrollaron intervenciones de enseñanza de las ciencias sustentadas por esa teoría. El análisis nos permitió enunciar lineamientos teórico-metodológicos para la planificación de intervenciones didácticas sustentadas en la teoría de los perfiles conceptuales.

Palabras clave:
Teoría de los perfiles conceptuales; Planificación didáctico-pedagógica; Enseñanza de las ciencias.

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DIRETRIZES PARA PLANEJAMENTO DO ENSINO DE CIÊNCIAS BASEADO NA TEORIA DOS PERFIS CONCEITUAIS

RESUMO:

Perfil conceitual é um modelo que caracteriza a heterogeneidade do pensamento conceitual na significação dos conceitos científicos, assumindo a coexistência, nos indivíduos, de dois ou mais modos de significar um mesmo conceito, quando ele é mobilizado em diferentes contextos. Esta pesquisa partiu da seguinte questão: quais diretrizes podem fundamentar o planejamento do ensino de ciências baseado na teoria dos perfis conceituais? Para tanto, lançamos mão de um estudo teórico-bibliográfico a partir do qual analisamos um conjunto de teses e dissertações que desenvolveram intervenções de ensino das ciências amparadas por essa teoria. Essa análise nos permitiu enunciar diretrizes teórico-metodológicas para o planejamento de intervenções de ensino respaldadas pela teoria dos perfis conceituais.

Palavras-chave:
Teoria dos perfis conceituais; Planejamento didático-pedagógico; Ensino de ciências.

INTRODUCTION

A conceptual profile is a model that characterizes the heterogeneity of conceptual thinking in the meaning of scientific concepts, assuming the coexistence, in individuals, of two or more ways of signifying a same concept, when the latter is mobilized in different sociocultural contexts. This is the central idea of *the research program on conceptual profiles*[1] (Mortimer *et al*., 2014). Since its emergence, the theoretical framework on the conceptual profile has been maturing as a theory on teaching and learning and as a methodology for building profiles (Sepulveda, 2020). However, as a result of its diffusion in the area of Science Education, an important agenda has been highlighted in recent years: the use of this theory and of the models developed through it for planning science teaching (Aguiar Jr., 2014; Sabino and Amaral, 2018; Sepulveda , 2020).

Studies such as those by Aguiar Jr. (2014) and Sepulveda (2020), for example, have already proposed ways of using the theoretical framework and the results of empirical investigations on profiles in the design of activities for science teaching. Still, there is a vast diversification between the methods of planning and implementing practices based on the theory in the literature on conceptual profiles, as evidenced by the works analyzed in the review presented in this article, emphasizing that a generalizable understanding of the use of profiles in science teaching planning has not yet been explicitly systematized. That said, we start this study with the following question: *What guidelines can support a didactic-pedagogical planning of science teaching in accordance with the theory of conceptual profiles?*

We consider as basic elements in a didactic-pedagogical planning the definition of objectives, contents, methodology, didactic strategies, and evaluation methods in an intervention. The *Objectives* are the starting point from which intentional and systematic actions are structured in the teaching process. The general objectives express broader purposes, related to demands arising from intentionalities shaped by the social context, while the specific objectives have a pedagogical character and encompass the approach to content and development and to learning (Libânio, 2013). The *contents*, in turn, can be classified as: conceptual, related to the understanding of concepts, principles and evidence that structure a discipline; procedural, which touch the methodological dimension and relate to the exercise and application of techniques and methods; and attitudinal, which encompass an axiological dimension related to values, norms, attitudes and behaviors (Zabala, 1998).

In planning, *teaching methodology* is characterized as a theoretical-practical guiding axis, governed by concepts about learning, the nature of science, the functions of school education and the role of the teacher

and the students in the classroom, and assumes a structuring dimension in didactic-pedagogical planning. *Didactic strategies* make up a set of intentional and planned actions by the teacher to achieve the specific learning objectives proposed in the planning. They must be flexible, molded from a teaching methodology, and based on the delimitation of purposes (Alves and Bego, 2020). The planning also foresees the different *modes of evaluation* adopted in an intervention, modes that support different perspectives that range from traditional conceptions to emancipatory conceptions on the evaluation of learning (Luckesi, 2014).

The objectives of this theoretical-bibliographical study are: *to characterize* the objectives, contents, methodologies, strategies, and modes of evaluating teaching interventions implemented in studies on the theory of profiles; and *propose* guidelines for the use of this theory in the didactic-pedagogical planning of science teaching. To do so, we gathered data from a set of studies that implemented interventions to analyze teaching and learning processes with the contribution of the theory of profiles, and we interpreted the characteristics of these interventions based on assumptions of this research program, which supported the proposal of guidelines for the use of conceptual profiles in science teaching planning.

This research is especially aimed at teachers and researchers who wish to use conceptual profiles to base their teaching practices and intends to contribute to the consolidation and expansion of this research program as a reference for the development of science teaching. Next, a section on the theoretical bases of the concept of conceptual profiles will be presented, followed by a section dedicated to the methodology used in the study. Then, we will discuss the results in each category analyzed and the guidelines outlined, and finally the final considerations.

THEORETICAL BASES OF THE RESEARCH PROGRAM ON CONCEPTUAL PROFILES.

From a socio-interactionist point of view, *concepts* can be understood as generalizations/abstractions situated on a social, supra-individual level, which result in meanings attributed to entities and phenomena (Mortimer *et al*., 2014), such as, for example, the concepts of the atom and heat. Broader categories, which are at the same time scientific and metaphysical objects, such as matter, life, mind, and society, are classified as *ontoconcepts* (Coutinho *et al*., 2007). *Conceptualization,* in turn, is an emergent process, produced through the interaction between an individual and some event or social experience, a process that occurs in the subject's thinking and is socially oriented (Mortimer *et al*., 2014).

Taking into account the perspective on concept and conceptualization presented, the theory of profiles assumes that concepts and ontoconcepts are not cognitive constructions originated and accommodated in the minds of individuals and defends the possibility of individuals conceptualizing their experiences in different ways, based on the variety of contexts in which they occur, which underlies the existence of *conceptual profiles*. The models that embody a conceptual profile are structured by *zones* that represent the different ways in which a given concept can be signified in different contexts. The characterization of each zone, in turn, is based on the epistemological, ontological, and axiological *commitments* that support the different ways of mobilizing the concept (Mortimer *et al*, 2014).

Epistemological commitments concern the way knowledge is produced through different philosophical substrates and a variety of interpretations of nature and its phenomena. Some of these epistemological perspectives identified in zones proposed for different profiles are realism, substantialism, empiricism, rationalism, and ultra-rationalism (Silva & Silva, 2017). *Ontological commitments* dimension the existential nature of the being and the properties that guarantee their essence. Examples of ontological categories are the classification of "things" as materials, abstractions, or processes (Chi, 1993, quoted by Dimov *et al*., 2014). *Axiological commitments*, in turn, are related to the values and purposes attributed to entities, as well as to the affective character and moral judgment of the subjects' relationship with the world as they represent it (Sepulveda, 2020).

The arrangement of zones in a profile is organized based on the stages of the sociocultural genesis that directs the meaning of the concept, and the commitments direct the different ways of meaning it in a given situation (Sepulveda, 2020). Figure 1 presents an example of a conceptual profile developed by Amaral and Mortimer (2001) for the concept of heat. Other concepts and ontoconcepts have already been modeled in this same perspective, such as the atom (Mortimer, 1994), entropy and spontaneity (Amaral, 2004), life (Coutinho, 2005), adaptation (Sepulveda, 2010), substance (Silva & Amaral, 2013), energy (Simões-Neto, 2016) equilibruim (Silva Costa & Santos, 2022), among others.

Figure 1. Conceptual profile of heat (Mortimer & Amaral, 2001)

Zones	Description
Realist	Heat understood by common sense and related to the sensations of hot and cold.
substantialist	Heat understood as a material substance flowing between bodies.
animist	Heat considered as a living substance that gives life to other beings/substances.
empirical	Heat related to temperature measurements using a thermometer.
Rationalist	Heat presented as a mathematical relationship and understood as a form of energy that manifests itself through the contact between two bodies at different temperatures.

Source: Adapted from Amaral and Mortimer, (2001).

The different ways of signifying a scientific concept expressed by a conceptual profile can coexist in the same subject and can be used in different situations, insofar that one way of signifying this concept does not replace another (Mortimer *et al*., 2014). This was the main argument used as a counterpoint to the theoretical model of Conceptual Change (CC) (Posner, 1982, quoted by Mortimer, 2011), a perspective that was rather widespread in science teaching research at the time of the emergence of the concept of conceptual profile.

The CC theoretical movement argues that conceptual learning is based on the idea of replacing simpler or more spontaneous ways of conceptualizing with more complex and comprehensive ones, when the subject is exposed to learning situations that cause cognitive conflicts (Mortimer, 2011). However, conceptual learning from the point of view of the theory of profiles is conceived through two interconnected dynamic processes: a *cognitive process*, which occurs through the enrichment of a conceptual profile in the individual, made possible by the acquisition of new ways of thinking about a certain scientific concept, which is understood as an expansion of the profile towards new zones; and by a *metacognitive process*, which occurs through the subject's awareness of both the multiplicity of modes of thought that constitute the profile, as well as the way in which they can plausibly be applied in different social situations (Mortimer *et al*., 2011; Mortimer *et al*., 2014).

The way in which the research program in profiles conceives the teaching and learning processes scales the theory's potential to support a science teaching that, by promoting dialogue between different ways of conceptualizing the world, makes it more plural, enabling teachers and students to build a holistic view of the different ways of understanding concepts (Diniz Júnior *et al*., 2015). One of the pioneering studies that used the profiles' approach to systematically base the planning and implementation of a didactic-pedagogical intervention was that of Aguiar Jr. (2014). For this author, the idea of context is central when considering the use of profiles for teaching planning.

Aguiar Jr. (2014) took into account different context scales in the design of the proposed intervention in his study. The *macrocontext* involves both the science classroom, where different conceptions of the world and values coexist, and the materiality of the school with its didactic and methodological resources; the *mesocontext* is characterized by the teaching sequence to be implemented, which is organized around a theme, with specific purposes and characteristics; and the *microcontext* are the activities arising from this teaching sequence, which

mobilize ways of thinking about the concepts and their explanatory power for phenomena and situations. Contexts, then, can be understood as situations dynamically created through interactions, via negotiation and intersubjective contracts established between the participants in a given sphere of human activity (Aguiar Jr., 2014).

Another category addressed by Aguiar Jr. (2014) are the learning routes. Routes are understood as developmental paths for a concept, enabling it to assume the plausible meanings in the language of school science. Such routes aid in the choice of teaching activities for the mobilization of profile zones in a way appropriate to a specific situation (Aguiar Jr., 2014). Sepulveda (2020), for example, used the notions of context scales and learning routes, along with empirical results of studies on the conceptual profile of adaptation, to propose planning principles for teaching Evolution in Biology in High School. However, some studies proposed teaching interventions to be analyzed in the light of the theory of conceptual profiles, designing them intuitively, or without an explicit methodological alignment, corroborating multifaceted understandings about the use of profiles in didactic-pedagogical science teaching planning – an issue that we intend to elucidate in this study.

METHODOLOGICAL COURSE

This is a qualitative theoretical-bibliographical study, developed through a systematic bibliographic review (Ramos *et al*, 2014) of theses and dissertations, and through the theoretical interpretation of the results of this review based on the fundamental bibliography of the research program in conceptual profiles. Therewith, we aimed at producing a reference framework (Demo, 2010) on the use of this theory in the classroom, enunciating this understanding as theoretical-methodological guidelines for teaching planning based on the theory of conceptual profiles.

The *scope* chosen for delimiting a *corpus* of analysis of the systematic review was the Digital Library of Theses and Dissertations (*Biblioteca Digital de Teses e Dissertações* – BDTD), as it offers advanced and complex search tools that make it possible to operate different types of metadata using descriptors and combinations of temporal cut-outs (Coelho *et al*., 2021). The *research equation* used in the search were the descriptors "conceptual profile" or "profile zones" anywhere in the text, in investigations developed between 2010 and 2020. This time frame was adopted based on a preliminary study that provided evidence that research that uses conceptual profiles to support the planning of actions in teaching began to be implemented in significant numbers from 2010 onwards (Santos & Santos, 2021).

Using the adopted research equation, 45 papers were initially identified in the BDTD. Following the reading of their titles, keywords, abstracts, summaries, and introductions, 27 studies were previously selected, observing the *inclusion criteria* for studies that used the theory of conceptual profiles as the main theoretical framework for the analysis of teaching and learning processes in scientific disciplines. From this pre-selected group, 17 papers were excluded based on at least one of the following *exclusion criteria*: (a) studies on the elaboration/proposition of conceptual profiles; (b) investigations that did not have teaching and learning processes occurring in the classroom as their study subject; (c) investigations that did not use a conceptual profile already proposed as a reference or that presented divergent interpretations to the theoretical framework presented by Mortimer *et al*. (2014). The 10 selected studies were identified with alphanumeric codes T1 to T10, as shown in Figure 2.

Figure 2. Theses and dissertations selected in the study

Code	Title of the research	Author/ Year	Area	Profile used
T1	Mapping of the conceptual profile zones of heat through an educational game for EJA[2] students	Leite, 2018	Chemistry teaching	Heat (Amaral & Mortimer, 2001)
T2	Addressing the concepts of entropy and spontaneity from the theory of conceptual profiles	Guimarães, 2019	Chemistry teaching	Entropy and Spontaneity (Amaral, 2004)
T3	The use of the conceptual profile of substance in the classroom: from teaching planning to the analysis of the students' learning process	Sabino, 2015	Chemistry teaching/ Natural Sciences	Substance (Silva & Amaral, 2013)
T4	Analysis of different ways of thinking and ways of speaking on the concept of acid/ base in a socially situated experience by undergraduate Chemistry students	Silva, 2017	Chemistry teaching	Substance (Silva & Amaral, 2013)
T5	A metacognitive teaching strategy: contributions to the conceptual profile of strength in Physics undergraduates	Chicóra, 2018	Physics Teaching	Force (Radé, 2005)
T6	The evolution of the conceptual profile of atom through experimental spectroscopic activities	Lopes, 2017	Chemistry teaching	Atom (Mortimer, 1994; 2011)
T7	Concepts of heat and temperature from the perspective of the pedagogical moment of initial problematization	Araújo, 2015	Chemistry teaching	Heat (Amaral & Mortimer, 2001)
T8	Conceptual profile regarding the atomistic conception for the physical states of matter of a group of youth and adult education students – EJA	Menezes, 2019	Chemistry teaching	Atom (Mortimer, 1994; 2011)
T9	The notion of reference: a cognitive interaction between Newtonian and relativistic mechanics	Dias, 2010	Physics Teaching	Reference (Ayala Filho & Frezza, 2007)
T10	Discovering natural selection: a teaching proposal based on the history of science	Cortez, 2018	Biology Teaching	Adaptation (Sepulveda, 2010)

Source: Elaborated by the authors.

The qualitative analysis of the selected bibliographic material was carried out through a thorough reading in order to identify the data related to the categories: (1) objectives of each intervention; (2) the contents addressed; (3) teaching methodologies adopted; (4) didactic strategies used; and (5) assessment modes implemented in each intervention. The interpretation of this information was articulated with theoretical assumptions used by the research program on conceptual profiles and, based on the understanding developed in each category, we enunciated five theoretical-methodological guidelines that have the purpose of guiding the planning of educational actions based on the theory of profiles.

RESULTS AND DISCUSSION

Among the levels of education addressed in the interventions of the selected theses and dissertations, Basic Education (BE) was the most researched level, with a total of six works. Among them, there are two studies focusing on Elementary Education (EE), two investigations focusing on Secondary Education (SE) and two studies focused on Youth and Adult Education (EJA in Portuguese). Higher Education (HE), in turn, was addressed in four works, which investigated didactic experiences in teacher training courses in Chemistry, Physics and Biological Sciences.

Figure 3 presents a summary of the objectives, contents, teaching methodologies and didactic strategies identified in the interventions. Considering that all works assumed to promote contextualization in their interventions, those that did not explain the teaching methodology were classified as "contextualization with a focus on everyday life", when using scientific knowledge to interpret common day-to-day situations, or "contextualization with a focus on everyday life". focus on the nature of science", when promoting discussions on the elaboration of scientific knowledge.

Figure 3. Set of Objectives, Contents, Methodology and Teaching Strategies

CD	Objectives	Contents	Methodologies	Strategies
T1	Promote the emergence of profile zones of heat / expand profile zones of heat/ awareness of the profile itself.	Endothermic/ exothermic processes, calorie/ joule, enthalpy, enthalpy change of reactions.	Playful approach / Contextualization with a focus on everyday life.	Didactic-pedagogical game.
T2	Help students understand scientific concepts/mobilize scientific zones.	Entropy and spontaneity, processes involving laws of thermodynamics.	Contextualization with a focus on everyday life.	Application of questionnaires, text reading, film exhibition, solving problem situations and experiments.
T3	Enable the emergence of profile zones of substance.	Simple substances, compound substances, mixtures, and medications.	Contextualization with a focus on everyday life.	Text reading, debates, digital simulator, lectures, reading of medication leaflets, group discussion.
T4	Promote different ways of thinking associated with ways of speaking on the acid/base concept in a socially situated experience related to hair beauty professionals.	Acids and bases.	Problem-based learning.	lectures, text reading, video exhibition, carrying out interviews, Case Study development.
T5	Promote awareness among undergraduates about their own way of thinking about the concept of force.	Contents related to the teaching of Physics in teacher training.	Metacognitive approach.	Application of questionnaires, reading of texts, seminar.

CD	Objectives	Contents	Methodologies	Strategies
T6	Promote the evolution of the conceptual profile of the atom.	Electromagnetic radiation, electromagnetic spectrum, natural light.	Inquiry-based teaching.	Application of tests, lectures, experiments.
T7	Carry out a survey of cognitive barriers related to the concept of heat (mapping of non-scientific zones) at the time of initial problematization.	Heat and temperature.	Freirean approach/ Pedagogical moments.	Reading texts in groups and solving questions, application of questionnaires, application of tests.
T8	Deal with the atom and the composition of matter from the conceptual profiles' perspective, respecting and discussing the different ideas related to the students' context.	Composition of matter and physical states of matter.	Contextualization with a focus on everyday life.	Application of questionnaires, demonstrative experiments, elaboration of drawings, explanation about situations.
T9	Explain the student's notions of relativity in order to establish their position in the profile/promote the awareness in each student of their notion of reference.	Newtonian mechanics and relativistic mechanics.	Contextualization with a focus on everyday life.	Reading texts, solving tests, using virtual animations.
T10	Promote the teaching and learning process of the scientific concept of natural selection (mobilizing the scientific zone) and the meta-scientific aspect of collective work in science.	Natural selection, aspects of the characteristics of Science.	Contextualization with a focus on the nature of Science.	Storytelling, *slide show*, use of music, text reading, use of didactic games, group work.

Source: Elaborated by the authors

CATEGORY 1: THE OBJECTIVES OF THE INTERVENTIONS – COGNITION AND METACOGNITION

Although some specific objectives have varied according to the theme and the contents addressed, the analyzed interventions shared at least one of these characteristics: (a) the mobilization of zones of a conceptual profile; and/or (b) promoting the acquisition of new areas; and/or (c) promoting awareness of the heterogeneity of ways of thinking about the concepts and their use in a manner compatible with a situation addressed in the classroom, as shown in Figure 3.

Correlating the identified objectives with the assumption of conceptual learning defended by the conceptual profiles program, some objectives were related to a cognitive dimension, such as, for example, mobilizing zones of a conceptual profile and/or promoting the acquisition of new zones, while other objectives assumed a metacognitive dimension, such as promoting awareness of the heterogeneity of ways of thinking (the zones) about a concept and knowing how to use them appropriately in different situations.

Objectives that encompass a cognitive dimension of learning, for example, were identified in T6, whose intervention defined the objective of promoting the evolution of the conceptual profile of the atom (scientific zones) during the development of experimental activities , and T2, which sought to mobilize scientific zones of the concept of entropy and spontaneity. Research T5, on the other hand, presented how one of the purposes of its intervention was to provide students with an awareness of their own way of thinking about the concept of force, a purpose that encompasses a metacognitive dimension.

CATEGORY 2: THE CONTENT OF THE INTERVENTIONS – THE CENTRALITY OF CONCEPTUAL PROFILES

By analyzing the way in which the contents are approached in each intervention, we verified that a conceptual profile already proposed in the literature assumes a central role in the approach of the curricular contents of a discipline, since the understanding of different definitions, ideas, processes, and phenomena mobilize zones of the profile of a specific concept. We illustrate this understanding using data from studies T1, T3 and T4 as an example.

Throughout the application of the pedagogical game developed in T1, for example, we identified the emergence of the conceptual profile zones of heat in discursive interactions involving "endothermic and exothermic phenomena", "calorie", "enthalpy" and other definitions of Thermochemistry. The study addressed in T3 presented the emergence of zones of the conceptual profile of substance in a discussion about "medicines". Results of this research showed that more than half of the students' group mobilized the rationalist zone of the profile of substance during the discussions on the issue during the intervention, since a definition of "medicine" goes through the sieve of understanding what a chemical substance is.

In the investigation proposed in T4, the author started from the assumption that the process of conceptualizing acids and bases can be supported by the zones of the conceptual profile of substance and adapted this profile to analyze the discourse of undergraduate students in Chemistry in situations related to a community of practice formed by hairdressers. The results showed that the concept of acids was mobilized in different contexts through ways of thinking about and speaking of the characteristics of substance profile zones.

In the literature, one of the justifications for proposing the conceptual profile of heat and substance pointed out by the authors of these profiles was that they are important concepts for learning other scientific concepts (Amaral & Mortimer, 2001; Silva & Amaral, 2013). In this sense, data from T1, T3 and T4 expose this relationship and show how zones of a conceptual profile traverse the understanding of different curricular contents. In addition, these results converge with what Santos and Sepulveda (2017) point out, when they argue that the zones of a specific conceptual profile can emerge in the approach of other concepts and definitions underlying the latter.

Based on this understanding, we corroborated that the concepts that have a conceptual profile in the literature are central, and the zones of this profile support the understanding of different *conceptual contents* – definitions, ideas, processes, events, etc. In addition, data from the T6 investigation also demonstrated that a conceptual profile, in addition to being connected with the conceptual contents' approach, can also have its zones mobilized in the learning of *procedural contents*, as this study presented an intervention through which students mobilized zones of the conceptual profile of the atom for the understanding of experiments involving the emission of electromagnetic radiation.

Research T10, on the other hand, demonstrated that a conceptual profile can be mobilized in discussions about values and attitudes, that is, through the approach of *attitudinal contents*. In this specific case, the conceptual profile of adaptation was mobilized in discussions about the nature of science and about the role of scientists in the elaboration of the theory of natural selection. A conceptual profile, therefore, can guide the approach to conceptual, procedural, and attitudinal contents, since the profiled concepts assume a central role in the organization of the contents of a discipline and the zones of these profiles make it possible to structure the understanding of different contents.

CATEGORY 3: TEACHING METHODOLOGIES – THE IMPORTANCE OF CONTEXTUALIZATION

The table expressed in Figure 3 also presents a summary of *the teaching methodologies* used in each intervention. In this research, these methodological approaches were classified based on the understanding that methodology is a theoretical-practical guiding axis governed by pedagogical concepts that guide teaching (Alves & Bego, 2020). It should be noted that, although not all the methodologies adopted were explicitly assumed by the authors of the works, the analysis of the characteristics of each intervention enabled the construction of the table. Consequently, it was possible to verify that all methodologies expressed a common point: the search for a contextualization.

Contextualization is a term that can assume different perspectives in science teaching, as there are several approaches that are labeled as contextualized (Wartha et al., 2013). However, the analyzed interventions sought contextualization as a way to promote the mobilization of different zones of a profile, presenting students with contexts that represented everyday situations and situations that required the use of scientific language. In these cases, the relationship between conceptual profiles and teaching methodologies is characterized by the implementation of contextualized approaches.

The relationship between concept and context conceived from the perspective of the theory of conceptual profiles denotes the possibilities of this theory to weave interlocutions with different methodological teaching approaches that focus on the creation of different contexts in the classroom, since the research program on profiles argues that it is the contexts that evoke the different zones of a conceptual profile (Aguiar Jr., 2014). The investigation reported in T7, for example, used an approach on heat and temperature based on the initial problematization stage of the Pedagogical Moments proposed by Delizoicov and Angotti (1992). The pedagogical intervention proposed in T8, developed in the context of EJA, included discussions committed to elements of the social context in approaching the concept of atom in debates on properties of matter.

From the perspective of context scales (Aguiar Jr., 2014; Sepulveda, 2020), the teaching methodologies adopted in these interventions have the status of mesocontext , as they involve a teaching sequence with characteristics and purposes aimed at conceptual learning and its relationship with sociocultural contexts inherent to the classroom and school – the macrocontext. Inquiry-based teaching (IBST), Problem-Based Learning (PBL) and the Pedagogical Moments or the Freirean Approach are examples of teaching methodologies[3] identified as interventions that materialize as a mesocontext.

Data from the investigations also revealed that, in addition to the scientific zones, which are characteristic of the language of school science, the non-scientific zones of a conceptual profile must be taken into account in the didactic-pedagogical planning, since, in the development of a teaching methodology, a conceptual profile can be mobilized through zones that do not harbor commitments to the scientific language. Despite this, these non-scientific zones can have pragmatic values in the face of different types of discussions that traverse the classroom.

Examples in this direction can be seen in T7, which reports an activity of reading texts about the idea of "cold" in antiquity. The investigation data showed that the scientific zones of the conceptual profile of heat were not mobilized in this activity. However, the discussions developed were quite fruitful, as they showed the students' spontaneous knowledge, as well as how these ideas can be used to explore the understanding of some everyday phenomena. A similar situation occurred in T9, in which EJA students mobilized non-scientific areas of the profile of the atom to express their perceptions about situations presented in the classroom, a step that ended up arousing the students' interest in seeking scientific explanations for the phenomena. In this sense, the mobilization of non-scientific zones assumed the role of learning routes towards scientific zones.

Therefore, the contextualization of curricular contents is an important contribution that must be taken into account in teaching interventions based on profiles, since the theory recommends the choice of me-

thodologies that allow the immersion of students in multiple contexts in which the zones of a profile may be widely mobilized in classroom discussions. The data from the analyzed investigations confirmed this trend.

CATEGORY 4: DIDACTIC STRATEGIES – ENGENDERING MICROCONTEXTS

With regard to didactic strategies, our analysis took as a starting point the perspective that strategies are intentional actions, planned with the support of a teaching methodology, and with the purpose of achieving specific learning objectives (Alves & Bego, 2020). When analyzing the implementation of the different strategies, it was possible to verify that the type of developed activity influenced the mobilized zones of a profile. Strategies such as experimentation, simulations, modeling and solving problem situations, for example, tend to guide the mobilization of scientific zones of a profile. On the other hand, strategies such as reading and discussing texts on the History and Philosophy of Science, discussions about videos and films and reading journalistic texts in groups have been shown to influence the mobilization of non-scientific zones.

As examples, we cite the implementation of experimentation in study T6 and the use of simulators with representative animations of phenomena related to the Special Theory of Relativity, in T9. Both strategies challenged the students to express ideas about a given scientific concept (atom and frame of reference) from areas related to a scientific perspective – an epistemological commitment – and to address the concepts in an abstract language – an ontological commitment. Thus, in situations where approaching a concept is more appropriate parting from scientific language and an abstract ontology, such as, for example, the mobilization of the quantum zone of the conceptual profile of the atom, teaching strategies for this purpose should include activities that challenge students to express their ideas based on these perspectives. Therefore, activities such as the use of simulators, the microscopic interpretation of experiments or the resolution of problem situations are more suitable for these purposes.

However, when non-scientific zones of a profile emerge in a teaching approach, being useful for understanding what is being discussed, it is appropriate to adopt strategies committed to the epistemological and ontological aspects that support these zones. In this sense, socialization strategies and contextual approaches that require dialogue and the expression of ideas about the concept in a more informal and intuitive way can be chosen.

Correlating the observations presented with the idea of context scales (Aguiar Jr., 2014), it is admissible to state that the epistemological and ontological commitments that sustain the zones of a conceptual profile can be used as indicators for choosing the didactic strategies to be developed in an intervention, in a manner that such strategies may be able to generate microcontexts that direct the meaning of a concept from zones of its profile that appear plausible to a specific situation.

In this sense, when there is an intention to approach scientific zones of a conceptual profile, it is worth highlighting the importance of the learning routes, which help to direct the meaning of a concept aligned with the discourse of school science. The routes can be materialized through the type of didactic strategy developed in the classroom, as well as through the teacher's discourse, when intersubjective contracts are established in which the subjects are oriented to share points of view and are predisposed to transcend their particular world to accommodate the perspective of the other (Aguiar Jr., 2014; Sepulveda, 2020).

CATEGORY 5: WAYS OF ASSESSING LEARNING – THE CENTRALITY OF DISCOURSE

The evaluation of learning from the perspective of the theory of profiles can be related to: (a) the analysis of zones that students already mobilize before the instruction process; (b) the analysis of the acquisition of new zones of a profile; (c) the analysis of awareness about the heterogeneity of ways of thinking about a concept; and (d) the analysis of the mobilization of zones in a context-appropriate way. However, in

the didactic interventions analyzed in each research, most authors did not explicitly refer to the evaluation methods used in the developed interventions. The investigation presented in T1 was the only study that clearly mentioned the evaluation possibilities from the conceptual profiles approach. In this investigation, the author suggested that formative assessment is a coherent way to assess the emergence of the zones and their relationships with the contexts presented in class.

In the analyzed studies, we identified both the emergence of zones of a profile and processes of awareness of the heterogeneity of ways of thinking about a given scientific concept. The instruments used in these analyses bring important information that can be used to think about ways of evaluating when an intervention in the classroom is methodologically guided by a conceptual profile. In the investigations raised in our review, there is a predominance of the analysis of discursive interactions and interviews, which suggests that the mode of evaluation through discursive analysis can be very fruitful.

Taking into account the evaluation of learning in a dialogic, procedural and dynamic perspective (Luckesi, 2014), and also the mediating conception (Hoffmann, 2011) – which seeks to detach itself from the verification of right/wrong answers and from authoritarianism to guide itself by an investigative and reflexive sense of the teacher in relation to the students' manifestations – the evaluation in the scope of the theory of profiles can be developed by the analysis of the different ways in which the students express their ideas, mainly orally. In this way, the evaluation of learning can be carried out by articulating different instruments that allow the teacher to be in permanent contact with the different ways of thinking and speaking of the students about scientific concepts, thus prioritizing orality.

Based on the interpretations developed in each analyzed category, we systematized five guidelines that aim to guide the didactic-pedagogical planning of teaching interventions based on the theory of conceptual profiles. Figure 4 presents a summary of these guidelines.

Figure 4. Theoretical-methodological planning guidelines based on the theory of profiles

Elements	Guidelines
Objectives	The objectives of a teaching intervention based on conceptual profiles should encompass a cognitive dimension related to the mobilization of zones and/or acquisition of new zones of a conceptual profile, and/or a metacognitive dimension, related to the awareness of the heterogeneity of ways of thinking and the mobilization of zones of a profile in a coherent way in different contexts.
Contents	Conceptual profile models are central to the organization of teaching contents, as their zones are mobilized in the understanding of conceptual, procedural, and attitudinal contents that one wishes to address in a discipline. Therefore, it is necessary to define which conceptual profile should guide the intervention.
Methodology	Teaching methodologies are structured as a *mesocontext* which should provide a contextualized approach to teaching content, exploring themes that mobilize every day and scientific knowledge, seeking a reflective attitude towards the themes presented.
Strategies	The didactic strategies are *microcontexts,* therefore, they should be defined based on the commitments that support zones of the conceptual profile that one wants to mobilize and implemented with the help of intersubjective contracts and learning routes.
Evaluation	The assessment should take into account different instruments that make it possible to verify the students' ways of thinking about a certain concept, prioritizing orality.

Source: Elaborated by the authors.

FINAL CONSIDERATIONS

In this investigation, we started with the following question: Which guidelines can support a didactic-pedagogical planning of science teaching in accordance with the theory of conceptual profiles? Based on a review of the elements of intervention planning, implemented in research that used the theory to analyze teaching and learning processes, and its correlation with assumptions of this research program, we enunciated five guidelines that can indicate the definition of objectives, contents, methodologies, strategies and methods of evaluation in teaching practices supported by the theory of conceptual profiles and by the profiles already proposed in the literature.

The guidelines set out here summarize our understanding built throughout the data analysis, in synergy with theoretical assumptions aligned with the theoretical framework of Mortimer *et al*. (2014). These are generalizable guidelines, which are intended to guide the development of different teaching proposals. In this sense, their dissemination is important to inspire teachers and researchers in the elaboration of new interventions theoretically and methodologically guided by the theory of conceptual profiles, as well as for the refinement of the guidelines themselves, here presented.

In addition, the results of this study may open up new research fronts in the research program on conceptual profiles related to the relationship between profiles and curricular contents, to the potentialities of the articulation between different teaching methodologies with the approach of profiles, to the pragmatic dimension of didactic strategies in mobilizing zones of a profile in different situations, and to the learning assessment fostered by theory. Future investigations should expose the potentialities, possibilities, and limits of the proposed guidelines, enabling their refinement and consolidation.

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NOTES

1 The research program on conceptual profiles has recently matured (Sepulveda, 2020). It emerged in the late 1990s through an investigation that culminated in the proposition of the conceptual profile of the atom (Mortimer, 1994). In 2014, with the publication of the work entitled: "Conceptual Profiles: A theory of teaching and learning scientific concepts" organized by Eduardo Mortimer and Charbel Niño El-Hani, the notion of conceptual profiles was disclosed to the scientific community as a theory about teaching and learning. learning concepts and has been gaining greater repercussions in the area of Science Education, being used as a reference in national and international research.

2 EJA: *Educação de jovens e adultos*: Youth and adult education.

3 It should be noted that we mention TI, PBL and the Pedagogical Moments as teaching methodologies based on the characterization presented by Alves and Bego (2020) and adopted in this study. Other authors may scale them differently based on national literature.

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